31st RMC 2025

Raman Memorial Conference

Celebrating 100 years of Quantum Physics

"Quantum Science and Technology"
(पुंजकीय विज्ञान आणि तंत्रज्ञान)

BOOK OF ABSTRACTS

21st – 22nd February 2025

Organized by

Research Students
Department of Physics
Savitribai Phule Pune University, Pune

In association with

IPA, Pune Chapter

RAMAN MEMORIAL CONFERENCE (2025)

"Quantum Science & Technology (पुंजकीय विज्ञान आणि तंत्रज्ञान)"

FEBRUARY 22, 2025

Department of Physics,

Savitribai Phule Pune University, Pune.

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FOREWORD

It is with great enthusiasm that I write this foreword for the 31st Raman Memorial Conference, scheduled to take place on the 21st and 22nd of February, 2025, in the Department of Physics of Savitribai Phule Pune University. The Department of Physics is proud to present this conference, a cherished tradition organized by our research students since 1994 with the continued support and guidance of our faculty members. Since its beginning, the Raman Memorial Conference (RMC) has evolved into an elite forum for exchange of ideas, and this year's milestone 31st edition reinforces its unwavering commitment to the progress of physics. The theme for RMC 2025, "Quantum Science and Technology (पुंजकीय विज्ञान आणि तंत्रज्ञान)" strongly resonates with the scientific times we live in. Quantum Science has become a ground-breaking discipline, rewriting the textbooks in computing, communication, cryptography, and sensing in the last 100 years since its discovery. From quantum algorithms that provide unmatched computational power to entangled systems that goes above classical limits, the discipline is on the edge of revolutionizing technology and human knowledge. By focusing the conference on this theme, we hope to spark debates on frontier developments and interdisciplinary investigations, and the ethical aspects of quantum innovations, so that the participants are exposed to both the promise and the pitfalls of this dynamic discipline.

For over three decades, this event has been organized with the motto “by the students, for the students”, reflecting the dedication and enthusiasm of the research students. As a result, the conference has become a hallmark of our department’s culture. We are excited to continue this legacy, not only to nurture academic expertise but also to develop leadership and organizing skills.

The conference this year will feature distinguished speakers and visionaries from various fields. The students will have the opportunity to explore subjects such as quantum computing, quantum materials, and quantum-enabled sustainable solutions. Apart from lectures, the conference will also provide lively debates, poster presentations, and networking sessions, where an atmosphere is fostered where ideas take shape and partnerships develop. I wish to extend my sincere appreciation to the organizing team, faculty advisors, and participants whose collective efforts ensures RMC's continued success. To the delegates, I encourage you to engage deeply, question boldly, and imagine the quantum-driven future we are collectively working to shape.

Prof. Sanjay D. Dhole

Head,
Department of Physics,
Savitribai Phule Pune University,
Pune.

FOREWORD

It is with great pleasure and immense pride to present this Abstract Book for the 31st Raman Memorial Conference (RMC) – February 21st – 22nd 2025, organized by the Department of Physics, Savitribai Phule Pune University, Pune, in collaboration with the Indian Physics Association, Pune Chapter. This year, the conference focuses on the theme "Quantum Science & Technology (पूंजकीय विज्ञान आणि तंत्रज्ञान)", a field that is at the forefront of modern scientific advancements, shaping the future of computation, communication, and sensing technologies. With the rapid progress in quantum mechanics applications, it has become imperative to bring together researchers, academicians, and industry professionals to explore new frontiers in this domain. The Raman Memorial Conference, dedicated to the legendary physicist Sir C.V. Raman, has always served as a prestigious platform for sharing knowledge, fostering collaborations, and inspiring future generations of scientists. This year's edition continues that legacy, featuring distinguished keynote speakers, insightful technical sessions, and vibrant discussions on recent breakthroughs in quantum science and technology.

This Abstract Book showcases the collective contributions of researchers from diverse backgrounds, covering a broad spectrum of topics such as quantum computing, quantum materials, quantum materials in medical sciences, and beyond. The research presented here reflects the dedication, hard work, and innovative spirit of scientists pushing the boundaries of knowledge.

I extend my sincere gratitude to all the invited speakers, participants, and contributors for enriching this conference with their research and insights.

I hope that this conference and the knowledge shared within these pages will serve as a source of inspiration and further drive advancements in the fascinating field of Quantum Science & Technology.
Wishing you all a productive and engaging conference experience!
With best regards,

Anupama Kadam

Chairperson,
Organizing Committee
31st Raman Memorial Conference 2025
Department of Physics,
Savitribai Phule Pune University, Pune.

FOREWORD

On behalf of the organizing committee, it is my pleasure to welcome you all to the **Raman Memorial Conference (RMC-2025).** This year, the conference focuses on the theme **"Quantum Science and Technology** (पुंजकीय विज्ञान आणि तंत्रज्ञान)". The conference brings together the brilliant minds in the field of quantum research, providing an exciting opportunity for learning, sharing, and advancing our understanding of this transformative area of science and technology.

Quantum science and technology are rapidly evolving fields that promise to revolutionize numerous industries, from computing and communication to healthcare and energy. The recent breakthroughs in quantum algorithms, quantum cryptography, and quantum sensing have opened new frontiers, and we are on the cusp of witnessing their real-world applications. This conference aims to explore these advancements, providing a platform for researchers and practitioners to engage in meaningful discussions and collaborate on the future of quantum technologies.

We are privileged to host distinguished speakers who will share their expertise through keynote presentation and the invited talks. In addition, the various sessions organized in the conference will provide an opportunity for deep dives into the latest research and development. I would like to take this opportunity to express my sincere gratitude to the organizing committee, volunteers, sponsors, and all contributors who have made this conference possible. A special thanks to our speakers and participants for your commitment to advancing the field of quantum science. Without your invaluable contributions, this event would not have been possible. I encourage each of you to actively engage in the sessions, share your insights, and build the collaborations that will shape the future of quantum technology.

Thank you once again for being a part of this exciting event. I hope you find the discussions insightful, and the experience enriching.

Swati Rahane

Secretary,
Organizing Committee
31st Raman Memorial Conference 2025
Department of Physics,
Savitribai Phule Pune University, Pune.

RAMAN MEMORIAL CONFERENCE – 2025

THEME

"*Celebrating 100 Years of Quantum Physics*"

"*Quantum Science & Technology* (पुंजकीय विज्ञान आणि तंत्रज्ञान)"

Quantum mechanics is one of the ground-breaking achievements of not just science, but human history. We have entered the era of nanotechnology that rely on the principles of quantum mechanics. Beyond its theoretical temptation, quantum mechanics has paved its way from lasers, semiconductors to quantum computing. Propelling towards a worthy act in humankind's development, quantum mechanics will continue to expand the horizons of scientific knowledge and technological innovation.

With this inspiration, aiming at researchers from different fields to illuminate this transformative force, we are happy to announce the RMC 2025.
Join us to explore the invisible realm of atoms riding on the waves of quantized particles!! Although the theme itself is multidisciplinary and wide enough to cover almost every research topic, to mention a few, the planned sessions include the following topics:

- Quantum materials / Low dimensional semiconductors
- 2D materials at an atomic scale
- Energy storage
- Innovation technology
- Quantum materials in medical sciences

RMC 2025 is a platform to bring together researchers from the broad areas of science to deliver talks, discuss and exchange new ideas on recent advances of respective fields.

साभार – 'सकाळ' वृत्तपत्र समूहाच्या सौजन्याने

पुंजकीय विज्ञान-तंत्रज्ञानाचे बिगुल

विज्ञानवाटा

डॉ. संजय ढोले

संयुक्त राष्ट्रांनी पुंजकीय विज्ञान अथवा क्वांटम मेकॅनिक्स या संकल्पनेला किंवा शोधाला १०० वर्षे पूर्ण होत असल्याबद्दल चालू वर्ष हे पुंजकीय विज्ञान व तंत्रज्ञान वर्ष म्हणून साजरे करण्याचे जाहीर केले आहे. पुंजकीय विज्ञानाचे जागतिक बिगुल आता भारतातही वाजायला सुरुवात झाली आहे.

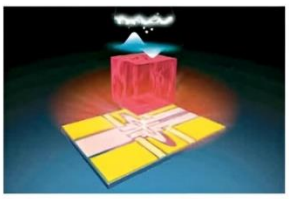
■ लेखक पदार्थविज्ञानाचे प्राध्यापक आहेत.

संयुक्त राष्ट्रांनी पुंजकीय विज्ञान अथवा क्वांटम मेकॅनिक्स या संकल्पनेला, विकासाला किंवा शोधाला १०० वर्षे पूर्ण होत असल्याबद्दल चालू वर्ष हे वर्ष पुंजकीय विज्ञान व तंत्रज्ञान वर्ष म्हणून साजरा करण्याचे जाहीर केले आहे. वर्नर हायजेनबर्ग या जर्मन शास्त्रज्ञाने पुंजकीय विज्ञान रुजविणारा पहिला संशोधननिबंध १९२५-२६ मध्ये प्रकाशित केला होता. हा निबंध सूक्ष्म व अतिसूक्ष्म शास्त्रातील घडामोडींसाठी एक वेगळे दालन शास्त्रीयजगतात उघडण्यास कारणीभूत ठरला.

महत्त्वाचे विविध शास्त्रीय विषयातील अद्भुत घटनांचे पृथक्करण तर होऊच लागले, पण सूक्ष्म विश्वातील रहस्यमय घडामोडींची ही उकल होण्यास मदत होऊ लागली. म्हणूनच पुंजकीय विज्ञान व तंत्रज्ञान हा एक जागतिक उपक्रम असून त्याचा उद्देश मुख्यतः मूलभूत विज्ञान आणि विज्ञान शिक्षणात राष्ट्रीय व आंतरराष्ट्रीय क्षमता मजबूत करणे हा आहे. याशिवाय भौतिक विश्वाबद्दलचे आपणा सर्वांचे वाढलेले ज्ञान आणि ते समजून घेण्यासाठी पुंजकीय विज्ञानाचे योगदान महत्त्वाचे ठरेल.

सभोवतालचे जग कुठल्या नियमांच्या आधारावर चालते, याचा शोध घेण्याचा प्रयत्न प्राचीन काळापासून होतो आहे. डोळ्यांना सहज दिसणाऱ्या वस्तूंचे अवलोकन करत असताना दूरदर्शीच्या साह्याने मानवाने अंतराळात झेप घेतली, तर सूक्ष्मदर्शीच्या सहाय्याने तो पदार्थांच्या अंतरंगातही डोकावू लागला... ही मानवाची जिज्ञासा होती म्हणूनच हे विश्व कोणत्या नियमावर चालते याचा शोध खऱ्या अर्थाने न्यूटनने गती, गुरुत्वाकर्षण, प्रकाश या शोधाच्या माध्यमातून उलगडण्याचा प्रयत्न केला. पुढे त्याच कालावधीत मॅक्सवेल यांनी प्रकाशाचे एक नवे रूप दाखवणारी फिल्डची कल्पना मांडली.. याच विज्ञानाला पुढे 'क्लासिकल मेकॅनिक्स' म्हणून संबोधले गेले... आणि काही काळ विश्वातील सर्वच वस्तू हे नियम पाळतात असे गृहीत धरले गेले. पण त्याच वेळी विसाव्या शतकाच्या प्रारंभी अणूचा शोध लागल्यानंतर ते मात्र न्यूटन-मॅक्सवेलचे नियम अजिबात पाळत नाहीत, हे कळल्यानंतर शास्त्रीय जगतात पुन्हा चलबिचल झाली.. आणि पुंजकीय विज्ञान किंवा क्वांटम मेकॅनिक्सचा जन्म झाला.. आणि विसाव्या शतकातील ही कल्पना खूपच क्रांतिकारी ठरली.

या विज्ञानामुळे मुख्यतः इलेक्ट्रॉन, प्रोटॉन, न्यूट्रॉनसारखे अणूमधील कण आणि फोटॉनसारखे ऊर्जेचे कण हे नेमके कोणते नियम पाळतात, ते कळायला लागले. म्हणूनच दोन अणू एकमेकांसोबत कसे वागतील, याचा अचूक अंदाज त्याद्वारे शास्त्रज्ञांना येऊ लागला. विद्युतप्रवाह हा इलेक्ट्रॉन्सनी बनलेला असतो. तर प्रकाश हा फोटॉननी बनलेला, हे कळल्यानंतर शास्त्रज्ञांना दिलासा मिळाला. सूक्ष्म घटकांचे पृथक्करण होण्यास



पुंजकीय विज्ञानाच्या प्रवाहाचे संकल्पनाचित्र.

मदत होऊ लागली. याशिवाय हे 'क्वांटा' एकाच वेळी कणांसारखे व लहरींसारखे वागतात हे 'क्वांटम मेकॅनिक्स' सांगतो आणि याची सिद्धता संशोधक लुई द ब्रो यांनी समीकरण मांडून केलीच, पण छोटे मूलकणही प्रसंगी लहरींसारखे वागतात हे सिद्ध केले. पुढे श्रोडिनजर आणि हयजेनबर्ग यांनी कण आणि लहरी या 'व्हेव पार्टिकल ड्यूऑलिटी'च्या आधारावर पुंजकीय विज्ञानात भर घालून खऱ्या अर्थाने क्वांटम मेकॅनिक्सचा जन्म झाला. म्हणूनच या पुंजकीय विज्ञानातील प्रगतीमुळे आपण टेलिव्हिजन, कंप्युटर, मोबाईल, आयपॅड, स्मार्टफोन आणि प्रगत उपकरण वापरू लागलो. महत्त्वाचे म्हणजे अतिसूक्ष्म विज्ञानाचा उदय व प्रगती हो केवळ 'क्वांटम मेकॅनिक्स'मुळे होऊ शकली. जगाची एक तृतीयांश अर्थव्यवस्था ही पुंजकीय विज्ञानावर आधारित आहे.

शास्त्रज्ञ सत्येंद्रनाथ बोस यांनी पुंजकीय संख्याशास्त्राचा प्रवाह १०० वर्षांपूर्वीच रुजवला. मॅक्सवेल व बोल्डझमन यांनी वायूतील रेणूंच्या समूहाचा वर्णनाचा अभ्यास करण्यासाठी एक सांख्यिकीतंत्र शोधले होते. त्याची सांगड फोटॉन व इलेक्ट्रॉनसारख्या मूलकणांशी घालण्याचा प्रयत्न शास्त्रज्ञ करीत होते. यात बोसही अग्रभागी होते. त्यांनी आईन्स्टाईनच्या साह्याने सूक्ष्मकणांना लागू होईल, असे 'पुंजकीय सांख्यिकीतंत्र' विकसित केले. या सिद्धांतानुसार बहुसंख्य कण जपून ठेवले तर परस्परक्रिया नसलेले संपूर्ण कण हे विशिष्ट न्यूनतम तापमानावर स्वतःची स्थिती संक्रमण करतील, असे आईन्स्टाईनने नमूद केले. यालाच 'बोस-आईन्स्टाईन संघटन' संबोधले गेले. 'क्वांटम कम्प्युटर' हे एक यंत्र असून, यातील आकडेमोड ही पुंजशास्त्रातील नियमांवर आधारित असते. त्यातील सूक्ष्म कणांची वागणूक आण्विक पातळीवर गृहीत धरली जाते. खऱ्या अर्थाने फिनमन यांनी १९८२मध्ये 'क्लासिकल भौतिक' ऐवजी पुंजशास्त्रातील नियमांवर आधारित यंत्र निर्माण करण्याची कल्पना मांडली. १९८५ मध्ये डेव्हिड डेच यांनी पुंजकीययंत्र विकसित करून पुंजकीय सारणी सर्वसमावेशक आहे हे निदर्शनास आणले. पीटर शोर आणि लोव्ह ग्रोवर यांनी क्वांटम अल्गोरिदम विकसित करून पूज्यकीय संगणकाची निर्मिती केली. यामुळे हे स्वप्न साकार होऊन, गुंतागुंतीची गणितीय आकडेमोड व मुबलक प्रमाणात माहिती साठविणे शक्य होणार आहे. पुंजकीय विज्ञानाचे जागतिक बिगुल आता भारतातही वाजायला सुरुवात झाली आहे.

पुंजकीय तंत्रज्ञान हा ऊर्जानिर्मितीचा एक चांगला व व्यवहार्य स्रोत होऊ शकतो, असे शास्त्रज्ञांना वाटत आहे. सध्या टोकियो विद्यापीठातील संगणककेंद्रातील शास्त्रज्ञांचा एका गटाने अलीकडे या पुंजकीय ऊर्जानिर्मितीत मोठे योगदान दिले आहे. त्यामुळे पुंजकीय विद्युतघट हा एक मोठा ऊर्जेचा पर्याय उपलब्ध होऊ शकतो. पारंपारिक रासायनिक विद्युतघट चार्ज होण्यासाठी लिथियमसारख्या सामग्रीवर अवलंबून राहावे लागते. पण दुसरीकडे मात्र पुंजकीय विद्युत गटात ऊर्जा साठविण्यासाठी फोटोसारख्या मूलभूत कणांचीच गरज लागणार आहे. याशिवाय पुंजकीय विज्ञानावर आधारित पुंजकीय यंत्र (क्वांटम इंजिन) हा महत्त्वाकांक्षी उपक्रम पुढे येतो आहे. जर्मनीतील केसरस्लॉटर्न विद्यापीठातील संशोधकांनी अलीकडेच यात मोठे योगदान दिले आहे. पारंपारिक इंजिन उष्णता किंवा औष्णिक ऊर्जेचे यांत्रिक कार्यात रूपांतर करण्यासाठी कारनॉट सायकलचा वापर करतात, तर हे विशिष्ट क्वांटम इंजिन फोटॉन कणांच्या सांख्यिकीय गुणधर्मांच्या परिणामी उद्भवलेल्या तत्त्वावतीवर काम करते.महत्त्वाचे म्हणजे जोसॉन हे सर्वात कमी ऊर्जेच्या अवस्थेत जमा होतात. तर फर्मिऑन्स एकमेकांच्या वर चढत जाऊन ऊर्जाग्रणालीची निर्मिती करतात. आता पुंजकीय विज्ञानावर आधारित सक्षम ऊर्जायंत्रे निर्माण करणे शक्य होणार आहे.

अतिसूक्ष्म कण, क्वांटम डॉट, फुलरीन, कार्बन नॅनो ट्यूबसारख्या अतिसूक्ष्मपदार्थांची निर्मिती प्रयोगशाळेत होऊन समाजातच नाही तर मानवी शरीरातही त्याचा वावर मोठ्या प्रमाणात वाढणार आहे. त्यामुळे पृथ्वीतलावर त्यांचे प्रबळतत्त्व मोठे ठरणार आहे. मुख्य म्हणजे हे पदार्थ पुंजकीय विज्ञानाचेच नियम पाळणार असून ते मानवी जीवनासाठी फायदेशीर ठरणार आहे. कारण या माध्यमातूनच सशक्त कम्प्युटर्स, क्वांटम मशीन्स, नॅनोब, क्वांटम दळणवळण यांसारखी निर्मिती होऊन औद्योगिक, वैद्यकीय व कृषिक्षेत्रही कार्बोज करेल. वैद्यकीय क्षेत्रात या पुंजकीय विज्ञान व तंत्रज्ञानाला चालना देण्यासाठी भारतानेही क्वांटम मिशनची योजना आखली असून. पुढील आठ वर्षांसाठी सहा हजार कोटींची भरीव तरतूद केली आहे. याचा अर्थ जागतिक विज्ञान पुंजकीय मोहिमेत भारत सामील झाला असून, शास्त्रज्ञ पुंजकीय घटकांची निर्मिती करून भारताला जागतिक टप्प्यावर नेतील.

About the Raman Memorial Conference

Sir Chandrasekhara Venkata Raman was an Indian physicist. He employed monochromatic light from a mercury arc lamp which penetrated transparent material and was allowed to fall on a spectrograph to record its spectrum. He detected lines in the spectrum which he later called Raman lines. He presented his theory at a meeting of scientists in Bangalore on 16 March 1928, and won the Nobel Prize in Physics in 1930. In his memory, research students in Physics department of Savitribai Phule Pune University organise Raman Memorial Conference every year.

RMC, The Raman Memorial Conference, started in the year 1994, is organized annually by the research students of the Department of Physics, Savitribai Phule Pune University. The two-day conference is enriched by scientific talks and discussions. There are five invited talks with oral sessions. The invited talks are delivered by eminent scientists from various fields to promote the interaction between the scientists and the students. The open discussion after each oral presentation and at poster session is a key to self-assessment and self-understanding. Ever since the event started, it has continuously grown in all aspects. The conference aims to encourage young researchers working in physical sciences and related areas to present their work, interact among themselves and with eminent scientists in relevant fields.

Motivation of RMC

We, at RMC strive to bring together researchers from the broad areas of science to deliver talks, discuss and exchange new ideas on recent advances of different fields. The purpose of this conference is to provide a platform for discussing promising developments in different areas as outlined below. Further, this gathering will enable delegates to establish research collaborations as well as link up for future collaborations.

We anticipate that the Raman Memorial Conference outcome will lead to significant contribution to the current state of knowledge in these up-to-date fields. In the interest of presenting original abstracts as either oral presentations or posters, the organizing committee of the conference invites prospective authors to submit their abstracts.

Topics covered

- Quantum in AI and Machine learning
- Energy materials & devices
- Astronomy & Astrophysics
- Biophysics & Bioinformatics
- Catalysis
- Chemical Physics
- Computational Physics
- Density Functional Theory
- Energy Studies
- Fluid Dynamics
- LASER & Optics
- Material Science
- Nanoscience & Nanotechnology
- Non-Linear Dynamics
- Nuclear Physics
- Plasma Physics
- Soft Matter Physics
- Thin Films & Vacuum Techniques
- Interdisciplinary

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INVITED TALKS

Quantum Materials and Heterostructures

P S Anil Kumar*

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Quantum materials display novel electronic phenomena arising from reduced dimensionality, quantum confinement, topology of wave functions, and other factors. These materials, such as graphene, topological insulators (TIs), Weyl semimetals, spin-liquids, and others, have attracted extensive research interest from condensed matter physicists and materials scientists in recent decades as they offer promising prospects for the next generation of electronic devices due to their superior properties. The emergence of TIs and semimetals has opened up a new realm of low-energy electronic devices that enable dissipation less transport through their highly spin-orbit coupled conducting channels. Dual TIs possess two different topological surface states protected by different symmetries. Scanning Tunneling Microscopy and Spectroscopy have identified topological surface states and one-dimensional conducting channels in these materials. Introducing superconductivity to dual TIs can result in topological superconductivity, potentially hosting Majorana fermions for quantum computing. In BiTe/$NbSe_2$ and BiSe/$NbSe_2$ heterojunction, evidence of p-wave superconductivity was found through electrical transport measurements, revealing anisotropic p-wave and s-wave superconducting gaps.

*In collaboration with Gagan Rastogi, Abhinab Mohapatra, Ambili KK, and R Ganesan

India's Energy Transition: An Overview

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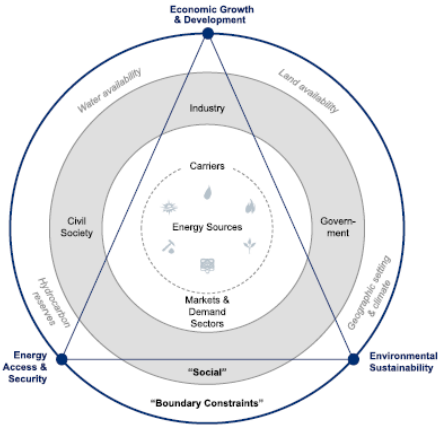
Fundamental transitions across global energy systems are underway which are characterized by unprecedented complexity. Technology advances and discoveries have created a range of energy sources which are changing the way energy is generated and consumed. As the demand for energy surges worldwide, the requirement to adopt new approaches and strategies to fundamentally change the energy architecture has become top global priority [1].

To deliver a sustained economic growth rate of 8% to 9% through 2031-32 and to meet life time energy needs of all citizens, India has to increase the primary energy supply by 3 to 4 times and electricity generation capacity about 6 times. There has been 80% increase in the power demand (243 GW) which has attracted $139 Bn investment in the power sector and has increased the installed renewable energy capacity by 71%.



Energy decisions are being underlined by the urgency of addressing the climate debate. This can be well visualized by Energy Triangle. The production, transformation and consumption of energy clearly have significant negative environmental externalities. The widely known aspect of renewable energy is its infinite and non-GHG emitting nature and the increase electrical energy generation by Solar and Wind Energy Generators is seen in many countries including India.

A secure, affordable and environmentally sustainable energy supply will create a lasting balance in management of the three sides of the energy triangle: economic growth and development; environmental sustainability; and energy access ((Energy Poverty) and security.

Smalley in his presentation on "Future Global Energy Prosperity: The Terawatt Challenge" has discussed the issues related to increased energy demand and the technological needs to meet the demand without causing damages to the environment [2]. It is interesting to find that some of the ideas discussed are what the current global Energy Transition trajectory is following.

The data from the literature will be presented to discuss the trajectory being followed by India and other countries, with the emphasis on electrical energy.

The modern energy systems comprising diverse electrical energy generators and consumers requires proper methodologies for meeting all the system characteristics. Quantum technologies afford several possibilities and will be discussed in the presentation.

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Tuneable Ferromagnetic and Antiferromagnetic States in the Charge Transfer materials: A Case Study of $SrCoO_x$ Thin Films

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UGC-DAE Consortium for Scientific Research, Indore.

The Metal-insulator transition (MIT) in $SrCoO_x$ (x =2.5 & 3) systems, via electrochemical reaction, is attributed as a Mott-transition, which has tremendous prospects in the new branch of physics called the Mottronic. The reversible switching between the insulating $SrCoO_{2.5}$ and the metallic $SrCoO_3$ phases can be achieved via very small electric bias. To improve the functionality of these devices it is crucial to understand the electronic structure across the different switching states in insulating and metallic regions of the constituent materials. In this framework, our group has recently explored different regions of the Zaanen−Sawatzky−Allen (ZSA)-diagram by varying electronic correlation parameters in $SrCoO_x$ by varying strain in its thin film form. For instance, bulk $SrCoO_{2.5}$ is in the insulating positive charge transfer energy (Δ) regime in the ZSA-diagram and is an antiferromagnetic-insulator. However, by strain engineering, $SrCoO_{2.5}$ thin films move into the insulating negative Δ regime and become ferromagnetic-insulator. On the other hand, oxygen intercalation in $SrCoO_3$ systems (both bulk and thin films) induce a transition into metallic negative Δ regime and become a ferromagnetic-metal. Interestingly, $SrCoO_{2.5}$ can be reversely converted to $SrCoO_3$ by electric biasing also in an all oxide heterostructure, leading to colossal volto-magnetic effect. With these examples, we demonstrate that electronic functionality of $SrCoO_x$ systems can be largely modulated by strain, redox reaction or electric biasing, showing a big potential for Mottronic devices.

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Fabrication of 2nm GAA logic devices: A correction to Moore's law from the quantum perspective

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With the recent explosion of AI (artificial intelligence) computational techniques. The need to perform complex calculations with millions of parameters with a fraction of resources has become the need of time. For this purpose, many of the semiconductor fabricators are trying to develop large die size logic chips with a greater number of transistors. However, with increasing number of transistors the power input and thus the thermal dissipation is as high to the limit of melting the device. The only way to overcome this huge power consumption is to reduce the size of the transistor. With a smaller size of the transistor the operating currents are reduced thus reducing the overall power consumption. Interestingly, till around 24nm gate sizes the physical dimensions of the transistor were almost equivalent to effective gate length of the designed MOS (metal oxide semiconductor) device. In practice, Moore's law was valid till 24nm gate lengths [1]. For effective gate lengths below 24nm, the shrinking of the physical dimensions of the transistor is limited by the quantum effects, mainly tunneling at the oxide-semiconductor interfaces.

In planer transistors, there is a single oxide-semiconductor interface, but planar transistors are limited to only around 24nm gate length. Below 24nm gate length a FinFet (fin type field effect transistor) type of design was adopted to increase the control over the gate [2]. Inherently, FinFet has 3 oxide-semiconductor interfaces. Thus, there is an increase in the probability of quantum effects. Interestingly, the FinFet structure shows deviation from the physical gate dimensions as compared to the effective gate length. For a typical 3nm effective gate length the physical gate length is around 12-18nm.

In this talk, I will discuss the development of 2nm effective gate length GAA (Gate all around) transistors, which are a step ahead of the current FinFet technology. FinFet technology cannot be scaled below 3nm effective gate length. It is predicted that the 2nm GAA transistors will further reduce power consumption by 20% as compared to 3nm FinFet devices, with almost 15% more number of transistors in the same die area. However, even a

3 NS (nano sheet) has more than 6 oxide-semiconductor interfaces, which drastically increases the quantum effects and further limiting the physical shrinking of the gate length[3]. New high-K (K = dielectric constant) oxide materials are required to control the gate of the transistor, at the same time low-K dielectric materials are necessary around the Cu wiring to reduce the RC delay affecting the switching speed of these transistors. Finally, I will introduce the BSPDN (Backside power supply network) very latest technology under development, which simulations show that, can further reduce the power consumption of the 2nm GAA devices by reducing the heat islands across the logic die as compared to the SRAM (static random-access memory) components of the logic device. In conclusion, Moore's law below 24nm deviates from its original definition as the physical dimensions and the effective dimensions do not match each other. Hence, there is a huge need to redefine Moore's law in the sub-nanometer regime.

Acknowledgements:

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This work was carried out at Albany Nanotechnology Center, NY in collaboration with IBM Corp., Albany, NY. The data generated and shared is collected by IBM Corp. on IBM tools. I am grateful to Donald Canaperi, Daniel Schmit, Rishi Krishnan and Govind Bajpai of IBM Corp. for the deep dive discussions and sharing the valuable data.

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Magneto-Raman Spectroscopy of van der Waals Antiferromagnet

Amit Pawbake,[1,*] Florian Petot,[2] Florian Le-Mardelé,[1] Tristan Riccardi,[1,3] Julien Lévêque,[2] Bing Wu,[4] Zdeněk Sofer,[4] Benjamin Piot,[1] Benoît Grémaud,[2] Andrés Saúl,[2] Johann Coraux,[3] Milan Orlita,[1] and Clément Faugeras[1,*]

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It was recently discovered that the family of van der Waals (vdW) bonded materials includes members with magnetic properties that persist down to the monolayer. This breakthrough opens up numerous opportunities both in fundamental physics and for practical applications based on these intriguing materials. They present different magnetic ground states that can be probed with optical techniques combined with magnetic fields. One such material is CrOCl, a stable frustrated vdW antiferromagnetic insulator, with a low-symmetry orthorhombic structure. The magnetic frustration in principle produces very rich magnetic phase diagrams comprising highly-degenerate disordered phases and complex spin orders. Varying the temperature, magnetic field or hydrostatic pressure, one can navigate through these exotic phase diagrams. Along with remarkable properties, including anisotropic thermal conductivity, spin interactions of different natures, magnetic phase transitions, and optical anisotropy. However, a comprehensive understanding of the magnetic phase dependent phonon modes in CrOCl is still lacking.

We report on the Raman scattering spectroscopy of bulk CrOCl and observed anomalies in the phonon modes at the magnetic transitions. We observe the appearance of a series of low intensity phonon modes below T_N ~ 13 K, characteristic of the size of the magnetic unit cell and the phonon band structure through the phonon zone folding effect. When applying an external magnetic field, we stabilize new magnetic ground states with different magnetic unit

cells which can be identified by the series of folded phonon modes. The spectroscopy of such zone folded phonons (ZFP) provides a unique insight into the field induced magnetic phases of frustrated vdW magnets.

In this talk, based on our low temperature and high magnetic field experimental results I will establish ZFP spectroscopy is an efficient way to probe different magnetic periodicity.

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Quantum Subspace Optimization and Energy Landscape Burrowing

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Recent quantum-classical hybrid algorithms pertaining to electronic structure theory primarily focus on dynamic ansatz compression with measurement-based selection of important operators. While such algorithms provide extremely accurate results under ideal noiseless circumstances, the associated number of measurements and circuit complexity rapidly proliferate with the system size, leading to extremely erroneous results when implemented in available noisy quantum hardware. Moreover, the associated optimization often gets trapped in local-minimas or Barren-Plateaus, hindering effective energy minimzations even under noiseless circumstances. To mitigate the effects of such problems, we propose a theoretical framework that exploits the nature of the non-linearly coupled parameter optimization trajectory in quantum computing framework. The proposed methodology assumes an *adiabatically decoupled* structure in the many-body operator space consisting of a core *principal* and a peripheral *auxiliary* subspace[1, 2]. The optimization problem is effectively projected onto a lower dimensional manifold with fixed or dynamic structure, spanned by only principal operators. This drastically reduces the quantum resource utilization such as the number of CNOT gates and quantum measurements. Further, we establish a functional relationship that predicts the auxiliary parameters from the reduced dimensional principal subspace via either machine learning or analytical techniques. This leads to a suite of non-iterative *auxiliary subspace corrections (ASC),* ensuring a 'vertical burrowing' in the energy landscape to a better minima without requiring any additional quantum resources. Additionally we suggest a new initialization technique based on the adiabatic principle that can lead to relatively faster optimizations with much less requirements for quantum measurements. We have heuristically shown that ASC can effectively escape higher-energy local minimas. This formalism is a general theoretical framework that can be clubbed with any variable or fixed structured ansatze. As an example, our numerical studies demonstrate, when the method is clubbed with the state-of-the-art adaptive derivative

assembled problem tailored variational quantum eigensolver (ADAPTVQE), our method provides one or two-orders of magnitude better energy estimations for strongly correlated molecular systems in both noiseless and noisy scenarios.

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THESIS PRESENTATIONS

Photoelectrochemical Investigation of ZnO based photoanodes for water splitting application

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Abstract:

Hydrogen production via photoelectrochemical water splitting is a promising route to convert solar energy into chemical fuel, reducing energy crises and boosting environmental health. ZnO is extensively studied as a photoanode for water splitting application. But, limited optical absorption and recombination losses of photogenerated charge carriers supressed its efficiency of PEC water oxidation [1]. The PEC activity of ZnO can be enhanced by coupling with low band gap semiconductor. Here, we report the fabrication of ternary ZnO/CuO/Au heterostructures by electrodeposition and chemical bath deposition methods. Au plasmons incorporated in ZnO/CuO heterojunction enhance the optical absorption and promote fast free charge carrier transport at the interface through the surface plasmon resonance (SPR) effect[2]. The ZnO/CuO/Au photoanode exhibits a photocurrent density of 1.08 mA/cm^2 at 1.0 V Vs SCE, two times higher than pristine ZnO. Also, we report the synthesis of pristine ZnO nanosheets (ZNS), nanorods (ZNR), and ZnO nanotubes (ZNT) thin films via electrodeposition. Then, a few layered MoS_2 were deposited on these morphology-dependent ZnO thin films using RF-magnetron sputtering to form ZnO/MoS_2 heterostructures for PEC (PEC) water splitting. The UV-Visible spectroscopy analysis showed that the pristine ZnO has a strong absorption in the UV region. However, the absorption spectra spread over a visible region for the ZnO/MoS_2 heterostructures [3]. PEC (PEC) activities of synthesized pristine ZnO with different morphologies and ZnO/MoS_2 heterostructures were investigated by chronoamperometry, linear sweep voltammetry (LSV), electrochemical impedance spectroscopy (EIS), and Mott-Schottky (M-S) analysis. The ZnO/MoS_2 heterostructure with nanotube morphology of ZnO (ZMS-T) exhibited the highest PEC activity, with the current density ~1.28 mA/cm^2 at 1.0 V Vs. SCE.

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Engineering Semiconducting Metal Oxide Nanocomposites for Efficient Hydrogen Production and Sustainable Environmental Remediation

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Abstract:

The growing energy demand and environmental pollution call for sustainable solutions in clean energy and wastewater treatment. Hydrogen, a renewable energy carrier, is a viable alternative to fossil fuels, with semiconductor-based photocatalysis offering an efficient and eco-friendly generation method. Additionally, organic dye pollutants, contributing 1.6 million tons annually to water contamination, pose serious ecological risks. Photocatalysis effectively degrades these pollutants through photo-induced electron transfer. This study explores the synthesis, characterization, and photocatalytic performance of semiconducting metal oxide nanocomposites for hydrogen production and dye degradation. A series of cobalt oxide-based nanocomposites such as Co3O4-VO2 (CV), Co3O4-TiO2 (CT), and Co3O4-ZnO (CZ) were successfully synthesized via a hydrothermal method, with varying molar ratios (1:1, 1:2, and 2:1) to optimize their photocatalytic performance. The structural, morphological, and optical properties of these nanocomposites were thoroughly characterized using advanced techniques, including TEM, FESEM, XPS, BET, Raman spectroscopy, PL, XRD, UV-DRS, and FTIR. The results revealed that the Co3O4-VO2 (CV-21) nanocomposite with a 2:1 molar ratio, Co3O4-TiO_2 (CT-12) with a 1:2 ratio, and Co3O4-ZnO (CZ-11) with a 1:1 ratio exhibited significantly enhanced photocatalytic activity. The optimized nanocomposites demonstrated superior hydrogen evolution efficiency, with hydrogen generation rates of 2270, 1120, and 2643 µmol/g·h for CV, CT, and CZ, respectively. Additionally, the photocatalysts exhibited rapid dye degradation, achieving complete degradation within 5–10 minutes under natural sunlight, highlighting their potential for sustainable energy production and environmental remediation. This study advances the critical role of molar ratio optimization, crystallinity,

and structural engineering in enhancing the catalytic efficiency of metal oxide-based nanocomposites for sustainable hydrogen production and wastewater treatment.

Keywords: Photocatalysis, Semiconducting Metal Oxides, Nanocomposites, Hydrogen Generation, Dye Degradation.

Spectroscopic Insights into Halide Perovskites for Solar Energy Conversion

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Abstract:

Lead-free halide double perovskites (HDPs), such as $Cs_2AgBiCl_6$ and their doped variants, have emerged as promising, environmentally safe materials for optoelectronic applications due to their structural stability, nontoxicity, and favourable photoelectric properties.[1-3] Doping has proven to be an effective method for enhancing the optoelectronic performance and reducing defect state density in these materials. Among the various doping strategies, Fe and In alloying have been shown to improve the properties of $Cs_2AgBiCl_6$ perovskites, but the detailed understanding of their excitonic behaviour and charge carrier dynamics remains an area of active research. This study investigates how Fe doping influences the structural and optical properties of $Cs_2AgBiCl_6$ perovskites, with a particular focus on self-trapped exciton (STE) dynamics. Using experimental and computational approaches, we explore the effects of Fe incorporation on the optoelectronic properties of the material. Successful doping of Fe^{3+} ions is confirmed through X-ray diffraction (XRD) and Raman spectroscopy. Further, the Fe-doped $Cs_2AgBiCl_6$ perovskites show enhanced absorption, indicating sub-band gap transitions related to surface defects as revealed from optical absorption spectroscopy. Photoluminescence (PL) studies reveal a significant increase in PL intensity, attributed to higher radiative recombination rates and increased STE density. Time-resolved PL (TRPL) and temperature-dependent PL measurements further elucidate the radiative kinetics, exciton-phonon coupling, and activation energy, providing valuable insights into the charge carrier dynamics. Similarly, the study also explores In-alloyed $Cs_2AgIn_xBi_{1-x}Cl_6$ nanocrystals (NCs), synthesized through a novel approach, to gain a deeper understanding of their structural, morphological, and optoelectronic properties. XRD and energy dispersive spectroscopy (EDS)

confirm the successful incorporation of In, while Raman spectroscopy highlights three active vibrational modes, confirming the crystalline quality of the materials. The NCs exhibit tunable band gaps ranging from 2.7 eV to 3.5 eV depending on the In/Bi ratio. Detailed PL and TRPL studies offer insights into exciton-phonon coupling and radiative decay kinetics. The density functional theory (DFT) calculations predict an indirect band gap for $Cs_2AgBiCl_6$ and a direct band gap for $Cs_2AgInCl_6$. The band edge positions, determined by cyclic voltammetry (CV), provide further insights into the electronic properties of the materials and their potential for optoelectronic applications. Our findings enhance the fundamental understanding of charge carrier dynamics, particularly in relation to STEs, and offer valuable guidance for the design of more efficient lead-free perovskite materials for optoelectronics and photocatalysis. By investigating both Fe-doped and In alloyed double perovskites, this study provides a comprehensive approach to optimizing these materials for a range of advanced technological applications.

Keywords: charge carrier dynamics, exciton-phonon coupling, halide double perovskites, nanocrystals, optoelectronics, etc

Acknowledgements: Swati Rahane expresses gratitude to the Chhatrapati Shahu Maharaj Research Training and Human Development Institute (SARTHI) for their generous financial assistance.

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Understanding the interplay of correlated orders in layered materials

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Abstract:

Correlated orders in layered crystals play a crucial role in determining their electronic, magnetic, and structural properties. These materials, including transition metal dichalcogenides (TMDCs), van der Waals magnets and non-van der Waal kagome layered superconductor, exhibit complex interactions between charge, spin, orbital, and lattice degrees of freedom. The carrier doping and strong spin orbit coupling modifies electron-phonon coupling can lead to emergent phenomena such as charge density waves, superconductivity, and unconventional magnetism. The scanning tunneling microscopy (STM) has provided deeper insights into the interplay of these correlated states. Furthermore, external tuning parameters like charge carriers, structural site occupancy allows to control over these orders, offering potential applications in quantum technologies. Understanding and manipulating correlated orders in layered crystals is essential for developing next-generation electronic and quantum devices.

Here, we worked on three layered crystals:1T-$TiSe_2$, $Fe_{5-x}GeTe_2$, and $CsV_{2.9}Mn_{0.1}Sb_5$. 1T-$TiSe_2$ is prone to a CDW phase below its CDW transition temperature. We successfully reported the effect of Ti self-intercalation on the transition temperature and electronic local density of states (LDOS) using temperature-dependent STM measurements. In $Fe_{5-x}GeTe_2$, we observed two distinguishable, coexisting structural orderings (as shown in Fig. 1), each with different electronic densities of states. We successfully linked this variation to the magnetization observed in bulk measurements. In the 2D kagome lattice $CsV_{2.9}Mn_{0.1}Sb_5$, we determined the ordered and disordered structures of Cs ions on the surface. We characterized these ordered and disordered surfaces and showed that variations in the local density of states may play an important role in the bulk properties.

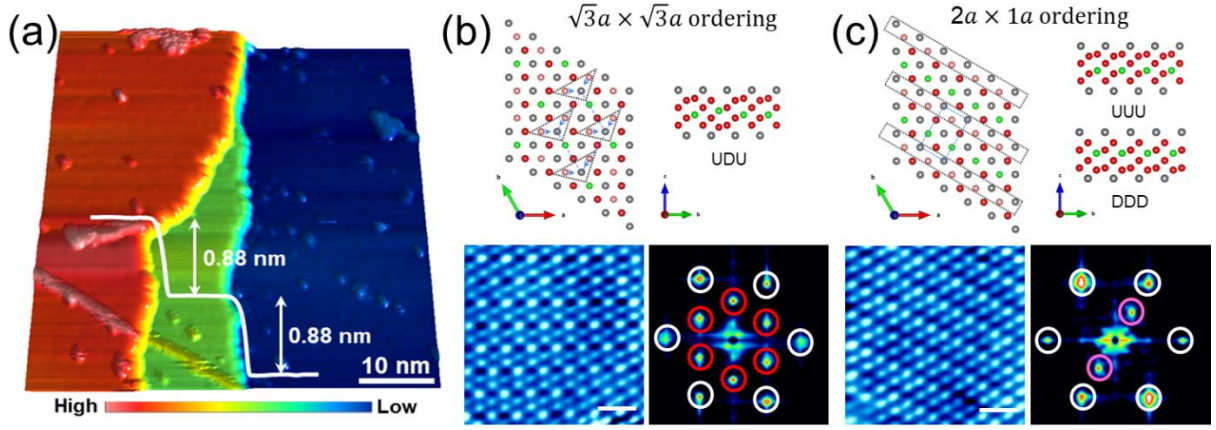

Fig. 1: (a) 3D view of the Fe5−xGeTe2 surface (V = 1 V, I = 0.1 nA) showing layer cascade. (b) In the upper panel, the structural origin of the UDU arrangement is shown in the top view (left) and side view (right). The STM topographic image shown in lower left is 3a × 3a R30∘ structural ordering (V = −100 mV, I = 100 pA). To the lower right is the corresponding FFT of the STM image, which shows the lattice peak (marked by white circles) and the structural ordering peaks (marked by red circles). (c) In the upper panel, the top view (left) and side view (right) of the structural arrangement with alternating UUU and DDD stripes is shown. The STM topographic image shown in lower left is 2a × 1a structural ordering (V = −100 mV, I = 100 pA). The lower right shows the corresponding FFT of the STM image, which shows the lattice peaks (marked in white) and the structural ordering peaks (marked in magenta**).**

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Developing High Performance Dielectrics for Electrowetting Based Applications and Electric Signal Generation

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Abstract:

This study presents a fabrication of various bilayer dielectric films for Electrowetting (EW) and energy harvesting applications. The EW response on bilayer dielectric geometry made from PMMA and top fluoropolymer shows a consistent change in contact angle without any EW hysteresis for both AC and DC voltage. This PMMA-Fluoropolymer dielectric is employed in the fabrication of a miniaturized liquid lens and successfully achieved manipulation of the oil-water curvature of the oil-liquid demonstrating optical magnification of the object kept in the plane of the focus [1]. Further, Nematic liquid crystals (LC) are incorporated into PMMA polymer to enhance its dielectric as well as optical properties that are characterized using polarized optical microscopy (POM) and photoluminescence spectroscopy [2]. The POM images enhanced birefringence and light transmission with increasing LC content. Photoluminescence studies show increased emission intensity and a shift in peak wavelength. Finally, EW on PDLC dielectric is investigated by applying external AC and DC voltage on liquid droplets. A parallel plate PDLC cell is prepared to demonstrate an optical switch with an external electric field. Finally, EW on bilayer ferroelectric polymer, PVDF-HFP with a top layer of hydrophobic Teflon AF is demonstrated. The ferroelectric layer increases the effective dielectric constant of the bilayer geometry; however, it introduces remnant polarization in the dielectric layer resulting in a pinned EW response. The effectiveness of such dielectric is discussed for rapid low-voltage EW based mixing on the droplet scale for both sessile as well as parallel plate geometries [3]. The concept of reverse electrowetting energy harvesting on PVDF-HFP is demonstrated from the application point of view [4]. Theoretically, the reverse electrowetting can be approximately modelled using a lumped element-based electrical circuit. The output voltage obtained for ferroelectric PVDF-

HFP is greater than Teflon AF due to its high dielectric constant. Furthermore, reverse electrowetting on charged Teflon is carried out to eliminate the use of constant bias voltage. But, unfortunately, very low output voltage is obtained on charged Teflon. Thus, PVDF-HFP is a suitable material for reverse electrowetting-based energy harvesting.

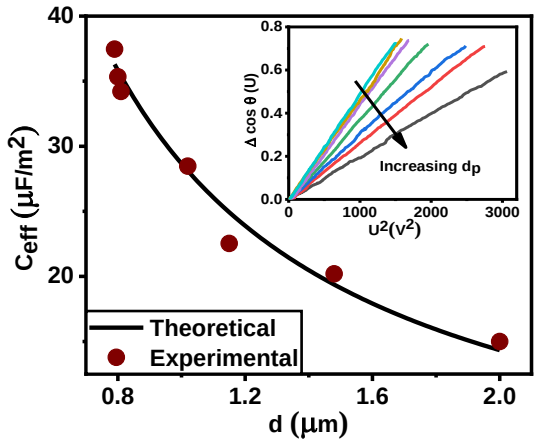

Fig.1: Effective capacitance plotted for various thickness values of PMMA. Inset shows the EW response with varied PMMA thickness

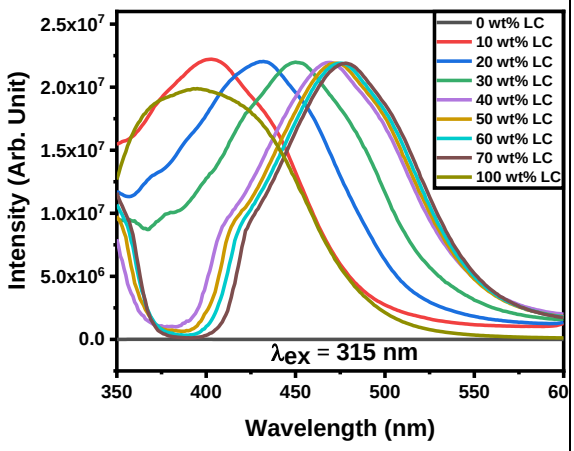

Fig. 2: Photoluminescence emission (PL) spectra recorded at excitation wavelength of 315 nm for PDLC films with varying LC concentration

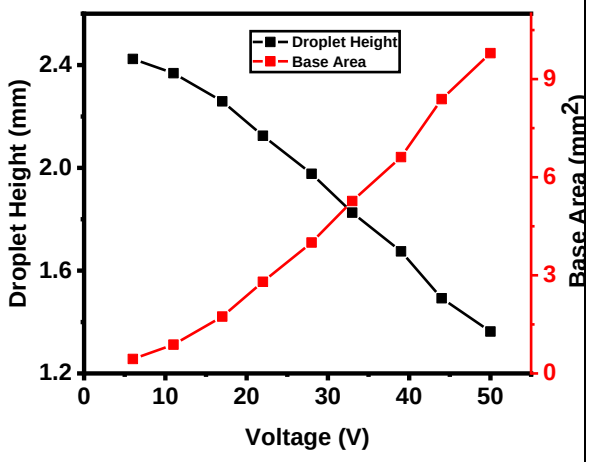

Fig.3: Droplet height and base area variation with voltage using spherical cap model

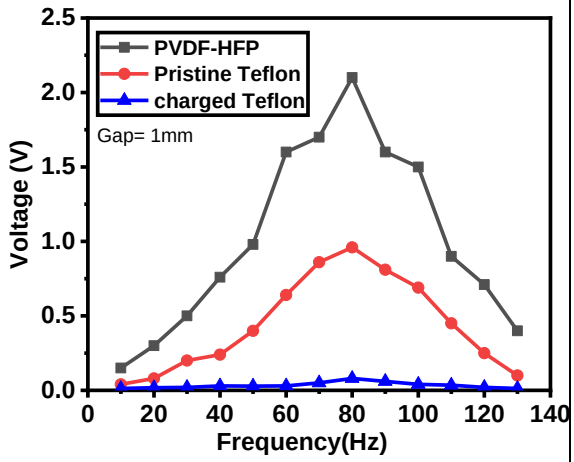

Fig. 4: Output voltage using Reverse Electrowetting on PVDF-HFP, Pristine Teflon and charged Teflon

Keywords: Bilayer dielectric, PDLC, effective capacitance, liquid lens, reverse electrowetting etc.

Publications list:

1. *Optical and Electrowetting investigation of PMMA dispersed Nematic Liquid Crystals dielectric*

   Pranjali Yedewar, Swapnil Doke and Arun Banpurkar

   Journal of Material Science, 59, 18814-18825, (2024)

2. *Polymethyl Methacrylate (PMMA)/Fluoropolymer Bilayer: A Promising Dielectric for Electrowetting Applications*
   Pranjali Yedewar, Sandip Wadhai, Yogesh Sawane and Arun Banpurkar
   Journal of Material Science, 57, 9018-9027, (2022)
3. *In Vitro Comparison of the Wettability of a Bioceramic Root Canal Sealer on Dentin With and Without Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) Laser Irradiation*
   Poonam Joshi, Rajesh Shetty, Arun Banpurkar, Dr. Vini Mehta, Gargi Sarode, **Pranjali Yedewar**, Tanvi Sharma
   Cureus, 14 (3), 1-7, (2022)
4. *AC and DC voltage electrowetting on ferroelectric polymer for low voltage applications*
   Pranjali Yedewar, Sandip Wadhai and Arun Banpurkar
   AIP Conference Proceedings 2265 (1), 030309, (2020)
5. *UV-resistant superhydrophobic surface on copper foil*
   Sandip Wadhai, Anurag Kanase, Rajashree Deokar, **Pranjali Yedewar** and Arun Banpurkar
   AIP Conference Proceedings 2104 (1), 030037, (2019)

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ORAL PRESENTATION

Interface defects study of the CFTS absorber layer and CFTS/CdS interface layers using SCAPS-1D simulation

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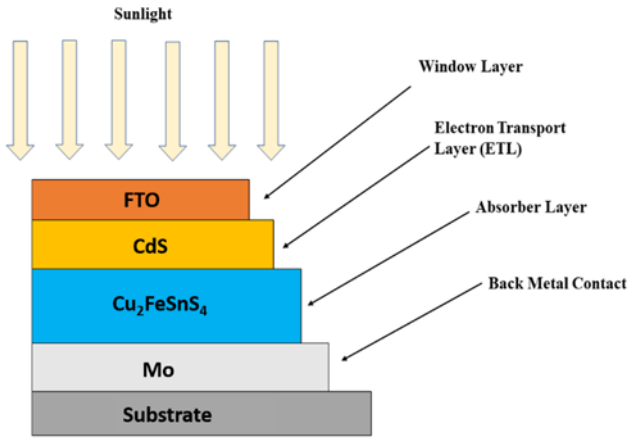
Abstract:

Quaternary chalcogenide semiconductors have garnered significant attention in photovoltaics due to their promising optoelectronic properties. Among them, Cu_2ZnSnS_4 (CZTS) has been extensively studied for solar cell applications due to its direct bandgap and high absorption coefficient. However, Cu_2FeSnS_4 (CFTS) remains relatively underexplored despite exhibiting comparable potential as a photo-absorbing material. In space, solar cells are exposed to various forms of radiation, which leads to formation of defects. These defects can be analyzed using the Solar Cell Capacitance Simulator (SCAPS-1D) by adjusting the defect parameters of both individual and the interface layers [1]. In this study, we investigate the photovoltaic performance of a simulated FTO/CdS/CFTS/Mo solar cell using the Solar Cell Capacitance Simulator (SCAPS-1D) under standard illumination conditions (AM1.5G, 1000 W/m²) at cell temperature 300 K. The defect density in the interface layer was varied from 10^{10} to 10^{15} cm^{-3}, while the absorber layer defect density was varied from 10^{14} to 10^{18} cm^{-3}, to understand their impact on key solar cell parameters, including short-circuit current density (Jsc), open-circuit voltage (Voc), fill factor (FF), and power conversion efficiency (PCE). Our findings reveal that while changes in the absorber layer defect density significantly impact Jsc, variations in the interface defect density exhibit negligible effects on Jsc but strongly influence FF and Voc. These results provide useful guidance for improving the design and fabrication of radiation-resistant CFTS-based solar cells, particularly for space applications.



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Optical Properties of ZnSe Nanoplatelets

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Abstract:

In the present work, ZnSe Nanoplatelets (NPLs) of 4 and 2.5 monolayer (ML) were synthesized using hot-injection chemical route method. [1] These NPLs show two narrow and sharp absorption peaks at 347, 329 nm and 294, 282 nm for 4ML and 2.5 ML ZnSe NPLs respectively due to heavy hole (hh) and light hole (lh) state. [2] The difference between the hh and lh states decreases from 18 nm to 12 nm for 4ML and 2.5ML ZnSe NPLs respectively. Photoluminescence of 4ML ZnSe NPLs observed at 349 nm with narrow FWHM of 8.2 nm. Further temperature dependent PL study carried out to determine exciton binding energy and thermal expansion coefficient of 4ML ZnSe NPLs.

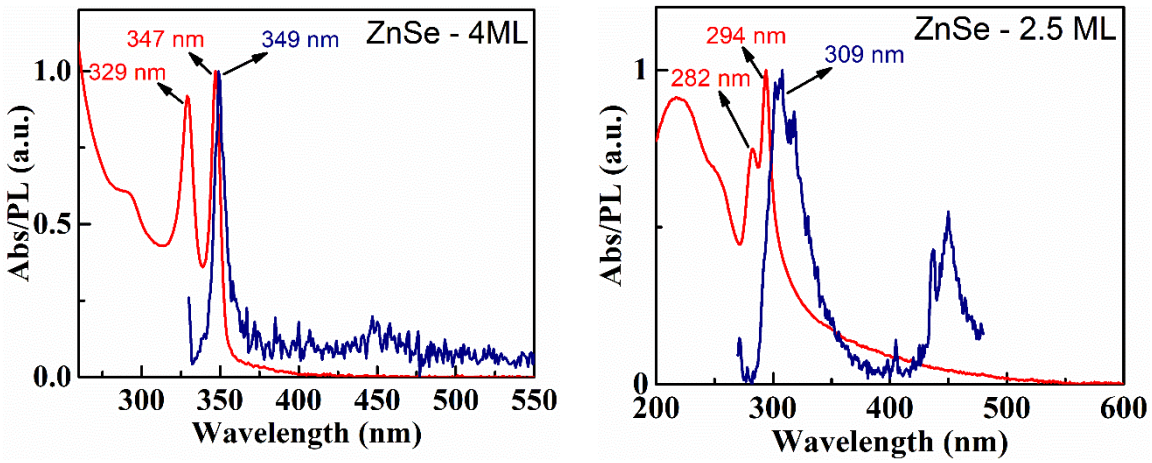

Figure 1: Absorption and Photoluminescence spectra of 4ML and 2.5 ML ZnSe NPLs.

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Advanced Optical Liquid Crystal Biosensor for Real-Time Detection of Protein-Ligand Interactions via Non-Covalent Mechanisms

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Abstract:

This study focuses on the fabrication and development of a liquid crystal (LC) biosensor leveraging non-covalent protein-ligand interactions for the detection of target biomolecules. Avidin-conjugated silica nanoparticles (Avidin@Silica NP) and biotin-conjugated gold nanoparticles (Biotin@GNP) were synthesized and characterized using X-ray diffraction (XRD), ultraviolet-visible spectroscopy (UV-Vis), and field emission scanning electron microscopy (FESEM) to analyze their structural, optical, and morphological properties. The LC sample cell was constructed in a sandwich configuration using DMOAP-coated glass slides separated by a 20 µm Mylar spacer, sealed with Araldite adhesive. The bottom substrate was functionalized with Avidin@Silica NP and Biotin@GNP to form the sensing interface. Nematic liquid crystal (NLC) was introduced into the cell via capillary action. Biosensor cells were prepared with varying concentrations of Avidin@Silica NP (0 µl to 30 µl) and observed under a polarizing optical microscope. While Biotin@GNP alone did not disturb the NLC

alignment, increasing concentrations of Avidin@Silica NP (0.5 µl to 30 µl) progressively disrupted the homeotropic alignment, resulting in birefringence in the optical textures. These findings demonstrate that the LC-based biosensor, driven by specific protein-ligand interactions, offers a sensitive and effective alternative to traditional antibody-based detection methods. This platform holds significant potential for the diagnosis of various tumors and surface antigens through targeted biomolecular interactions.

Keywords: *Liquid crystal, Biosensor, GNP, Silica Np, Avidin, Biotin*

Synthesis of CeO_2/ g-C_3N_4 nanocomposites with improved photocatalytic activity for degradation of Rhodamine-B dye

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Abstract:

This work reports the photocatalytic activity of CeO_2/g-C_3N_4 composite for degradation of Rhodamine-B (Rh-B) dye. CeO_2 and g-C_3N_4 were synthesized by hydrothermal and calcination methods respectively and were well characterized by various analytical techniques. The 5%, 10%, 15% and 20% CeO_2/g-C_3N_4 composite were synthesized by facile impregnation method.XRD analysis confirmed the FCC crystal structure of CeO_2.The lower angle shift in 2θ suggests successful impregnation of CeO_2 on g-C_3N_4 surface. The FTIR result supports the XRD analysis. The UV-DRS studies signifying a blue shift in bandgap of composite compared to bare g-C_3N_4 showed increase in light absorption capacity by composite formation. The decrease in PL intensity of composite versus bare g-C_3N_4 validate the increase in lifetime of electron-hole pair. The photocatalytic degradation of Rh-B for composite showed remarkable increase in % degradation (99.31 %) which is typically 1.6 times greater than that of bare g-C_3N_4 (63.79%) and 2.4 times than that of bare CeO_2 (41.67%) in 150 minutes. Additionally, the optimization of CeO_2 percentage with the 10% CeO_2/g-C_3N_4 composite (10CCN) has been identified as optimal for the degradation of RhB. Thus, composite formation can be a viable strategy to improve the photocatalytic degradation of a pollutant.

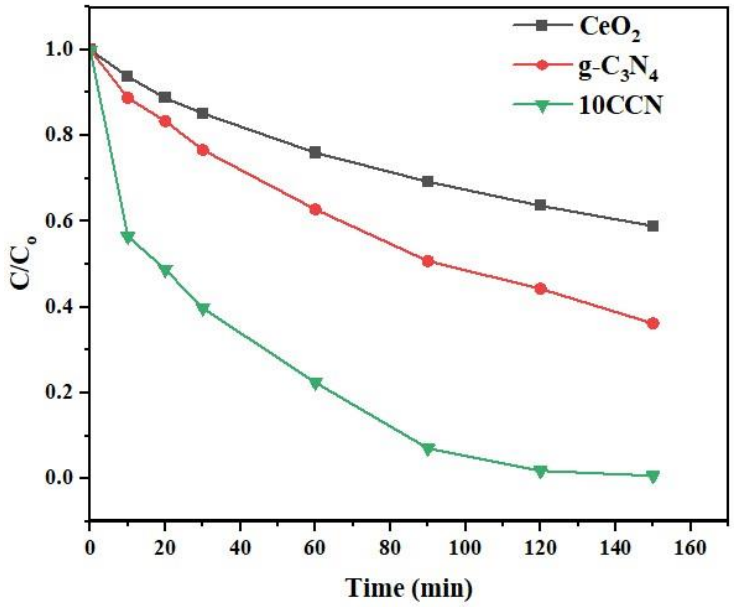

Fig.1 Photocatalytic degradation of Rh-B by CeO_2, g-C_3N_4 and 10 CCN composite

Investigation of low-cost solution-processed CdTe thin films for the development of solar cells

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Abstract:

We used hydrothermally synthesized CdTe powder and a paste coating technique to prepare CdTe thin films on FTO. The CdTe composition was controlled systematically by varying the Cd concentration, which was further examined using various properties. The impact of the sintering temperatures on CdTe films was also examined. CdTe samples were characterized by X-ray diffraction, Raman spectroscopy, UV-Vis-NIR spectroscopy, scanning electron microscopy, and energy dispersive spectroscopy. CdTe thin films were utilized with a glass/FTO/CdS/CdTe/Au configuration to construct photovoltaic devices. Photovoltaic properties were studied using current density-voltage and external quantum efficiency measurements.

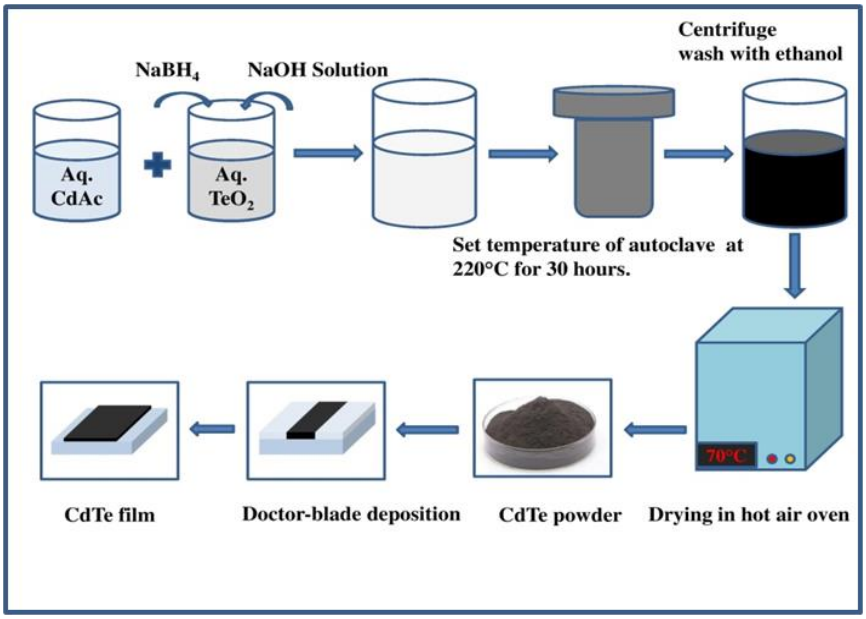

Fig. 1: Schematic representation of preparation of solution based CdTe films

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Advanced $CuWO_4/C_3N_4$ Nanocomposites for Enhanced Photocatalytic Hydrogen Production and Efficient Dye Degradation under Visible Light.

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Abstract:

This study investigates the hydrothermal synthesis and photocatalytic performance of $CuWO_4/C_3N_4$ nanocomposites with varying C_3N_4 content (1–4%) for efficient hydrogen generation and dye degradation under visible light irradiation. The synthesized materials were systematically characterized using X-ray diffraction (XRD) for phase purity, field emission scanning electron microscopy (FESEM) for surface morphology, and UV–Vis diffuse reflectance spectroscopy (UV-DRS) for optical absorption analysis. XRD analysis confirmed the triclinic crystal structure of $CuWO_4$ (JCPDS 88-0269) with an average crystallite size of 35.21 nm, exhibiting a high-intensity peak at the (11$\bar{1}$) plane. UV-DRS studies revealed enhanced absorption across the entire visible spectrum for the nanocomposites. Photocatalytic evaluations demonstrated that the $CuWO_4/C_3N_4$ (3%) nanocomposite exhibited a remarkably high hydrogen evolution rate of **7990 µmol/g/h**, significantly outperforming pristine $CuWO_4$. This enhancement is attributed to the collaborative interactions between $CuWO_4$ and C_3N_4, which improved charge carrier separation efficiency and extended the optical response into the visible region. Additionally, the optimized nanocomposite facilitated the near-complete degradation of methylene blue dye (**84% in 120 min**) under visible light irradiation. Kinetic analyses indicated that the superior photocatalytic activity stemmed from enhanced surface charge transfer dynamics and suppressed electron-hole recombination, facilitated by the presence of C_3N_4. The dual functionality of hydrogen production and organic pollutant degradation underscores the potential of $CuWO_4/C_3N_4$ nanocomposites as promising candidates for sustainable energy generation and environmental remediation. This work provides valuable insights into the development of next-generation photocatalysts to address critical global challenges in renewable energy and water purification.

Keywords: $CuWO_4$, C_3N_4, Nanocomposites, Photocatalysis, Visible-light absorption Hydrogen evolution, Dye degradation

Interplay of Ca^{2+} and Sn^{4+} compositional engineering in $BaTiO_3$ electroceramic for piezo energy harvesting and actuator applications

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Abstract:

Lead-free $(Ba_{1-x}Ca_x)(Sn_yTi_{1-y})O_3$ (BCST) ceramics were synthesized via a solid-state reaction method, with varying compositions (x = 0.016, y = 0.024; x = 0.032, y = 0.048; x = 0.048, y = 0.072; x = 0.064, y = 0.096; and x = 0.08, y = 0.12 mol%). A detailed structural investigation, combining Rietveld refinement, Raman spectroscopy, and temperature-dependent dielectric analysis, revealed the coexistence of rhombohedral, orthorhombic, and tetragonal (R-O-T) phases at room temperature for the composition x = 0.064 and y = 0.096 (BCST-4). Because of the R-O-T multiphase coexistence, BCST-4 shows the enhancement in properties viz. kp ~ 0.45, and an improved d_{33} ~ 452 pC/N, which is greater than commercially available soft PZT ceramics (d_{33} ~ 370 pC/N). Maximum converse piezoelectric coefficient d_{33}* 649 pm/V and maximum strain 0.100% were measured in an electric field of 5.62 kV/cm and 22.5 kV/cm, respectively. For BCST-4 ceramics, an exceptional electrostriction coefficient Q_{33} ~ 0.0434 m^4/C^2 value was attained. The temperature-dependent DC strain measurements were carried out in ε_{33} and ε_{31} modes respectively. The maximum obtained DC strain for ε_{33} mode is 130 με and for ε_{31} mode is 188 με. Energy harvesting performance was evaluated, with BCST-4

demonstrating a maximum output power of 1.03 mW, a maximum output current of 88 µA, an open-circuit voltage (V_{pp}) of 28 V, and a power density of 13.5 µW/mm^3. The harvested energy successfully illuminated forty red commercial LEDs panel consisting symbol '*SPPU*'. The improvement in electrostriction coefficient, piezoelectric charge coefficient indicates that BCST-4 ceramic has the potential for actuator and energy harvesting applications.

Keywords: $BaTiO_3$; piezoceramics; ferroelectrics; energy harvesting; actuator.

NMR and μSR study of the S=1/2 1D Heisenberg antiferromagnetic Chain Cu(Ampy)ClBr

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Abstract:

We report a spin gap phase in Cu^{2+} (S=1/2) Heisenberg antiferromagnetic (HAF) chain, Cu(Ampy)ClBr, as proposed in a recent theoretical study by Uematsu et al. on the random-bond S = 1/2 HAF zigzag chain, mixing Cl and Br may generate randomness in the nearest-neighbor exchange necessary to satisfy the criteria. To study its magnetic and structural properties, various bulk and local probe measurements were performed on a polycrystalline sample. ^{1}H nuclear magnetic resonance (NMR), allows for probing low-lying excitations, ^{1}H NMR spin lattice relaxation rate follow an exponential temperature-dependent behaviour, indicating that the compound exhibits gapped magnetic excitations. Furthermore, persistent spin dynamics down to 88 mK observed by zero-field μSR evidences lack of any static magnetism. We attribute these experimental results to the stabilization of a dimer singlet phase in the presence of a next-near neighbor interaction.

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Exploring Bismuth Halides For High Performance Photodetectors.

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Abstract:

The pursuit of lead-Free halide perovskite has gained momentum due to their promise for environmentally friendly optoelectronic applications. Bismuth-based perovskite have emerged as safer alternatives to lead-containing materials. In this study, we synthesized lead-free inorganic Cs3Bi2X9(X= Cl, Br, I, Cl/Br, Cl/I, Br/Cl) nanocrystals for photovoltaic applications using the antisolvent method. A comprehensive investigation of their crystal structure, morphology, optical properties, band structure and stability were conducted. Thin film of the synthesized material was deposited at room temperature and analyzed for structural, morphological and optical characteristics. X-ray Diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) confirmed the formation of pure and mixed Cs3Bi2X9 perovskites. The XRD patterns revealed that Cl-, Br- and I- based nanocrystals, which varies with the X-site halide, was found to range from 1.9 eV to 3.2 eV, exhibiting colour transitions from light blue to red as the halide shifts from Cl to I. The films displayed indirect bandgaps, while field emission scanning electron microscopy (FE-SEM) and energy dispersive X-ray spectroscopy (EDS)revealed hexagonal and irregularly round and thin layered with detailed elemental distributions. Time- dependent Photoresponse measurements showed fast response and recovery times of charge carriers, highlighting the potential of bismuth -based perovskites for next- generation photovoltaic and optoelectronic devices.

Keywords: Lead Free Perovskite, Low-cost material, Chemical method, Photodetection

performance.

Solvothermal ZnO Synthesis for Dye-Sensitized Solar Cells: Investigating Temperature and Ball Milling Effects

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Abstract:

Zinc oxide (ZnO) nanoparticles have gained significant interest in Dye-sensitized solar cell (DSSCs) applications due to their tunable optical and structural properties. However, optimizing their morphology, surface area, and particle size for enhanced light absorption and electron transfer remains a challenge.

This study investigates the synthesis of ZnO using the solvothermal method at different reaction temperatures and the subsequent effects of ball milling on its properties. The study examines the influence of reaction temperature and ball milling on nanoparticle size, crystallite structure, micro-strain, and dislocation density using X-ray diffraction (XRD) and Raman spectroscopy. Optical bandgap narrowing, observed through UV-Vis absorption. Additionally, X-ray photoelectron spectroscopy (XPS) highlights surface defects and enhanced Zn and O peak intensities due to increased surface area. The photovoltaic performance of DSSCs incorporating these nanoparticles is assessed through key parameters such as short-circuit current density (Jsc), open-circuit voltage (Voc), fill factor (FF), and efficiency (η). The findings provide insights into optimizing ZnO synthesis for advanced photovoltaic applications.

Keywords: Solvothermal, Ethylene Glycol, ZnO, Ball Milling

LaB_3O_6: Eu^{3+} A Novel Approach for Radiation Dosimetry

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Abstract:

Radiation monitoring is crucial for ensuring safety in various industries. Traditional radiation monitoring techniques available include Thermoluminescent Dosimeters (TLDs), Optically Stimulated Luminescence Dosimeters (OSLDs) and Film Dosimetry which often rely on complex and expensive equipment. Recently, researchers have explored the use of luminescent materials as a novel approach for radiation monitoring. One such material, LaB_3O_6:Eu^{3+}, has shown great promise in this regard.

The LaB_3O_6:Eu^{3+} phosphor was synthesized using the solid-state reaction method. X-ray diffraction (XRD) analysis revealed that the as-prepared phosphor possessed a monoclinic structure with an average crystallite size of 68.89 nm. Thermoluminescence (TL) analysis showed that the phosphor exhibited a typical single glow curve at 274 °C and provided an excellent linear response curve over a wide range of gamma doses from 1 Gy to 14 kGy.

The phosphor's fading characteristics were also investigated, and it was found that the fading was around 9% over 60 days. These results indicate that the LaB_3O_6:Eu^{3+} phosphor is a promising material for radiation monitoring applications. The use of LaB_3O_6:Eu^{3+} for radiation monitoring is advantages owing to its simplicity, cost- effectiveness, excellent linear dose response, low fading characteristics and ease of integration into various of devices and

systems. Additionally, it offers a wide range of gamma dose detection, making it versatile material for various radiation monitoring applications.

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Luminescence Properties of Eu Doped $Ba_2Al_2SiO_7$ Phosphor

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Abstract:

The current communication is primarily concentrated on the investigation of the synthesis, structural characteristics, and luminescence properties of europium (Eu^{3+}) activated $Ba_2Al_2SiO_7$ phosphors. Eu^{3+} doped $Ba_2Al_2SiO_7$ phosphors were synthesized using a solid-state reaction method. Structural properties were analyzed using powder X-ray diffraction and high-resolution transmission electron microscopy. The optical properties were examined using ultraviolet visible light spectroscopy and Fourier transform infrared spectroscopy, while the luminescence properties were investigated through a photoluminescence (PL) technique. The crystal structure of the synthesized $Ba_2Al_2SiO_7$ host and Eu^{3+} activated $Ba_2Al_2SiO_7$ phosphors was examined and determined to exhibit a hexagonal structure. The PL excitation spectra of $Ba_2Al_2SiO_7$: Eu^{3+} phosphor display narrow bands in the near ultraviolet (N-UV) range, while the PL emission spectra of $Ba_2Al_2SiO_7$: Eu^{3+} phosphor reveals sharp narrow bands characteristic of rare earth ions. The bands identified in the photoluminescence emission and excitation spectra of $Ba_2Al_2SiO_7$: Eu^{3+} phosphors can be attributed to the electronic transitions within the 4f configurations of rare earth ions. The excitation peaks for $Ba_2Al_2SiO_7$: Eu^{3+} are in the near-ultraviolet range. The results obtained indicate that these phosphors may be advantageous for the lamp industry.

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Perovskite $MnFeO_3$ nanoparticles for bifunctional photocatalytic application

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Abstract:

MnFeO3 (MFO) nanoparticles (NPs) synthesized by co-precipitation method with average size of ~86 nm are utilized for bifunctional application including photocatalytic degradation of organic dyes and interfacial solar steam generation (ISSG) of salty water. Cubic crystalline MFO NPs consisting of Mn^{3+}/Mn^{4+}, Fe^{3+}/Fe^{2+}, and O^{2-} oxidation states delivered band gap of 1.84 eV for harvesting maximum solar spectrum. Well characterized MFO NPs illustrated excellent photocatalytic degradation performance for various cationic and anionic dyes. MFO NPs delivered 98.99% degradation of crystal violet dye with rate constant and R^2 value of 0.25 min^{-1} and 0.93, respectively in 180 min exposure to Xenon lamp. The scavenging study confirmed active involvement of h^+ and O_2^- in effective removal of CV dye. Moreover, MFO photothermal evaporator coated on cellulose filter paper delivered 47.6 ℃ surface temperature at air/water interface with evaporation rates of 2.28 and 1.6 kg/m^2h under solar simulator and direct sunlight, respectively. Additionally, MFO provided the evaporation rates of ~1.89, ~1.58, and ~1.40 kg/m^2h for 3.5, 7.0, and 10 wt% simulated salt water, respectively. Therefore, MFO NPs are proficient and cost-effective materials for stable performance in water remediation and desalination.

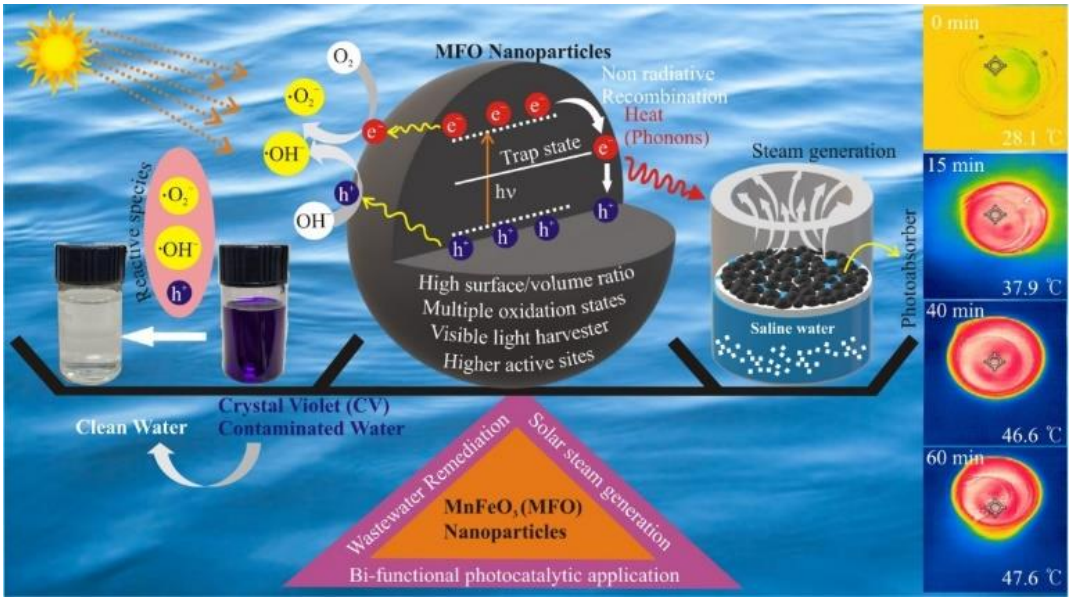

Fig. 1: Schematic representation of MFO NPs utilized for the bifunctional interfacial solar steam generation (ISSG) of salt water and photocatalytic dye removal of anionic and cationic dyes.

Electrochemical Quartz Crystal Microbalance Studies of Cobalt-Nickel Nanoelectrocatalyst for Ethanol Electrooxidation

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Abstract:

It is well known that the electrocatalytic performance of the nanoelectrocatalysts strongly depend on size, coverage and composition. The successive ionic layer adsorption and reaction (SILAR) is a simple method that allows to grow metal/alloy nanoelectrocatalyst with precise control of size, coverage and composition. Co-Ni metal and alloy nanoelectrocatalysts are grown on carbon paper by using SILAR method. The crystal structure, chemical bonding and oxidation states, elemental composition and morphology of Co-Ni metal and alloy nanoelectrocatalysts are analyzed by X-ray diffraction, X-ray photoelectron spectroscopy, energy dispersive spectroscopy and scanning electron microscopy techniques, respectively. By using cyclic voltammetry and chronoamperometry, the electrocatalytic activity and stability of the grown nanoelectrocatalyst are investigated. The alloy nanoelectrocatalyst' composition found to influence the onset potential and the current densities of ethanol electrooxidation. The electrochemical quartz crystal microbalance (EQCM) studies provide quantitative analysis of electrocatalyst mass variation during ethanol electrooxidation. The adsorption, dehydrogenation, and oxidation processes of ethanol on Co-Ni alloy nanoelectrocatalysts were thoroughly studied using the EQCM combined with cyclic voltammetry. Based on the obtained results we have found out the optimum composition of the Co-Ni alloy nanoelectrocatalysts demonstrating excellent electrocatalytic activity towards ethanol electrooxidation.

Key words: SILAR, cobalt, nickel, nanoelectrocatalyst, ethanol electrooxidation.

Acknowledgement: Mahatma Jyotiba Phule Research and Training Institute for MJRF-2022 Fellowship.

Melting of harder-than-diamond lonsdaleite using machine learned potential

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Abstract:

Lonsdaleite, also known as hexagonal diamond, is a rare poly-morph of carbon distinguished by its unique hexagonal structure and exceptional mechanical properties, which may exceed those of cubic diamond. Despite being identified in meteorite samples and generated under specific high-pressure conditions, questions about its electronic properties and stability at high temperatures remain unanswered. This study addresses these gaps by investigating the structural stability, electronic band structure, and thermodynamic properties of lonsdaleite using first-principles and molecular dynamics simulations. Phonon dispersion analysis confirms its structural stability, while band structure calculations reveal an indirect band gap of 3.06 eV. Our calculations yield a bulk modulus of B=450.946 GPa. We further employed non-equilibrium molecular dynamics simulations to evaluate its Gibbs free energy, indicating that lonsdaleite maintains stability up to approximately 2000 K; beyond this, a rapid decrease in free energy suggests a melting point close to 2100 K. These results provide new insights into the potential applications of lonsdaleite under extreme conditions.

Exploring Pt/$Ti_3C_2T_x$ Nanocomposite via γ-Radiolysis: Revealing Strong Metal-Support Interaction (SMSI) toward MOR and HER Electrocatalysis

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Abstract:

MXene have gained significant attention as a layered two-dimensional (2D) materials due to their excellent electrical conductivity and tunable surface properties. In this study γ-radiolytic synthesis approach through X-ray absorption spectroscopy (XAS) revealed a strong metal-support interaction (SMSI) between Pt and $Ti_3C_2T_x$, which plays crucial role in enhancing stability and facilitating electron transfer in electrochemical reactions.

The electrocatalytic performance of Pt/$Ti_3C_2T_x$ was evaluated for methanol oxidation reaction (MOR), and hydrogen evolution reaction (HER) using various electrochemical techniques. The MOR performance we assessed by its increased mass activity of 1343.11 mA/mg_{Pt} and CO tolerance of 1.29. Additionally, for HER, Pt/$Ti_3C_2T_x$ required a minimal overpotential of 65 mV, highlighting its potential as a viable alternative to Carbon-based electrocatalysts. All the studies were carried out in comparison with the state-of-art catalyst Pt/C. The superior

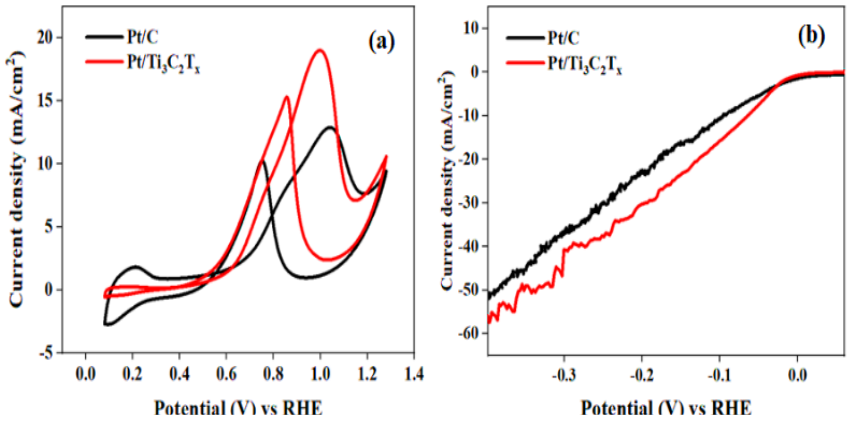

Fig. 1: (a) CV curve for MOR activity and (b) LSV curve for HER activity of Pt/$Ti_3C_2T_x$ and Pt/C.

performance of Pt/$Ti_3C_2T_x$ can be primarily attributed to SMSI effect, which can be duly utilized to achieve enhanced electrochemical outcomes

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Activation cross section measurements and estimation of photon induced nuclear reations for Manganese

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Abstract:

The bremsstrahlung spectrum-averaged cross sections for the $^{55}Mn(\gamma,n)^{54}Mn$ reaction at a bremsstrahlung endpoint energy of 15 MeV were measured using offline gamma spectrometry. These measurements were performed relative to the cross section of the $^{197}Au(\gamma,n)^{196}Au$ reaction as a reference. The uncertainties in the cross sections were carefully analysed using a detailed covariance method. The experimental data were compared with theoretical predictions from TENDL-2021[1] and TALYS-1.96 [2] nuclear models. This is the first $^{55}Mn(\gamma,n)^{54}Mn$ reaction has been measured at 15 MeV bremsstrahlung endpoint energy. Theoretical energy-dependent cross sections from TENDL-2021 and TALYS-1.96, based on eight different gamma-ray strength functions (GSF-1 to GSF-8), were converted to bremsstrahlung spectrum-averaged values for the 15 MeV endpoint energy. Further nuclear model calculations were performed using TALYS-1.96 with both default and optimized input parameters to achieve a better fit with the experimental data. The measured cross sections showed good agreement with the theoretical calculations.

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Enhancement in optical properties of ferroelectric liquid crystal by incorporation of Lithium Vanadate Nanobelts

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Abstract:

Ferroelectric liquid crystal (FLC) shows improvement in optical properties after incorporation of nanostructures due to manifestation of better alignment of FLC molecules. Nanobelts are more preferable for the incorporation into the FLC to modify and enhanced the properties of FLC material. A simple and low-cost ultrasonic-assisted chemical route was developed to synthesize Lithium vanadate (LVO) nanobelts. These nanobelts are 50–80 nm wide and 1–2 μm long. We demonstrate an improvement in the optical properties of ferroelectric liquid crystal (FLC) material by incorporating LVO nanobelts. The addition of LVO nanobelts is responsible for the increased photoluminescence intensity, decreased saturation voltage, improved optical contrast, and improved optical tilt angle. The improvement might have caused by a modification in the local ordering and orientation of the FLC molecules due to the presence of LVO nanobelts. We found out optimum LVO nanobelts concentration as 0.07 wt% to achieve excellent optical properties. The obtained results can be used to improve LC display devices.

Deciphering Strain and Ligand Effects in 2D-2D Pt@$Ti_3C_2T_x$-rGO Aerogel for Oxygen Reduction Reaction

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Abstract:

Developing high-performance, cost-effective Pt-based catalysts with minimal Pt content remains a challenge in oxygen reduction reactions (ORR). Conventional Pt catalysts suffer from site poisoning, weak support interactions, and degradation, limiting their efficiency.[1] To overcome these issues, a low Pt 3D porous aerogel was designed *via.*γ-radiolytic self-assembly of a 2D-2D MXene ($Ti_3C_2T_x$)-rGO heterostructure. This structure prevents $Ti_3C_2T_x$ restacking, enhances metal-support interactions (SMSI), and strengthens catalyst stability. The Pt@$Ti_3C_2T_x$-rGO catalyst achieved an impressive ORR onset potential of 0.957 V and exhibited excellent durability in acidic conditions.

To probe the improved catalytic activity, advanced spectroscopic analysis were utilized such as X-ray Photoelectron Spectroscopy (XPS) and X-ray Absorption Spectroscopy (XAS). These analyses revealed a downshift in the Pt d-band center due to ligand effect as well as compressive strain in the Pt-Pt bond distance due to strain effects.2 This shift is associated with improved catalytic activity by optimizng adsorption/desoprtion at active sites.

These findings highlight how strain and charge transfer engineering can drive next-generation electrocatalyst design for sustainable energy conversion.

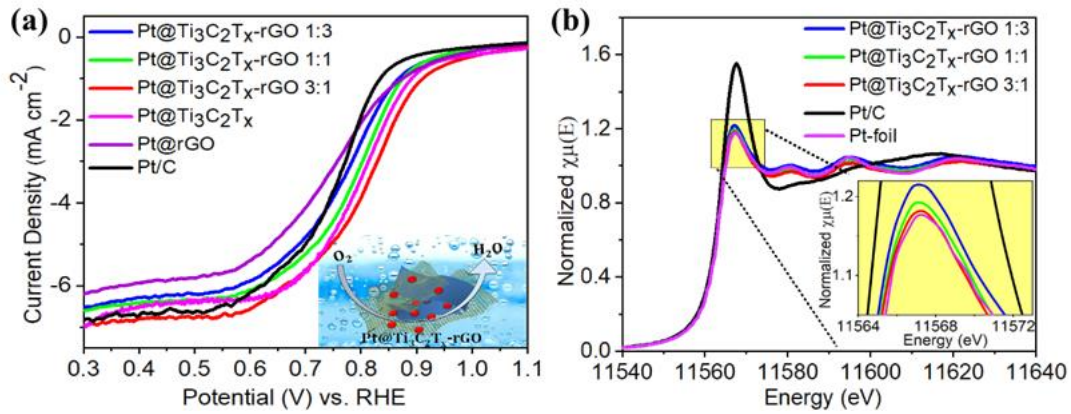

Fig. 1 (a) ORR polarization curves of various catalysts in O_2-saturated electrolyte at 10 mV/s (b) XANES features of the various catalysts at Pt L_3 edge.

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Stabilizing TiO_2/ $CsPbI_2Br$ Perovskite Buried interface for all Inorganic Perovskite Towards Highly Efficient Photodetectors

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Abstract:

Inorganic perovskites hold immense promise for optoelectronic applications, but their performance is often hindered by defects and trap states introduced during solution-based processing. This study demonstrates a facile approach to mitigate these challenges by employing in situ polyvinyl pyrrolidone (PVP) passivation during the hydrothermal growth of TiO_2 nanorods, improving the interface with $CsPbI_2Br$ (CPIB) perovskite. X-ray diffraction analysis confirmed the formation of TiO_2 nanorods with a crystallite size of ~ 49 nm and low micro strain. The PVP passivation layer effectively suppressed non-radiative recombination, leading to a significant enhancement in photoluminescence intensity. Photodetectors fabricated using PVP-treated TiO_2/CPIB interfaces exhibited significantly faster response times, with a rise time of ~ 11 ms and a decay time of ~ 0.3 ms, compared to devices without PVP. This resulted in an impressive photoresponsivity of ~ 0.9 mA/W and a detectivity of ~ 10^{12} Jones. This work demonstrates a simple yet effective strategy for improving the performance of all-inorganic perovskite-based optoelectronic devices, paving the way for their future applications in high-performance photodetectors, solar cells, and other optoelectronic devices.

Investigation of CQD-TiO_2 Photocatalyst for Methyl Orange Degradation

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Abstract:

Here, metal-free carbon quantum dot-TiO_2 (CQD-TNPs) composite has been shown to increase solar light-driven photocatalytic degradation of methyl orange (MO) dye. Here TiO_2 nanomaterial was synthesized by hydrothermal method and was further accurately characterized by XRD, FTIR, XPS, FESEM and EDS techniques. The photocatalytic degradation of MO has been investigated using different dosage of TiO_2 viz. 40mg, 50mg, 60mg which were labeled as 40mg TNPs, 50mg TNPs, 60mg TNPs. Under UV light irradiation, the synthesized 50mg TNPs revealed outstanding photocatalytic activity, enabling 77.63% degradation of MO in 50min. While 40mg TNPs and 60mg TNPs showed only 57% and 64% degradation in 50min respectively. Further the CQD-TNPs was synthesized by hydrothermal method and was well characterized by various characterization techniques and tested for MO degradation. This CQD-TNPs showed almost 100% degradation than bare TiO_2. Which means CQD enhanced the photocatalyst properties due to its upconverted photoluminescence behavior and electron reservoir properties [1]. Further kinetic studies for CQD-TNPs and bare TiO_2 were investigated. The degradation rate of CQD-TNPs 0.06623 (min^{-1}) was increased 3 times as compared to bare TiO_2 rate 0.02312 (min^{-1}). Overall, this study highlights the importance of metal free CQD decorated semiconductor photocatalyst for effective degradation of MO dye. The outcomes offer important insights into the design and development of high-performance TiO_2-based photocatalysts for wastewater treatment applications where organic dye degradation is a major problem.

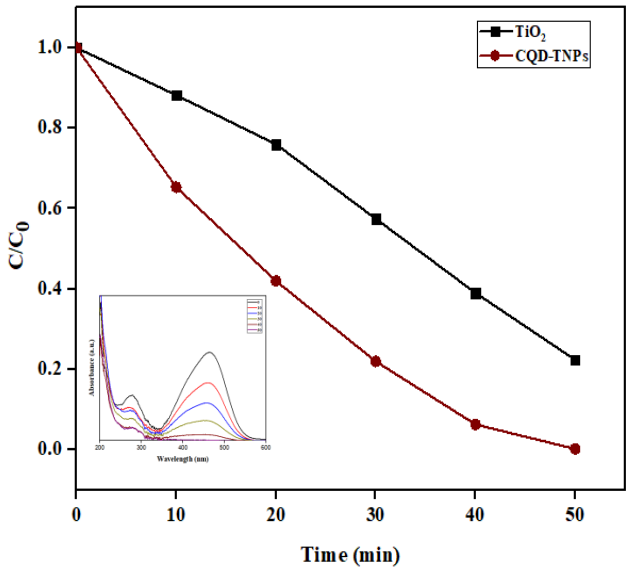

Fig. 1: Degradation pattern and UV-Vis spectra of MO dye

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Composition-dependent band structure parameters and band-gap bowing effect in a caesium lead mixed halide system: a cyclic voltammetry investigation

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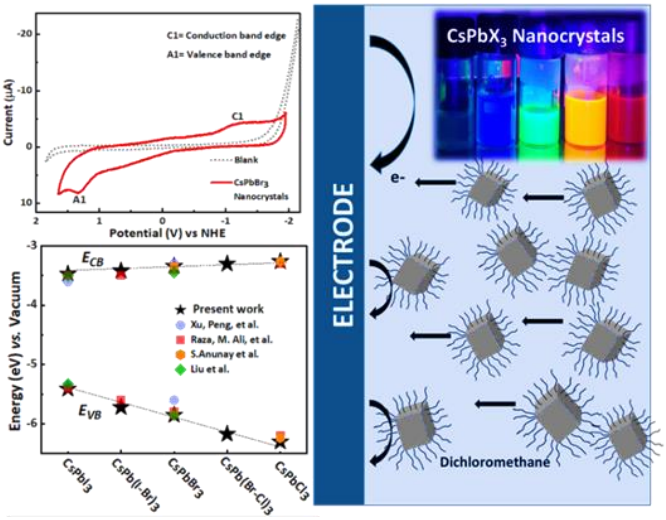
Abstract:

Cyclic voltammetry techniques have been employed to study the effect of halide substitution on band edge parameters and corresponding band gap bowing effect in case of $CsPbX_3$ [X=I, Br, Cl] perovskite nanocrystals (PNCs). Series of compositions viz. $CsPbI_3$, $CsPb(I\text{-}Br)_3$, $CsPbBr_3$, $CsPb(Br\text{-}Cl)_3$ and $CsPbCl_3$ have been prepared by a hot injection method. The material characterization of PNCs has been accomplished by powder XRD and HR-TEM. From that, the formation of highly crystalline, cubic phase of perovskite having crystallite size ranging from 7 nm to 20 nm have been confirmed. Sharp peaks in photoluminescence spectra suggest the formation of quantum dots with narrow-size distribution. The composition dependent optical band gap (ε_{gap}^{op}) for $CSPbX_3$ display systematic shift towards shorter wavelengths from I to Br to Cl substitutions. The cyclic voltammetry investigation on the dispersion of PNCs in nonaqueous solvents yielded prominent cathodic and anodic peaks. These are correlated to conduction (e_1) and valance band edge (h_1) positions, respectively. The h_1 have been decreased substantially upon substitution from I to Br to Cl in $CsPbX_3$. While, e_1 shows marginal increase. The values derived from CV data demonstrated excellent match UVPS results, reported for the similar system. From these results, quasi-particle gap (ε_{gap}^{qp}) and exciton binding energy have been estimated for all the compositions. The negative band gap bowing effect noted in these PNCs are attributed to the size quantization effect. The results band-edge parameters presented in this work would be valuable in matching these heterojunctions with suitable electron/hole transport materials for the optimum device-performance.



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Voltametric investigation of band edge parameters and electrochemical performances of Hercynite nanoparticles for the Electrolysis of Water in acidic and basic medium

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Abstract:

Electrochemical hydrogen production has become an alternative way of producing green hydrogen due to the scarcity of fossil fuels wherein the development of stable, low-cost and noble-metal free electrocatalysts remained a challenge. In this work, Hercynite nanoparticles were synthesized using sol-gel with a post-annealing method using tartaric acid as a chelating agent. Structural, morphological, thermal, optical, and electrochemical properties of Hercynite nanoparticles were studied using state of art characterization techniques. Along with its band edge parameters, electrochemical Hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) activity in acidic and basic electrolyte was determined for the first time. Band edge positions infer that material is more suitable for HER than OER due to its minimum conduction band position. The electrochemical water splitting study resulted in lowered HER overpotential of 70 mV than OER overpotential as 1.61 V in 1 M KOH. Similarly, acidic electrolyte gives HER overpotential as 613 mV and OER overpotential as 2.12V. Conclusively, lowered HER overpotential of $FeAl_2O_4$ nanoparticles in 1 M KOH makes it a promising alkaline electrocatalyst required for green energy generation. Hence,

it can be a good electrocatalyst mimicking similar properties of precious noble metal for green hydrogen generation.

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Electrowetting on dielectric (EWOD) for the microfluidic-chip application

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Abstract:

Wetting of liquids is a common surface phenomenon encountered in diverse fields such as material, biomedical, chemical and biological screening etc. Depending on application, these fields demands functional surfaces with special wetting capabilities such as super-hydrophobic (contact angle > 150^{O}) or super-hydrophilic (contact angle < 5^{O}) surfaces. Electrowetting on dielectric (EWOD) is the most promising technique used for controlled dynamic wettability behavior of liquid with application of external voltage.

In EWOD based microfluidic operations, hydrophobic (low surface energy) surface is needed for hysteresis free motion of droplet. EWOD devices always use fluorinated materials such as Teflon or Cytop as a top hydrophobic layer which often requires post fabrication treatment and has high production cost for large area application. We proposed commercially available nano-particle dispersion as a fluorine free, low cost and 'ready to use' top hydrophobic layer for EWOD application. This coating was characterized using FESEM and EDS for optimization of the deposition condition and surface area coverage. Contact angle measurement showed highest initial contact angle ($\theta = 151^{O}$) which is higher than the fluorinated Teflon AF coating ($\theta = 120^{O}$). This dispersion of silica nanoparticles can be applied as dip coating or by spray coating on a dielectric layer like Parylene C for excellent electrowetting response. EW response on various dielectric materials were extensively tested for their durability and long cycle operation. This bilayer exhibits hysteresis free EW for long cycle operations. As a proof of concept, the Parylene C-nano coat bilayer is utilized to perform the basic microfluidic operation like transport of microlitre sized droplet with different surface tension values on digital microfluidic (DMF) device.

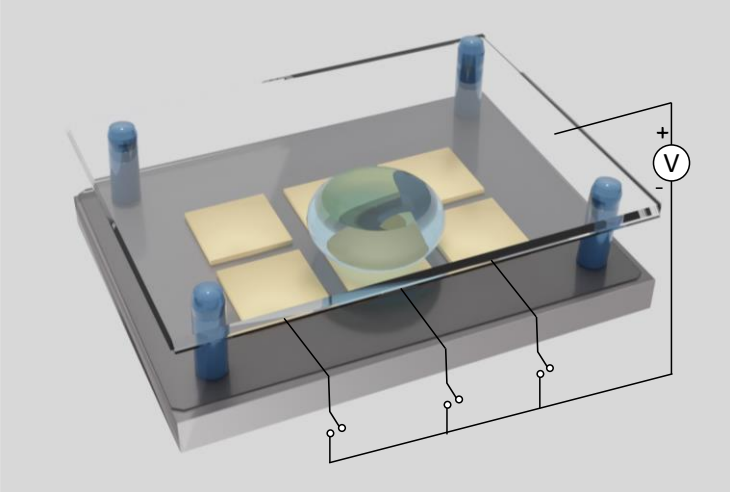

Fig: Representation of EWOD based DMF device

Keywords: Electrowetting on dielectrics (EWOD), silica nanoparticles, fluoropolymer, digital microfluidics (DMF), etc.

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Electrochemical insertion of Li ions in V_2O_5 electrode for improved supercapacitive performance

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Abstract:

Electrochemical conversion is an effective and efficient technique for producing pre-insertion layered materials, which play a crucial role in enhancing the performance of energy storage devices. Vanadium pentoxide (V_2O_5) is a promising electrode material for supercapacitors but suffers from relatively poor electrochemical performance due to its low electrical conductivity, poor structural stability and limited ion diffusion. In this study, we developed a strategy to enhance the performance of the V_2O_5 electrode material by electrochemically inserting lithium ions (Li^+) between the layers of the V_2O_5 structure. The lithium-inserted vanadium oxide ($Li_{0.4}V_2O_5$) electrode material was prepared by applying 800 CV cycles in Li_2SO_4 electrolyte. The structural, chemical, and morphological changes of the V_2O_5 before and after Li^+ insertion were analysed by using XRD, SEM, and XPS. XRD revealed crystallographic changes, while SEM provided insights into the morphological evolution of the V2O5 material after lithiation. XPS analysis showed changes in electronic structures. Generally, for the metal-ion batteries the extensive cyclic processes degrade the performance of electrode materials, however, in our study we observed that Li^+ insertion significantly enhanced the electrochemical performance in terms of specific capacitance and cyclic stability. The electrochemical CV, GCD, EIS and cyclic stability tests suggest that the intercalated lithium ions improved the structural and chemical stability of the V_2O_5 electrode material, which is crucial for maintaining long-term performance. The electrochemically converted $Li_{0.4}V_2O_5$ possesses a high specific capacitance with long-term cyclic stability.

Electrocatalytic Reduction of CO_2 to Formate Using Bismuth-Tin Bimetallic Catalyst: Mechanistic Insights and Performance Evaluation

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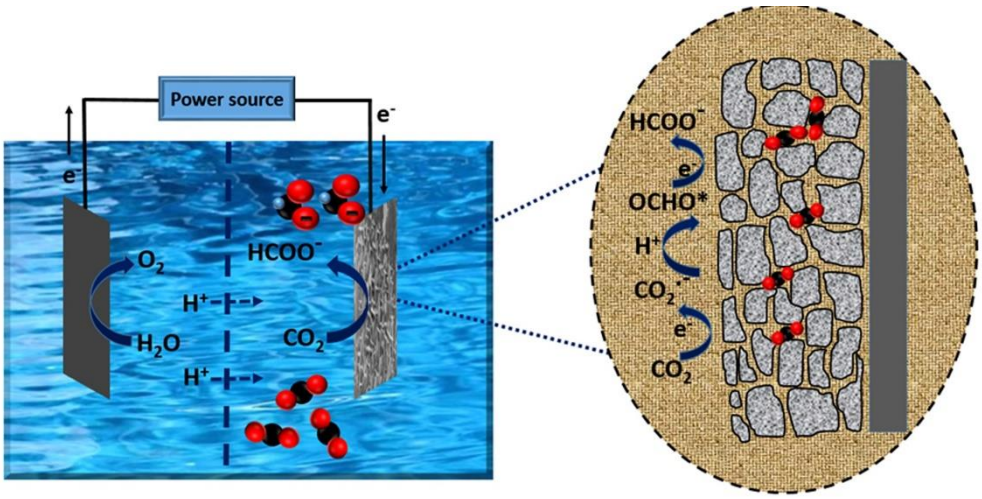
Abstract:

The electrochemical reduction of CO_2 to value-added products is a promising strategy for mitigating carbon emissions and promoting sustainable energy solutions. In this study, a Bismuth-Tin (Bi-Sn) bimetallic catalyst was synthesized via electrodeposition and employed for electrocatalytic CO_2 reduction to formate. The catalyst exhibited an impressive Faradaic efficiency of 86% for formate. The electrochemical performance was systematically evaluated using Rotating Disk Electrode (RDE) voltammetry and ultramicroelectrode techniques. RDE data and Tafel analysis provided insights into the reaction kinetics, revealing the number of electrons involved in CO_2 conversion and identifying the rate-determining step. FESEM imaging confirmed a unique floral morphology with a high surface area, which significantly contributed to the catalyst's high efficiency. The results highlight the effectiveness of the Bi-Sn catalyst for selective CO_2 reduction and provide a deeper mechanistic understanding of the conversion process, paving the way for future advancements in electrocatalytic CO_2 utilization.



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Synthesis and Characterization of ZnO/Bi_2S_3 core-shell heterostructure for photoelectrochemical water splitting application.

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Abstract:

One of the most promising approaches for generating hydrogen from solar energy is through photoelectrochemical (PEC) water splitting. This innovative process involves using solar energy to drive the electrochemical splitting of water molecules into hydrogen and oxygen. Herein, we present the Electrodeposition and Successive Ionic Layer Adsorption and Reaction (SILAR) methods used to create ZnO-nanorod/Bi_2S_3 nanoparticle (ZnO/Bi_2S_3) heterostructures. The structural, optical, morphological, and PEC properties are investigated. UV-Visible spectroscopy analysis reveals the ZnO/Bi_2S_3 films have absorption edges in the visible and ultraviolet regions. The Bi_2S_3 loading directly impacts the PEC result of ZnO/Bi_2S_3 photoanodes. The M-S plots show a positive slope, indicating the n-type nature of ZnO and Bi_2S_3. Under illumination of 100 $mW.cm^{-2}$ power, the ideal photocurrent density reaches 2.97 mA/cm^2 at a bias of 0.8 V versus Saturated calomel electrode (vs SCE) and is four times greater than the pristine ZnO nanorods. The maximum applied bias photon to the current conversion efficiency (ABPE) of 0.25 % at 0.0 V vs. SCE is observed in the pristine ZnO photoanodes. In contrast, the ZnO/Bi_2S_3 photoanode has achieved 2.7 % at 0.0 V vs. SCE, which is almost 10 times greater than the pristine ZnO photoanode. Finally, the hydrogen evolution process and the mechanism of charge transfer in ZnO/Bi_2S_3 heterostructure are discussed.

Keywords: Electrodeposition, Photoelectrochemical cell, Water splitting

Acknowledgements: Vidya Doiphode expresses gratitude to the Ministry of New and Renewable Energy for their generous financial assistance.

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Ion-exchange route to boost PEC performance of ZnO by architecting type-II ZnO-NiO heterostructure

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Abstract:

Building of type-II ZnO-NiO heterostructure plays vital role to drastically increases photoelectrochemical cells (PEC) performance of ZnO. The ZnO nanorods were grown on ITO conducting substrate by SILAR method. Further, following ion exchange route fine and controlled core-shell type-II ZnO-NiO heterostructure is formed at room temperature. The shell thickness NiO layer on ZnO can be controlled by concentration of nickel ions solution and/or ion-exchange time. The Zno-NiO heterostructure formation is verified by XRD, UV-vis optical absorption, SEM, EDS, Raman spectroscopy and XPS techniques

Systematic photoelectrochemical measurement analysis such as Linear sleep voltammetry (LSV), Chronoamperometry (ON/OFF), Mott-Schottky, and electrochemical impedance spectroscopy (EIS) etc. show collectively enhancing performance of the photoelectrochemical cell performance due to architecting ZnO-NiO heterostructure.

The n-type ZnO and p-type NiO semiconductors have the potential to form junctions and create an electric field across their deflection regions. When photons strike the junction area, it encourages electron-hole separation, improving photoelectrochemical performance of ZnO-NiO heterostructure over ZnO. This results in better charge collection and a lower recombination rate.

Keywords: nanorods: ZnO; ZnO-NiO; ion-exchange; heterostructure; PEC

Phase-dependent broad-range photodetection by iron oxide nanorods

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Abstract:

Photodetectors play a crucial role in a wide range of applications, including environmental monitoring, optical communication, and biomedical imaging. Nanomaterials are particularly important for photodetectors due to their high surface-to-volume ratio, tunable optical properties, and enhanced charge carrier dynamics, which significantly improve light absorption and photoresponse efficiency in optoelectronic devices. This study focuses on the multi-phasic iron oxide nanorods (IONRs) and evaluates their performance as photodetectors operational in broad spectrum ranging from UV to visible light spectrum. The IONRs were synthesized using a wet chemical co-precipitation (COP) method under varying reaction conditions that resulted in multi phases. While sample labelled as COP1 consisted of mixed phases of α-FeOOH/α-Fe_2O_3/γ-FeOOH, the one labelled as COP2 showed ε-Fe_2O_3/γ-Fe_2O_3. Optical studies confirmed distinct energy bandgaps for IONRs samples. Transmission Electron Microscopy (TEM) analysis showed a reduction in nanorod length from 60±8 nm (COP1) to 14±3 nm (COP2) and diameter from 5±0.5 nm to 3±0.5 nm. As-synthesized powder was cast as thin film on the screen-printed electrodes to measure photocurrent under UV and visible light illumination. Both the samples exhibited quick photoresponse under UV light illumination at a low bias voltage of 0.5 V. whereas, the COP2 sample responded to visible light in addition to the UV light. The synthesis of multi-phase IONRs via a modified wet chemical method added a versatile approach for altering their properties for enhanced photodetection applications.

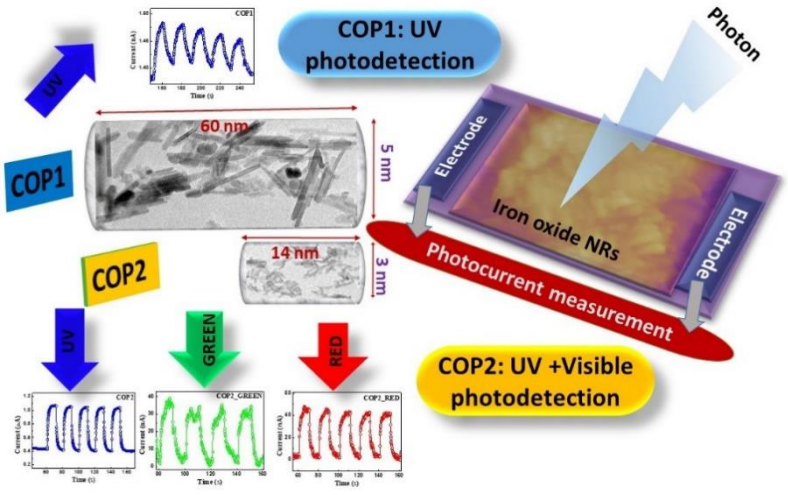

Fig. 1: Schematic of photocurrent generating mechanism in COP1 and COP2 IONRs samples.

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Engineered $BiVO_4$/C Nanocomposites for Superior Photocatalytic Dye Degradation and Sustainable Water Remediation

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Abstract:

Photocatalytic degradation of organic dyes is an effective strategy for mitigating water pollution and promoting sustainable environmental remediation. This study explores the photo-catalytic behaviour of $BiVO_4$ (Bismuth Vanadate) and its carbon-based composite, $BiVO_4$/C, synthesized via a facile dextrose-mediated in situ approach. Comprehensive characterization techniques, including X-ray diffraction (XRD), UV-Visible spectroscopy, Field Emission Scanning Electron Microscopy (FESEM), Raman spectroscopy, and Time-Resolved Photoluminescence (TRPL), were employed to investigate the physicochemical properties of the synthesized materials. XRD analysis confirmed the monoclinic crystalline phase of both $BiVO_4$ and $BiVO_4$/C, while UV-Visible spectroscopy shows an extended absorption in visible spectrum whereas TRPL measurements demonstrated enhanced charge carrier lifetime for $BiVO_4$/C (**16.34 ns**) compared to pristine $BiVO_4$ (**7.79 ns**), indicating improved charge separation and reduced recombination losses. The $BiVO_4$/C nanocomposite exhibited superior photocatalytic activity, achieving rapid degradation of methylene blue (MB) and methyl violet (MV) dye solutions (10 ppm) within one minute and complete degradation of **25 ppm** solutions within **10 minutes**, following pseudo-first-order kinetics. The enhanced photocatalytic efficiency of $BiVO_4$/C is attributed to the synergistic interaction between $BiVO_4$ and carbon, which improves light absorption, charge transport, and surface reaction dynamics. This study provides valuable insights into the development of advanced photocatalysts for effective pollutant degradation and clean water solutions.

Keywords: Photocatalysis, $BiVO_4$/C nanocomposite, Dye degradation, Water treatment, Environmental remediation, Advanced oxidation process

Agricultural Soil Analysis and Evaluation through Gamma Ray Attenuation

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Abstract:

This study explores the application of gamma-ray attenuation techniques to analyze soil porosity, a critical parameter in soil structure. By comparing nuclear methods to traditional techniques, the demonstrate the efficiency and non-destructive nature of gamma-ray attenuation in measuring porosity across various soil types. The analysis crucial for agricultural and environmental studies, particularly in water infiltration, root growth, and soil management.

Soil porosity is significant in environmental studies, affecting water infiltration, root growth, and the movement of air, water, and solutes within the soil. Nuclear techniques, such as gamma-ray attenuation (GRA), provide non-destructive and rapid measurement options, offering high spatial resolution. This research aims to explore the use of gamma-ray attenuation for evaluating soil porosity, comparing the results with traditional methods.

The attenuation coefficient of soil was determined using the gamma-ray attenuation (G.M.tube or NaI(Tl) method, based on the interaction of gamma rays with soil. According to the Beer-Lambert law, the transmitted intensity I through a material of thickness x is given by equation 1:

$$I = I_0 e^{-\kappa x} \qquad (1)$$

where κ is the linear attenuation coefficient. The mass attenuation coefficient (μ), which is almost independent of the physical state of the material,

Soil samples from various regions of North Maharashtra were analysed. Preliminary results indicate that the gamma-ray attenuation method offers precise and non-destructive measurements of soil porosity. Different soil types and crop-growing regions showed variations in porosity, with coarse-textured soils exhibiting lower porosity compared to fine-textured soils.

Gamma-ray attenuation provides a reliable and efficient method for measuring soil porosity, offering advantages over traditional methods in terms of non-destructive analysis and high spatial resolution. Further analysis is required to refine the measurement techniques and correlate the findings with environmental factors affecting crop growth and soil health.

Acknowledgements:

This research is funded by the Vice-Chancellor Research Motivation Scheme (VCRMS) from K.B.C. North Maharashtra, Jalgaon Maharashtra, India.

References:

1. R. Lal and M. K. Shukla, Principles of Soil Physics, Marcel Dekker, New York, NY, USA, 2004.
2. A. F. Baytaş¸ and S. Akbal, "Determination of soil parameters by gamma-ray transmission," Radiation Measurements, vol. 35, no. 1, pp. 17–21, 2002.
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The Synergy of AI and IoT: Unlocking New Frontiers in Automation and Innovation

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Abstract:

The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) represents a transformative paradigm shift in modern technology, unlocking unprecedented opportunities for automation, optimization, and innovation. AI empowers IoT devices to process andanalyze vast streams of real-time data at scale, enabling advanced capabilities such as predictive maintenance, anomaly detection, intelligent decision-making, and seamless operational automation. This integration is driving disruptive applications across diverse sectors, including smart manufacturing, precision healthcare, industrial automation, smartcities, and environmental monitoring, revolutionizing workflows and enhancing efficiency.

This paper provides a detailed exploration of the synergistic relationship between AI and IoT, focusing on their combined ability to improve system intelligence, adaptability, and operational reliability. It also highlights critical challenges, including data governance, privacy, cybersecurity, standardization, and the scalability of AI-IoT solutions in increasingly complex and interconnected ecosystems. By analyzing state-of-the-art advancements, innovative use cases, and emerging trends, this study aims to offer a comprehensive perspective on the transformative potential of AI-driven IoT, serving as a strategic guide for industrial stakeholders, policymakers, and researchers seeking to leverage these technologies for sustainable growth and competitive advantage.

KEYWORDS: Artificial Intelligence, Internet of Things, Automation, AI Models, Machine Learning, Neural Networks, Signal Optimization, Operational Reliability, Real-time Data Processingtanu.

POSTER PRESENTATION

Upcycling Automobile Industry Waste: Synthesis of Carbon Black Nanoparticles for Eco-Friendly Fabric Dyeing

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Abstract:

The increasing environmental concerns associated with automobile industry waste call for sustainable recycling strategies. This study explores the synthesis of carbon black nanoparticles (CBNPs) from waste generated by the automobile industry by physical method and evaluates their potential applications in fabric dyeing. Carbon black nanoparticles were synthesized using a thermal decomposition method, followed by characterization through techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR). The dyeing performance of CBNPs on cotton and polyester fabrics was assessed in terms of color fastness, wash durability, and eco-friendliness. The results demonstrated that the synthesized CBNPs exhibited excellent dyeing properties with enhanced fabric adhesion and durability. Furthermore, the use of CBNPs as a dye alternative reduces reliance on synthetic dyes, minimizing environmental pollution. This study highlights a novel, cost-effective, and sustainable approach to converting industrial waste into valuable nanomaterials for textile applications, contributing to a circular economy.

Keywords Upcycling Automobile Industry Waste: Synthesis of Carbon Black Nanoparticles for Eco-Friendly Fabric Dyeing

Carbon black nanoparticles, automobile waste recycling, fabric dyeing, eco-friendly textiles dyeing.

The Synergy of AI and IoT: Unlocking New Frontiers in Automation and Innovation

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Abstract:

The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) represents a transformative paradigm shift in modern technology, unlocking unprecedented opportunities for automation, optimization, and innovation. AI empowers IoT devices to process and analyze vast streams of real-time data at scale, enabling advanced capabilities such as predictive maintenance, anomaly detection, intelligent decision-making, and seamless operational automation. This integration is driving disruptive applications across diverse sectors, including smart manufacturing, precision healthcare, industrial automation, smart cities, and environmental monitoring, revolutionizing workflows and enhancing efficiency. This paper provides a detailed exploration of the synergistic relationship between AI and IoT, focusing on their combined ability to improve system intelligence, adaptability, and operational reliability. It also highlights critical challenges, including data governance, privacy, cybersecurity, standardization, and the scalability of AI-IoT solutions in increasingly complex and interconnected ecosystems. By analyzing state-of-the-art advancements, innovative use cases, and emerging trends, this study aims to offer a comprehensive perspective on the transformative potential of AI-driven IoT, serving as a strategic guide for industrial stakeholders, policymakers, and researchers seeking to leverage these technologies for sustainable growth and competitive advantage.

Table 1. Benefits of AI-IoT Integration Across Industries:

Industry	Efficiency Gains (%)	Cost Reduction (%)
Manufacturing	32	40
Healthcare	25	20
Agriculture	30	35
Smart Cities	28	15

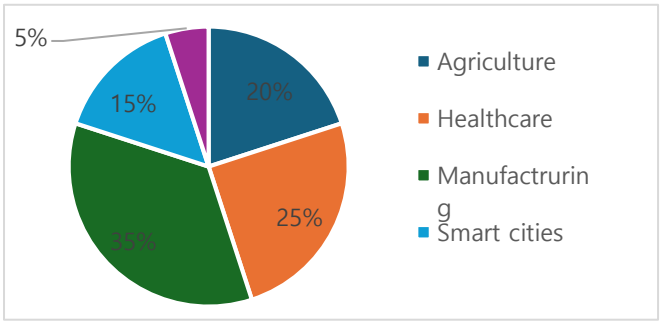

Figure 1: Distribution of AI-IoT Applications Across Industries

This pie chart illustrates the primary sectors leveraging AI-IoT integration.

Reference(s):

1. Y. Zhou and M. Zhang, "The Synergy of AI and IoT in Smart Factories," J. Ind. Eng., vol. 62, no. 3, pp. 115-123, 2022.
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Lunar Orbit Dynamics and Soft-Landing Techniques

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Abstract:

Effective transfer of a spacecraft is a very key component in studying Space exploration. In this study we will explore the Hohmann transfer trajectory and its applicability to the Lunar missions. We will investigate the calculations necessary for the minimum fuel use and trajectory planning by examining the dynamics of the Lunar Transfer orbit. This study will then make a transition to a lunar landing, including the intricacies of braking techniques, descent stages, and possible risks during the landing. This study will serve a foundation to further advancements in the Interplanetary trajectories and lunar landing.

Reference:

1. https://www.isro.gov.in/Chandrayaan3.html

Climate Effects on Dengue and Malaria Time-Series in Mumbai, India

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Abstract:

Over the last decade due to climate change there has been a worldwide surge in vector-borne diseases like Dengue, Chikungunya, Zika, Malaria etc. India has a huge burden of Dengue, affecting more than 1 million individuals between 2015 and 2023. India is vulnerable to climate change. In the present work, we analyzed the role of climate factors on the occurrence of Dengue and Malaria in the coastal metropolis of Mumbai, India over 9-years period (2015-2023). Due to shift in the low-level jet stream (LLJ) that drives SW monsoon, from Kerala (8º N) to Maharashtra (15º N), altered enhanced rainfall is rendered in coastal Maharashtra. The coastal districts, due to their geographical and climatic conditions, provide a unique environment to study the interplay between climate factors and dengue transmission.

In this study, time-series analysis was employed to investigate the relationship between district wise monthly dengue incidence and climate variables, including temperature (MXT, MNT, MT), rainfall (RF), humidity (RH), and diurnal temperature range (DTR). Data on dengue cases were obtained from the Maharashtra State Health Department, while climate data were sourced from the India Meteorological Department (IMD).

Preliminary results indicate a strong seasonal pattern in dengue and malaria incidences, with peaks typically occurring during monsoon season (June-October). Statistical analysis reveals significant correlations between dengue cases and all studied climate variables. We used different types of mathematical models with meteorological parameters as regressors in projecting dengue cases. Out of these SARIMA and Prophet provide the best fitting and

predictions.

This study contributes to the growing body of evidence linking climate change to vector-borne diseases and emphasizes the critical role of climate-informed public health strategies in mitigating dengue outbreaks in coastal cities.

***Keywords**: Dengue, Malaria, Climate Change, Time series, Mumbai, etc.*

Exploring the Plunging Black Hole Region: First Detections and Implications

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Abstract:

The plunging region of black holes, located between the innermost stable circular orbit (ISCO) and the event horizon, offers a unique opportunity to test general relativity in the strong field regime. Recent advancements in X-ray reverberation techniques have enabled the detection of emissions from this elusive region, providing insights into the dynamics of material as it spirals into the black hole. Notably, the X-ray binary systems MAXI J0637−430 and MAXI J1820+070 have shown evidence of thermal emissions originating from within the plunging region, challenging traditional disc models that neglect this area. These findings suggest that the plunging region contributes significantly to the overall X-ray spectrum, particularly in the high-energy bands, and may influence black hole spin estimations. Numerical simulations and analytical models have further revealed the complex three-dimensional structure of accretion flows within this region, highlighting the role of spiral arms and magnetic fields in mediating accretion. This poster will discuss the methodologies used to detect emissions from the plunging region, the implications for black hole physics, and the observational requirements for future studies.

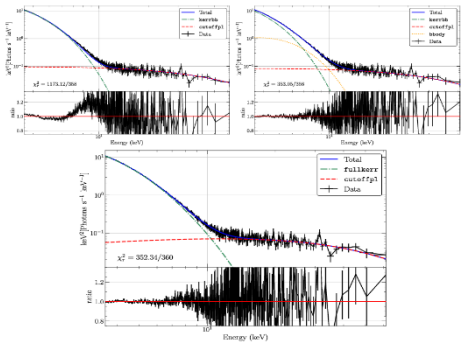

Figure : The Nu29 X-ray spectrum of MAXI J1820 (black points), compared

Reference(s):

1. Mummery, A., Ingram, A., Davis, S., & Fabian, A. (2024). Continuum emission from within the plunging region of black hole discs. Monthly Notices of the Royal Astronomical Society, 531(1), 366–386. https://doi.org/10.1093/mnras/stae1160

Structure and Morphology of Multiferroic Holmium-doped Lutetium Ferrite

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Abstract:

Multiferroics, particularly rare earth orthoferrites, have garnered attention for their ferroelectric and ferromagnetic properties [1,2]. Possessing a distorted perovskite structure, rare earth orthoferrites showcase unique physical properties, with $LuFeO_3$ being notable for its unique characteristics due to the small ionic radius of Lu^{3+} and its anti-ferromagnetism below 620K [3]. Holmium doping is reported to enhance multiferroic properties owing to high magnetic moments, crystal-field induced single ion magnetic anisotropy and ionic radii mismatch This study reports on structural and morphological changes in holmium-doped lutetium orthoferrite.

Room temperature X-ray diffraction reveals that increasing holmium substitution from 15% to 25% significantly alters peak splitting and intensity. This suggests structural changes that may lead to changes in the multiferroic properties. This may be successfully employed in potential nanogenerator applications.

Graphical Abstract:

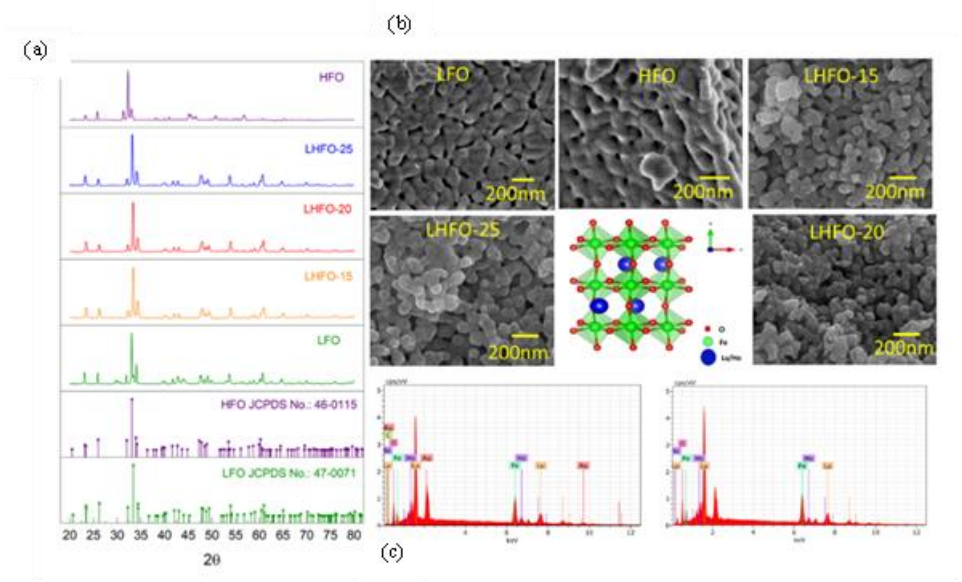

Figure 2: (a) X-ray diffraction measurements for LFO, LHFO-15, LHFO-20, LHFO-25 and HFO; (b) FESEM images for LFO, LHFO-15, LHFO-20, LHFO-25 and HFO; (c) EDX spectra of LHFO-15 and

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1. S.W. Cheong, M. Mostovoy, Multiferroics: a magnetic twist for ferroelectricity, Nat. Mater 6 (2007) 13-20.

2. B. Rajeswaran et al., Field-induced polar order at the Neel temperature of chromium in rare-earth orthochromites: interplay of rare-earth and Cr magnetism, Phys. Rev. B 86 (2012) 214409.

3. R.L. White, Review of recent work on the magnetic and spectroscopic properties of the rare-earth orthoferrites, J. Appl. Phys. 40 (1969) 1061-1069.

Synthesis and characterisation of ZnFe2O4 for Supercapacitor applications by spray pyrolysis on Nickel foam substrate

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Abstract:

Ferrite material can be promising materials to solve the global energy crisis and high energy density storage devices. For this, simple spray pyrolysis technique was used to prepared $ZnFe_2O_4$ on high porous and high conductive robust nickel foam substrate. While synthesis the effects of temperature (325, 350, 375, 400°C) on the structural, morphological and electrochemical characteristics of $ZnFe_2O_4$ ferrite material were observed in this work. The crystallinity, structural defects and interplanar d spacing are examined by the X-ray diffraction (XRD) pattern of $ZnFe_2O_4$@SS. Surface morphological aspects are observed by the field emission scanning electron microscopy (FESEM), and electrochemical properties like cyclic voltammetry (CV) galvanostatic charge discharge (GCD) and Electrochemical impedance spectroscopy (EIS) was performed to characterize the electrode. Optimal crystalline size and lower dislocation density with micro-strain was confirmed by XRD diffraction. Well structured nanoflower like morphology are executed by the FESEM studies. Electrochemical measurements of the ferrites material show better specific capacitance at a low scan rate. Thus, impact of controlling growth by temperature variation and resulted into improved electrochemical performance. The ferrite material can be promising materials for energy storage applications like supercapacitors.

Keywords: Ferrite material, $ZnFe_2O_4$, spray pyrolysis, nickel foam substrate Supercapacitor electrode.

$BaAlF_5$:Eu Phosphor: A prominent material for TL Dosimetry

Sanika Ghadage[a], Kapare Pranjal J.[a], Bale Komal[a], Sandhya B. Deshmukh[b], S. S. Dahiwale[b], S. D. Dhole[b] and Mahesh S. Bhadane[a,b*]

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(* Corresponding Author Email: mbhadane24@gmail.com)

Abstract:

In the present work, we systematically developed a Eu doped $BaAlF_5$ nano phosphor by solid state diffusion method. From XRD, we confirmed the material to be $BaAlF_5$ and obtained the crystallite size which is around ~33.5 nm. EDS confirmed the entire elements present in the material. From UV-Vis spectroscopy, we determined the band gap which comes out to be 3.5 eV. From SEM images, we analyzed the morphology of $BaAlF_5$:Eu Photoluminescence confirmed the Europium present in the BaAlF5 after doping. The $BaAlF_5$:Eu was annealed at 900 ^oC at 2hr and later irradiated by ^{60}Co gamma source for the analysis of TL properties. TL glow curve shows two peaks, one at temperatures 184.7 ^oC and another at 232.5 ^oC. The dose-response reveals that the linearity range is 300 Gy to 10 kGy and further obtained saturation. Fading was observed at 22.7 % over 60 days.

Reference:

1. M. S. Bhadane, P. P. Kulkarni, K.H. Gavhane, et al. Thermoluminescence studies of Dy-doped $BaAlF_5$ nanophosphor for radiotherapy application. J Mater Sci: Mater Electron **35**, 1453 (2024). https://doi.org/10.1007/s10854-024-13157-4.

Synthesis and characterisation of $ZnFe_2O_4$ for Supercapacitor applications by spray pyrolysis on stainless steel substrate

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corresponding author: balbhim02@gmail.com

Abstract:

Ferrite material can be promising materials to solve the global energy crisis and high energy density storage devices. For this, simple spray pyrolysis technique was used to prepared $ZnFe_2O_4$ on low-cost stainless-steel substrate. While synthesis the effects of temperature (325, 350, 375, 400°C) on the structural, morphological and electrochemical characteristics of $ZnFe_2O_4$ ferrite material were observed in this work. The crystallinity, structural defects and interplanar d spacing are examined by the X-ray diffraction (XRD) pattern of $ZnFe_2O_4$@SS. Surface morphological aspects are observed by the field emission scanning electron microscopy (FESEM), and electrochemical properties like cyclic voltammetry (CV) galvanostatic charge discharge (GCD) and Electrochemical impedance spectroscopy (EIS) was performed to characterize the electrode. Optimal crystalline size and lower dislocation density with micro-strain was confirmed by XRD diffraction. Well-structured nanoflower like morphology are executed by the FESEM studies. Electrochemical measurements of the ferrites material show better specific capacitance at a low scan rate. Thus, impact of controlling growth by temperature variation and resulted into improved electrochemical performance. The ferrite material can be promising materials for energy storage applications like supercapacitors.

Keywords: Ferrite material, $ZnFe_2O_4$, spray pyrolysis, stainless steel substrate Supercapacitor electrode.

Green Synthesis of Iron Nanoparticles Using Pomegranate Seed and Skin Extract: Applications in Seed Germination and Antibacterial Evaluation

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Abstract:

The green synthesis of nanoparticles using plant extracts is an eco-friendly and sustainable approach that eliminates the need for hazardous chemicals. In this study, Iron nanoparticles (FeNPs) were synthesized using pomegranate (*Punica granatum*) seed and skin extract as a natural reducing and stabilizing agent. The synthesized FeNPs were characterized using UV-Vis spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM) to confirm their formation, stability, and morphology. The effectiveness of these FeNPs was assessed for their role in promoting seed germination and their antibacterial potential against selected pathogenic bacteria. The results demonstrated that FeNPs significantly enhanced seed germination and early seedling growth due to their bioactive properties. Additionally, antibacterial activity was evaluated using the disk diffusion method, revealing potent antimicrobial effects against *Escherichia coli* and *Staphylococcus aureus*, suggesting their potential in biomedical and agricultural applications. This study highlights the dual functionality of biosynthesized FeNPs in plant growth promotion and bacterial inhibition, paving the way for sustainable nanotechnology applications.

Key words: Green synthesis, Iron nanoparticles, pomegranate extract, antibacterial activity, seed germination, nanotechnology, eco-friendly synthesis.

ZnO and TiO_2 Nanoparticles for the Photocatalytic Degradation of Azo Dyes: A Sustainable Wastewater Treatment

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[1*] *Department of Biotechnology, MES Abasaheb Garware College (Autonomous), Savitribai*

Phule Pune University, Pune 411004, Maharashtra, India

(*Corresponding authors: Dr.Maya Khater, email: msk.agc@mespune.in)

Abstract:

The discharge of azo dyes like Congo Red and Methyl Orange into water bodies poses severe environmental and health hazards due to their toxicity and non-biodegradability. This study investigates the photocatalytic degradation of these dyes using zinc oxide (ZnO) and titanium dioxide (TiO_2) nanoparticles under ultraviolet (UV) irradiation. The synthesized nanoparticles were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), and UV-Vis spectroscopy to determine their structural, morphological, and optical properties. The photocatalytic efficiency of ZnO and TiO_2 was evaluated by monitoring the degradation kinetics of the dyes under varying conditions of catalyst dosage, pH, and irradiation time. The results demonstrated that both ZnO and TiO_2 exhibited significant photocatalytic activity, with TiO_2 showing superior efficiency under UV light. The degradation followed pseudo-first-order kinetics, confirming the effective generation of reactive oxygen species for dye mineralization. This study highlights the potential of ZnO and TiO_2 nanoparticles as sustainable photocatalysts for wastewater treatment, offering an eco-friendly and cost-effective solution for azo dye removal.

Keywords:

Photocatalysis, ZnO nanoparticles, TiO_2 nanoparticles, azo dye degradation, Congo Red, Methyl Orange, wastewater treatment, , environmental remediation, nanomaterials.

Green Synthesis of Copper Nanoparticles Using Tulasi and Neem: Applications in Wastewater Treatment and Genotoxicity Assessment

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Abstract:

The green synthesis of copper nanoparticles (CuNPs) using plant extracts has emerged as an eco-friendly and sustainable approach, offering a viable alternative to conventional chemical synthesis methods. In this study, CuNPs were synthesized using aqueous extracts of Tulasi (Ocimum sanctum) and Neem (Azadirachta indica), which act as natural reducing and stabilizing agents at 4^0C and room temperature. The synthesized CuNPs were characterized using UV-Vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy (SEM) to confirm their structural and morphological properties. The application of these biosynthesized CuNPs in wastewater treatment was evaluated by assessing their efficiency in the degradation of organic pollutants Furthermore, the genotoxicity of the CuNPs was assessed using standard onion root tip assay to determine their potential cytotoxic effects on living cells. The results demonstrated that the green-synthesized CuNPs exhibit the spherical and oval shape and size at (18-29nm) significant pollutant removal efficiency and antimicrobial properties while maintaining biocompatibility at optimal concentrations. This study highlights the potential of plant-mediated CuNPs as an effective and environmentally friendly material for wastewater treatment with minimal ecological risks.

Keywords: Green synthesis, Copper nanoparticles, Tulasi (*Ocimum sanctum*), Neem (*Azadirachta indica*), Wastewater treatment, Antimicrobial activity, Genotoxicity, Eco-friendly nanotechnology.

Synthesis and Photoluminescence studies of LaB_3O_6:La phosphors

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[b]*Department of Physics, Savitribai Phule Pune University, Ganeshkhind Road, Pune, MH-411007.*

(* Corresponding Author Email: mbhadane24@gmail.com)

Abstract:

We synthesized LaB_3O_6 phosphor using a solid-state reaction method and characterized the material using X-ray diffraction (XRD) to confirm the crystal structure and phase purity of the material. XRD revealed the monoclinic phase of the as-prepared LaB_3O_6 phosphor and the lattice parameters matched with the JCPDS data. We then performed photoluminescence (PL) studies of the as-synthesized LaB_3O_6 samples using a fluorescence spectrophotometer to study their luminescence properties. Surface functional group properties and morphology properties were studied by using FTIR, and SEM, respectively.

Reference:

1. K. H. Gavhane, M. S. Bhadane, et al. T_m-T_{stop} analysis and dosimetric properties of Ce doped BaB_4O_7 phosphor. J All. & Comp. **817**, 152805 (2020).
2. https://doi.org/10.1016/j.jallcom.2019.152805.

Survey of spin, parity and half-life measurements of nuclear levels, for A = 1-260

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Abstract:

The study of nuclear excited states is crucial for understanding the fundamental structure and behavior of atomic nuclei. In particular, precise measurements of half-life, spin, and parity provide essential insights into nuclear models and decay mechanisms. This work presents a comprehensive survey of such measurements across a wide range of nuclei, spanning mass numbers 1 to 260.

Building upon a previous survey conducted in 2019 [1], this study evaluates the progress made over the past five years by analyzing updated nuclear structure data from the National Nuclear Data Center (NNDC) [2]. The primary objective is to identify trends in nuclear data availability and highlight regions within the nuclear chart where measurements remain scarce. Such an analysis serves not only as a reference for existing nuclear data but also as a guide for future experimental studies.

The dataset for this study has been extracted from the Evaluated Nuclear Structure Data File (ENSDF), and a dedicated computational approach has been employed to systematically retrieve and process relevant nuclear properties. By quantifying the fraction of known half-

life, spin, and parity values for various nuclei, this work provides a statistical overview of the completeness of nuclear data.

Through this survey, we aim to assess whether significant advancements have been made in nuclear data measurement since the previous study and to identify persistent gaps that warrant further investigation. The findings of this study can assist experimentalists in prioritizing future measurements and contribute to the broader efforts of refining nuclear structure models.

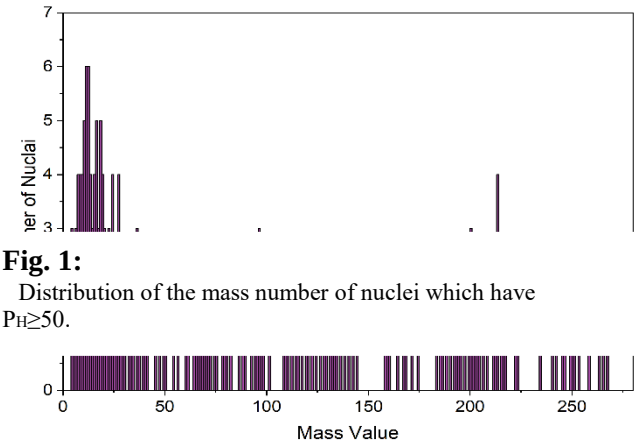

Fig. 1:
Distribution of the mass number of nuclei which have $P_H \geq 50$.

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Exploring the Bilateral Symmetry and Complexity of Human Eyes: Understanding Function, Pathology and Potential for Detecting Vision Deficiencies through Voltage Differences"

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Abstract:

This study investigates the human visual system, emphasizing its bioelectrical, bilateral, and physiological components to enhance the comprehension of ocular health and vision-related disorders. The research examines the functions and interrelations of both eyes, the production of bioelectrical signals, and their association with visual well-being, employing electro-oculography (EOG) to measure ocular voltage. Mathematical models are created to replicate eye movements and voltage differentials, aiding in the early detection of visual impairments. The research encompasses empirical, biophysical, and transcendental aspects, addressing both the physical and metaphysical dimensions of vision. Preliminary results indicate that individuals with normal vision display ocular voltages ranging from 0.5 to 0.9 mV, while values falling below 0.4 mV are linked to conditions such as myopia and astigmatism, and voltages exceeding 1.0 mV may suggest potential issues like glaucoma. The mathematical models demonstrate that eye movement and orientation are responsive to variations in voltage, providing a predictive framework for identifying visual anomalies. The study concludes that ocular voltage serves as a crucial indicator of visual health, and the combination of bioelectrical measurements with mathematical modeling enhances our understanding of visual functionality. Future research will aim to refine bioelectric measurement methods, utilize machine learning for predictive analytics, and investigate the convergence of physical and metaphysical aspects of vision to reveal new insights into human perception and consciousness.

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Variable stars: Study Intrinsic or Extrinsic properties variable star

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Abstract:

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Variable stars play a crucial role in astrophysical research, providing insights into stellar composition, cosmic distances, and exoplanet detection.and for understanding of galaxy formation and the expansion of the universe. Furthermore, variable stars serve as natural laboratories for testing fundamental theories of physics.Their pulsations and eruptions reveal internal stellar processes, while eclipsing binaries and brightness variations aid in identifying orbiting planets. Cepheid and RR Lyrae variables serve as "standard candles," enabling precise distance measurements to galaxies and refining the cosmic distance scale. Additionally, studying variable stars helps analyze star-planet interactions and test fundamental physics theories, including stellar fusion and general relativity. These observations contribute significantly to ourunderstanding of the universe's structure and evolution.

Keywords-Variablestars,Astrophysicalresearch,Cosmicdistances,Galaxyformation,Physics theories,Pulsations,EruptionsEclipsing,binaries,Brightnessvariations,Cepheidvariables,RR Lyrae variables, Standard candles, Star-planet interactions

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Magneto-priming effect on germination of Fenugreek seeds

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Abstract:

Fenugreek (*Trigonella foenum-graecum*) is a common ingredient in the Indian subcontinent. It has medicinal value and is extensively used as a food ingredient in the kitchen. In the present work, we studied the effect of static magnetic field on the growth mechanism of fenugreek seeds. Initially, the viability of fenugreek seeds was evaluated using tetrazolium salt. Viable seeds were exposed to different magnetic fields as B = 50, 100, and 150 mT for 30, 60, 90, and 120 min duration. Notable changes on seed weight, root length, shoot length, and vigour index were observed in the seeds magnetoprimed at B=100 mT. Both, control seeds and magnetoprimed seeds at 100 mT were characterized using SEM, FTIR, Raman and magnetic susceptibility. The surface wettability of seeds was determined using a contact angle measurement. Saplings are grown in the laboratory farm, and two-week-old sapling leaves are used to estimate photosynthetic parameters by Handy PEA instrument. Further, the leaf extract is characterized using UV-visible, Photoluminescence and Time-Resolved Photoluminescence spectroscopy. The saplings germinated from magnetoprimed seeds showed an overall improvement in growth. This study elucidates the potential of magneto-priming treatment as a viable and affordable strategy for improving seed germination and plant growth in the long term, with important implications for the agricultural sector. This is a physical process, a green and eco-friendly technique without involving chemical additives in the seeds.

Keywords: Magneto-priming, seed, germination, chlorophyll, spectroscopy

Molecular properties of gamma irradiated PVA

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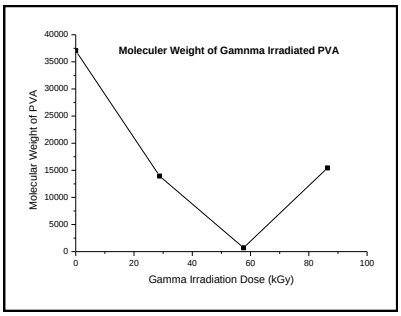
Abstract:

This study examines the effects of Co-60 gamma radiation on the molecular properties of gamma irradiated polyvinyl alcohol (PVA), focusing on molecular weight variations and refractive index changes. Initially, the molecular weight of pristine (pure) PVA was measured using an Ostwald viscometer at 25°C, serving as a reference. PVA samples were then irradiated with gamma radiation at the doses ranging from 28.8 kGy to 115.2 kGy and their molecular weights were determined using the Mark–Houwink equation based in intrinsic viscosity. The results show a gradual decrease in molecular weight up to a dose of 57.6 kGy due to radiation induced polymer chain scissioning. At 86.4 kGy, an increase in molecular weight is observed which suggests radiation induced crosslinking, while at the maximum dose of 115.2 kGy, a part of PVA became an insoluble gel, which also indicates further radiation crosslinking. To study corresponding optical property variations, the refractive index of PVA-water solutions was measured using an Abbe refractometer. A correlation was observed between the variations in molecular weight and refractive index, confirming structural changes in irradiated PVA. These findings provide insights into radiation-induced modifications in PVA, which are crucial for applications in biomedical materials, optical coatings, and radiation-processed polymers.

Table: Molecular weight of gamma irradiated PVA

Sample	**Irradiation period (hours)**	**Dose delivered (kGy)**	**Molecular Weight of PVA (g/mole)**	**Remark**
Pristine	0	0	37060	
1	48	28.8	13931	Scissioning
2	96	57.6	701	Scissioning
3	144	86.4	15434	Crosslinking
4	192	115.2	Gel fraction	Crosslinking

Figure: Variation of molecular weight with gamma dose



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Enhanced Photoelectrochemical Activity Apprehended from MoS_2 Thin Films synthesized by RF-Magnetron Sputtering for Water Splitting

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Abstract:

We report the synthesis of Molybdenum disulfide (MoS_2) thin films using RF-magnetron sputtering at different RF powers. The effect of change in RF power on structural, morphological, optical, and photoelectrochemical properties was studied using x-ray diffraction (XRD), Raman spectroscopy, field emission scanning electron microscopy (FESEM), UV-Visible spectroscopy, photoelectrochemical activity. The XRD data confirm the hexagonal crystal structure of MoS_2 with an average crystallite size of ~ 30 - 50 Å. Our FESEM analysis shows that the surface morphology of well grown MoS_2 nanosheets that are influenced by RF power. From the Energy dispersive spectra, we verified that at RF power~150 W, the synthesized MoS_2 nanosheets have stoichiometric in nature. Linear sweep voltammetry (LSV) was used to evaluate the photoelectrochemical activity of MoS_2 thin films. The film deposited at 150 W demonstrated the highest photocurrent density of 4.92 mA/cm^2, which indicates superior photoelectrochemical activity. Furthermore, the Mott-Schottky analysis revealed that the flat band potential shifted towards the negative side, suggesting that the fermi level shifted towards the conduction band. The MoS_2 film grown at 150 W demonstrated a majority charge carrier density of ~ 6.2x10^{19} cm^{-3}. The observed low charge transfer resistance of ~ 133 Ω contributed to the enhanced photoelectrochemical activity. Overall, these properties suggest that MoS_2 has the potential to serve as a suitable material for photoelectrochemical water splitting.

Solvent-Free Mechanochemical Synthesis of ZnO nanoparticles for Photocatalytic Application

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Abstract:

As an intro to studies on the photocatalytic degradation of Rhodamine B (RhB) dye, zinc oxide nanoparticles were synthesized from zinc oxalate dihydrate using a solvent-free mechanochemical method. The hexagonal wurtzite crystallite forms of ZnO were clearly seen in the ensuing XRD data. Zinc oxalate dehydrate conversion to ZnO was examined using FT-IR spectroscopy. ZnO optical band gap 3.14 eV was measured using UV-visible spectroscopy. Photocatalytic degradation studies using visible, UV-A and UV-C light to examine the effects of different catalyst concentrations ZnO on RhB dye. When exposed to both visible UV-A and UV-C rays, the as-synthesized ZnO exhibits the maximum breakdown rate, at 0.027 min^{-1}. Furthermore, the effect of catalyst dosages on efficiency demonstrates the complex interplay between light absorption and active sites. After 120 minutes of radiation, RhB exhibited the maximum degradation of 97%. Moreover, ZnO photocatalyst showed high recyclability with high activity (91.5% after 4 cycles) and thus can be considered as a potent photocatalyst for use in industrial water treatment and Hydrogen generation.

KEYWORDS: Mechanochemical Synthesis, ZnO, Photocatalysis, Rhodamine B Dye,

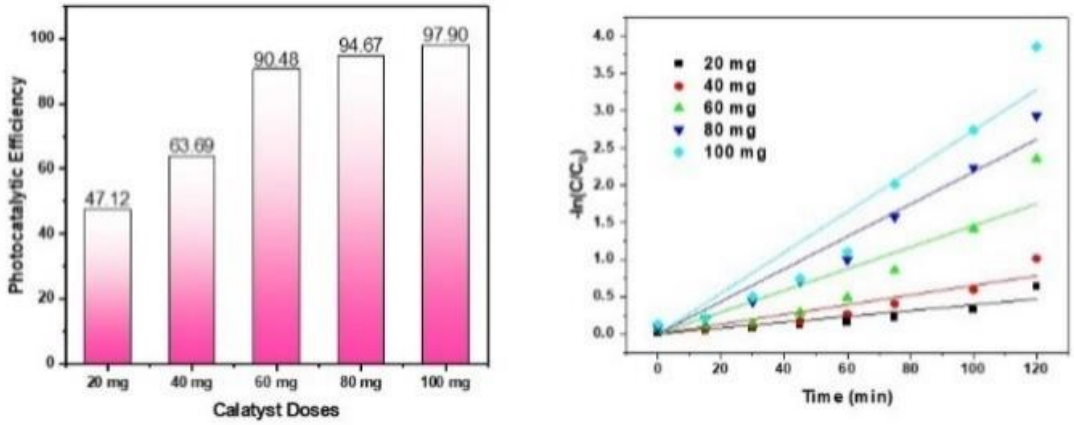

Fig 1. Catalyst Variations of ZnO, Photocatalytic degradation kinetics of Catalyst ZnO.

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A Novel $K_2Mg_2(SO_4)_3:Eu^{3+}$ Thermoluminescent Phosphor for Radiation Dosimetry

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Abstract:

Thermoluminescence (TL) dosimetry plays a crucial role in radiation monitoring for medical and environmental applications. This study investigates the synthesis and characterization of $K_2Mg_2(SO_4)_3:Eu^{3+}$ (KMS) phosphor as a potential TL material for radiation dosimetry. The KMS phosphor was synthesized using a solid-state reaction method. Characterization was performed using X-ray diffraction (XRD) to confirm phase purity and crystallinity, scanning electron microscopy (SEM) to analyze surface morphology, and photoluminescence (PL) spectroscopy to evaluate emission properties. X-ray diffraction (XRD) analysis revealed that the as-prepared phosphor has a cubic structure with an average crystallite size of ~ 53 nm and average particle size ~1.2 µm. Thermoluminescence (TL) glow curves were obtained to assess dosimetric properties, including peak temperature, sensitivity, and dose-response behaviour. The results indicate that $K_2Mg_2(SO_4)_3:Eu^{3+}$ exhibits a stable and efficient TL response, making it a promising material for radiation dosimetry.

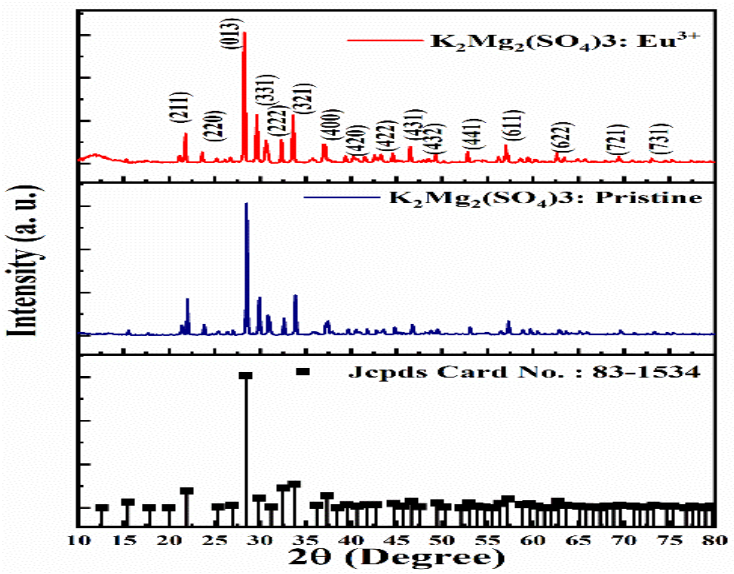

Fig. 1: XRD Pattern of $K_2Mg_2(SO_4)_3$ Phosphor

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Quantum Computing and Cryptography in Banking Security

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[1,2,3] *Department of Computer Science, Fergusson College (Autonomous), Pune, India*

(Email: uma.madje@fergusson.edu)

Abstract:

Online banking is a crucial financial service but faces growing cyber threats. Traditional encryption methods like RSA and ECC, though widely used, are at risk due to advancing quantum computing. This paper explores quantum computing's role in securing online banking, analysing cyberattacks such as the Cosmos Bank heist and C-Edge ransomware attack. It introduces solutions like Quantum Key Distribution (QKD) and Post-Quantum Cryptography (PQC) for enhanced security. The idea of introducing quantum cryptography aims to analyze the performance for the operational feasibility of the proposed solution. Combining quantum computing and classical algorithms can boost fraud detection performance and processing speed in financial transactions. Hence, the proposed scheme considers implementing a hybrid technique and QKD for secure online banking in a quantum cryptography environment.

Online Banking Security Threats:

- **Data breaches**: Unauthorized access to sensitive financial data.
- **Man-in-the-Middle attacks**: Interception of communication between users and banks.
- **Credential theft (phishing)**: Obtaining user credentials through social engineering.
- **Ransomware**: Encrypting financial data and demanding payment for decryption.

Classical cryptographic methods, including RSA and ECC, rely on mathematical problems that are difficult for conventional computers but solvable by quantum computers using

algorithms like Shor's Algorithm. With advancements in quantum computing, current encryption methods risk being compromised, necessitating the transition to quantum-safe security measures

Types of Quantum Computing for Bank Security

- **Quantum Key Distribution (QKD)**: Secure communication based on quantum mechanics for encryption key distribution.
- **Post-Quantum Cryptography (PQC)**: Quantum-resistant algorithms for long-term security.
- **AES-256**: A stronger symmetric encryption method that remains quantum-resistant.
- **Quantum Random Number Generation (QRNG)**: Uses quantum mechanics to generate truly random numbers, making cryptographic keys more secure.

Table 1 Comparison of Classical vs. Quantum Security in Banking

Parameters	**Classical Algorithms**	**Quantum Security**
Key Distribution	RSA, ECC (vulnerable to QC)	QKD (Quantum-secured)
Encryption Strength	AES-128, RSA-2048	AES-256, Post-Quantum Cryptography
Random Number Generation	Pseudo-Random Generators	Quantum Random Number Generation

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Synthesis and Characterization of Zinc oxide dope with Titanium dioxide by Autocombustion methods

D.B. Gadge[1*]& V.B. Sherkar[2]

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Abstract:

Fabrication of nanomaterials with strict control over size, shape, and crystalline structure has become very important for the applications of nanotechnology in numerous fields including catalysis, medicine, and electronics. To remove dye-induced, unsafe water pollution, pure Zinc oxide (ZnO) and ZnO-doped Titanium dioxide (TiO2) nanocomposites were synthesized using the sol-gel approach. A variety of investigation methods were employed to analyze the prepared ZnO-doped TiO2 nanocomposites, including X-ray diffraction (XRD), Scanning Electron Microscope (SEM), Ultraviolet (UV) & Fourier Transform InfraRed (FTIR) [1].

By using the sol-gel method pure ZnO and ZnO-doped TiO2 nanocomposites were produced. To determine the composition of Zn, O, and Ti atoms in the samples, a multidimensional X-ray analysis was performed. There is an energy gap between 3.61 eV, as determined by UV-vis spectroscopy. The hexagonal wurtzite phase in ZnO products was discovered by powder X-ray diffraction (XRD). In an XRD analysis of ZnO-doped TiO2 nanocomposites with a crystalline size of 8.92 nm, they were found to be spherical in shape. It was possible to effectively remove colours from aqueous solutions using ZnO/TiO2 nanocomposites. In this study, pure ZnO and ZnO-doped TiO2 nanocomposites were used to study the degradation of MB under visible light irradiation. Over an irradiation course of 6 h, a ZnO-doped TiO2 composite (84%) were studied. When ~pH was increased in methylene blue (MB) solutions, the photocatalytic degradation rate increased. It was found that when ZnO-doped TiO2 nanocomposites were photocatalyzed, they were able to degrade MB dye by 84%. The inhibition of MB dye evaporation by pure ZnO and doped TiO2 nanocomposites indicates that the synthesized candidate is suitable for degradation devices. According to BET surface area measurements, pure ZnO and doped TiO2 nanocomposites have a specific surface area

of 69 m2/g, while ZnO-doped TiO2 nanocomposites have a specific surface area of 46 m2/g. Antibiotic-resistant pure ZnO NPs doped with TiO2 were demonstrated to be effective against Gram-negative and Gram-positive bacteria. According to specific antimicrobial studies, microorganisms exposed to antimicrobial activity of ZnO with TiO2 nanocomposites showed cell inactivation at the levels of signalling and regulatory networks [1, 2].

As determined by the kinetic analysis, nanocomposites made from pure ZnO and ZnO-doped TiO2 followed pseudo-first-order kinetics. In the presence of ZnO-doped TiO2 nanocomposites, antibacterial activity was significantly improved.

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Synthesis and Characterization of $CuCo_2O_4$ filmfor Supercapacitor application

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Abstract:

We report the synthesis of Copper Cobaltite ($CuCo_2O_4$) films using Solvothermal Method with different molarities. The effect of change in molarities in Solvothermal methods, structural, morphological, optical, and photoelectrochemical properties was studied using x-ray diffraction (XRD), Scanning electron microscopy (SEM) Raman spectroscopy, UV-Visible spectroscopy, x-ray photoelectron spectroscopy, photoelectrochemical activity. The XRD data confirm the spinel cubic crystal structure of $CuCo_2O_4$ with an average crystallite size. Our SEM analysis shows that the surface morphology of well grown, porous $CuCo_2O_4$ nanoflowers. Cyclic voltammetry (CV) was used to evaluate the photoelectrochemical activity of $CuCo_2O_4$ thin films. The film demonstrated the highest photocurrent density, Energy density, which indicates superior photoelectrochemical activity. The $CuCo_2O_4$ film grown demonstrated a majority charge carrier density. Overall, these properties suggest that $CuCo_2O_4$ has the potential to serve as a suitable material which can act as electrode in supercapacitor.

Multi Walled Carbon Nanotube-Zinc Oxide Composite: An investigation into Enhancing Energy Storage and Antimicrobial performance.

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Abstract:

The present work introduces an innovative synthesis of ZnO nanoparticles embedded on functionalized MWCNTs, potentially advancing nanocomposite fabrication. The chemical reduction method for depositing ZnO on CNTs is both cost-effective and scalable, providing an efficient route for nanomaterial fabrication. By optimizing the deposition process, this study aims to control the dispersion of ZnO on CNTs, ensuring uniform coverage and enhanced functionality. The project will investigate the physicochemical interactions between ZnO and CNTs, evaluating the material's Electrochemical properties and antimicrobial activity. The antimicrobial properties of ZnO composited with MWCNTs towards both gram-positive and gram-negative bacteria species were studied.

Powder X-ray diffraction patterns will be analyzed to verify the crystalline nature of ZnO nanoparticals and their decoration on the MWCNT surface to form a nano-composite. Raman spectroscopy will be employed to study the expected changes in D and G band intensities due to ZnO nanorod decoration.

Scanning Electron Microscopy (SEM) will be employed to examine the surface morphology, size distribution, and spatial arrangement of ZnO nanoparticals on the MWCNT scaffold, offering a three-dimensional perspective of the nanocomposite structure.

Fourier Transform Infrared Spectroscopy (FTIR) will be performed to identify the functional groups present in the nanocomposite, particularly those associated with the MWCNT functionalization and the ZnO-MWCNT interface. This technique will help elucidate the nature of the chemical interactions between the ZnO nanopaticals and the MWCNT surface.

The effect of raw MWCNTs and MWCNTs composited with ZnO on the cell morphology and chemical composition of Staphylococcus aureus (*S. aureus*), Bacillus Subtilis and Escherichia coli (*E. coli*) will be studied.

The bacterial culture plates will be observed under a magnificent lens to see the zones of inhibition. The diameter of the zone of inhibition was determined around the material and recorded in mm for *E. coli*, *S. aureus* and Bacillus Subtilis.

The investigation will explore the electrochemical properties through cyclic voltammetry to evaluate the Electric double layer capacitor (EDLC) behavior of ZnO/MWCNT. The study will measure specific capacitance, targeting values around 189 Fg^{-1}. Quick charge-discharge performance will be assessed, with an expected capacitance of approximately 95 Fg^{-1}. Additionally, the research will evaluate the power density of the ZnO/MWCNT nano-composites, with an anticipated target of 2250 W kg^{-1}

Keywords: *Multiwalled CNT, Functionalization,Cyclic Voltammetry, Antimicrobial*

Dielectric, ferroelectric, and piezoelectric properties of Ca^{2+}, Zr^{4+}, and Sn^{4+} modified $BaTiO_3$ electroceramics for piezoelectric application

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Abstract:

Lead-free piezoelectric materials (1-x) $Ba_{0.91}Ca_{0.09}Sn_{0.084}Ti_{0.916}O_3$ (BCST) – (x) $Ba_{0.894}Ca_{0.106}Zr_{0.0705}Ti_{0.9295}O_3$ (BCZT) (x in mol% =0.00, 0.05, 0.10, 0.15, 0.20, 0.25) were synthesized by the conventional solid-state reaction method. The structural, dielectric, ferroelectric, and piezoelectric properties of (1-x) (BCST) – (x)(BCZT) ceramics were studied. The formation of perovskite structure for all ceramics without the presence of any impurity phases is confirmed by X-ray diffraction (XRD) analyses, which also reveals that the Ca^{2+}, Zr^{4+}, and Sn^{4+} are well diffused within the $BaTiO_3$ lattice. The surface morphology of all synthesized ceramics was studied using Scanning electron microscopy (SEM). For (1-x) BCST – (x-y) BCZT ceramics, significantly improved dielectric and ferroelectric properties were observed, including relatively high dielectric constant $\epsilon_r \approx >$ 8800 (at Curie temperature), dielectric loss tan$\delta \approx$ 0.01–0.02. The polarisation versus electric field (*PE*) hysteresis loop confirmed that all ceramics have a ferroelectric nature. The slim hysteresis loop of ceramics exhibits low energy loss as compared to $BaTiO_3$ ceramic. The $BaTiO_3$ ceramics have a piezoelectric charge coefficient (d_{33}) is 190 pC/N where the (1-x) BCST – (x-y) BCZT ceramics exhibits the improvement in the d_{33} (> 200 pC/N). The strain versus electric field (*SE*) measurements were carried out for all ceramics, which reveal the incorporation of the

Ca^{2+}, Zr^{4+}, and Sn^{4+} in $BaTiO_3$ is significantly beneficial to enhance their strain properties. Hence, the excellent comprehensive piezoelectric properties of (1-x) BCST – (x-y) BCZT ceramics have tremendous potential for piezoelectric device applications.

Keywords: *Lead-free, $BaTiO_3$, dielectric, ferroelectric, Piezoelectric*

Nanotechnology-Enabled Delivery Of Curcumin For Precision Medicine

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Abasaheb Garware College, Pune

Abstract:

Curcumin, a bioactive polyphenol extracted from turmeric, exhibits potent anti-inflammatory, antioxidant, and anticancer properties. However, its poor aqueous solubility, rapid metabolism, and limited bioavailability hinder its clinical applications. To overcome these challenges, developing and characterizing curcumin-loaded nanoparticles using a novel combination of curcumin nanoparticles & Stearic Acid Lipid Nanoparticles (SLNPs) can prove beneficial. The potential of curcumin nanoparticles as a novel therapeutic strategy for targeted disease management, including cancer, arthritis, and neurodegenerative disorders can be studied. The enhanced bioavailability, stability, and efficacy of curcumin nanoparticles pave the way for clinical translation and exploration of curcumin's therapeutic potential.

KEYWORDS:

Curcumin Nanoparticles, Anticancer, Anti-inflammatory, Targeted Therapy, Nano-medicine.

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Impact of Counter Electrodes on the Performance of Semiconductor-Sensitized Solar Cells

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Abstract:

Quantum dot-sensitized Solar Cells (QDSSC) have several advantages like constant power output, tunable energy band gap, high absorption coefficient, and generation of multiple electron-hole pairs with high energy excitons. The present work demonstrates that various factors affect the performance of CdS QDs sensitized TiO_2 photoanode for solar cell application. Here we studied the impact of Carbon (C), Copper Sulphide (CuS), Copper tin sulphide (CTS), and Silver Sulphide (Ag_2S) counter electrodes on the performance of CdS/ TiO_2 solar cells.

In this work, the pre-coated TiO_2 compact layer is important for avoiding back contact, which was deposited by simple chemical bath deposition, using $TiCl_3$, 0.1 M NaOH, solution in distilled water. Here TiO_2, film was deposited by the Doctor Blade method on a Fluorine doped Tin Oxide substrate. The prepared films were annealed at 450 °C for one hour and sensitized with CdS quantum dots by the Successive Ionic Layer Adsorption Reaction method. An optical, structural, and morphological property of the CdS/ TiO_2 photoanode has been studied. I-V characteristics of the sandwiched solar cell are measured with various counter electrodes (CuS, C, CTS and Ag_2S). Optical, structural, and morphological properties of the CdS/ TiO_2 photoanode have been studied by using UV. Vis. Spectroscopy, X-ray diffraction, and Scanning Electron Microscopy respectively. Here we found that SILAR deposited CTS Counter is the best choice for CdS/ TiO_2 based Solar Cell, here we get 1.43% photo conversion Efficiency, for the correlation of JV performance of Sandwiched Solar Cell EIS measurements was done.

Keywords: CdS/ TiO_2, Counter Electrode, SILAR, Quantum Dots, Ag_2S, CTS, CuS, C

Investigating Photoluminescence and Thermoluminescence of Lanthanide Activated $BaMgAl_{10}O_{17}$Phosphor

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Abstract:

Lanthanide-activated phosphors hold great promise for radiation dosimetry due to their superior luminescent properties. This study explores the photoluminescence (PL) and thermoluminescence (TL) characteristics of the novel phosphor $BaMgAl_{10}O_{17}$:Eu. While both solid-state and solution combustion methods were attempted for synthesis, the latter, using urea as fuel and a 550°C combustion temperature, proved successful. The resulting nanophosphor was subsequently annealed at 900°C for 2 hours. X-ray diffraction (XRD) confirmed the formation of the pure crystalline $BaMgAl_{10}O_{17}$:Eu phase (JCPDS 75-0658), with a crystallite size of 23.81 nm calculated using the Debye-Scherrer formula. Scanning electron microscopy (SEM) revealed an irregular morphology. The band gap was determined using UV-Vis spectroscopy. PL emission was observed in the red region of the visible spectrum. A TL glow curve was obtained with a peak at 166°C. Further study of TL analysis of the annealed samples at various temperatures is planned. These initial results highlight the potential of the solution combustion method for synthesizing $BaMgAl_{10}O_{17}$:Eu and provide a foundation for future research and optimization of its dosimetric properties.

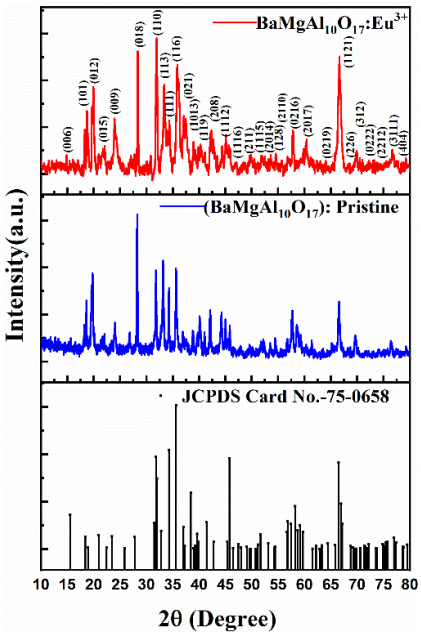

Fig. 1: XRD Pattern of $BaMgAl_{10}O_{17}$Phosphor

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Analysis of Electrochemical performance and Antimicrobial Activity of Ag-MWCNT Composite

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Keywords - *CNT's, Electrochemical, Cyclic voltammetry, Antimicrobial efficiency, Microbial Inhibition.*

Abstract:

Silver nanoparticles (AgNPs) exhibit exceptional thermal conductivity and antibacterial properties, making them ideal candidates for integration into carbon nanotube (CNT)-based materials. The present work focuses on the synthesis and characterization of silver nanoparticles onto multi-walled carbon nanotubes (MWCNTs) using a chemical reduction method to enhance the thermal and antibacterial performance of the resulting nanocomposites. Carbon nanotubes are well-known for their excellent mechanical strength, electrical conductivity, and high aspect ratio, while silver nanoparticles are recognized for their ability to kill a wide range of bacterial pathogens.

The combination of these materials could yield a multifunctional nanocomposite with potential applications in electrochemical properties for super capacitor and antimicrobial properties for application in filtration systems, and biomedical devices. The chemical reduction method for depositing AgNPs on CNTs is both cost-effective and scalable, providing an efficient route for nanomaterial fabrication. By optimizing the deposition process, we aim to control the dispersion and size of AgNPs on CNTs, ensuring uniform coverage and enhanced functionality. The project will investigate the physicochemical interactions between AgNPs and CNTs, evaluating the material's electrochemical properties and antibacterial efficiency. The composite will be characterized by using techniques such as scanning electron microscopy (SEM), RAMAN spectroscopy, Fourier transformation infrared (FTIR) spectroscopy, X-ray diffraction to confirm the morphology, distribution and crystal structure of the nanoparticles and the effective inhibition of bacterial growth, making these composites viable for thermal regulation in medical, industrial, and environmental settings. The investigation will explore the electrochemical properties through cyclic voltammetry to

evaluate the Electric double layer capacitor (EDLC) behavior of Ag/MWCNT composite and antimicrobial activity by Minimal Inhibitory Concentration (MIC).

Synthesis and Characterization of nickel oxide and Gd doped Ceria nanocomposite as Active Anode Material for Solid Oxide Fuel Cell (SOFC).

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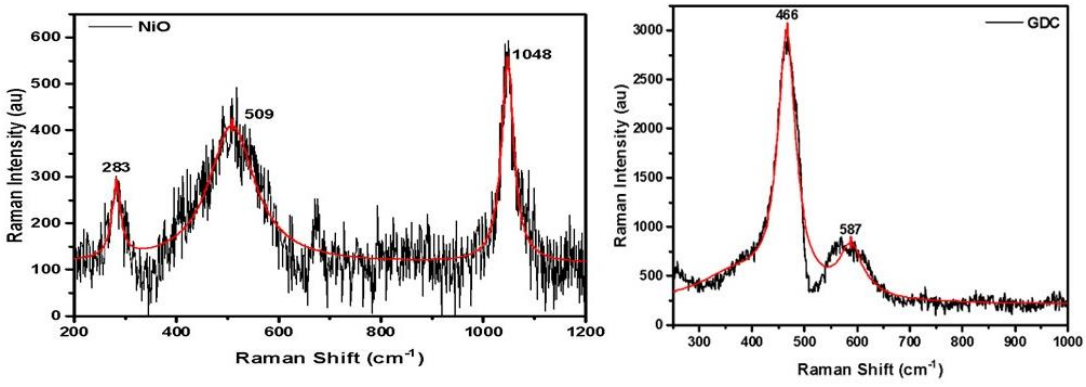
Abstract:

Solid oxide fuel cells (SOFC) are now being seriously considered for alternate energy source because of the environmental hazards associated with the use of fossil fuels and their limited availability. We have synthesis Nickel Oxide (NiO) and Gd doped Ceria (GDC) by ball mailing method and characterized by different characterization techniques like XRD, Raman, FESEM, HRTEM. In this paper, we present the study of NiO-stabilized GDC as an anode material in SOFC . The role of NiO in stabilizing GDC and the possible reasons for the increase in catalytic activity of the relevant composition have been discussed using the experimental data. The NiO-GDC synthesis, where a considerable improvement in activation energy is observed at the low-temperature region. Such low activation energies were later associated with the adsorption/desorption process of water molecules at the surface of NiO-GDC composite, indicating a high activity towards hydrogen oxidation.



Keywords: - Solid Oxide Fuel Cell (SOFC), Anode Material, Nickel Oxide (NiO), Gadolinium-Doped Ceria (GDC), Nanocomposite.

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2D Mxene and their Structural Modification in View of Supercapacitor Application.

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Abstract:

A decade after the first report, the family of two-dimensional (2D) carbides and nitrides (MXenes) includes structures with three, five, seven, or nine layers of atoms in an ordered or solid solution form. Dozens of MXene compositions have been produced, resulting in MXenes with mixed surface terminations. $Ti_3C_2T_x$ is one of the typical MXene materials, where T_x stands for various surface terminations (OH, O, and/or F groups). In this paper, our focus is specifically on the bare & delaminated $Ti_3C_2T_x$ MXene referred to as b-$Ti_3C_2T_x$ & d-$Ti_3C_2T_x$. The synthesis of $Ti_3C_2T_x$ MXene has been done by etching of Ti_3AlC_2 Max phase. Although bare $Ti_3C_2T_x$ shows high capacity, low diffusion barrier, and good electronic conductivity, we have synthesised d-$Ti_3C_2T_x$ / MnO_2 will be first composite and b-$Ti_3C_2T_x$ / MnO_2 will be the second composite to get high specific capacitance and good cycle stability.

MnO_2 composites were prepared by a simple hydrothermal synthesis method. At the same time, the d-$Ti_3C_2T_x$ the substrate can provide a carrier for the growth and uniform dispersion of MnO_2. The complementary working potential windows of MXene and MnO_2, along with proton-induced pseudocapacitance, significantly enhance the device performance. We have done the morphological, optical & compositional study of the pristine d-$Ti_3C_2T_x$ MXene, d-$Ti_3C_2T_x$ and MnO_2 as well as d-$Ti_3C_2T_x$ /MnO_2 composite using FESEM, UV-Visible, XRD. The electrochemical study has been done of the pristine materials including CV, GCD, EIS & Stability which show investigate the reduction and oxidation processes of molecular species, to evaluate the electrochemical performance of energy storage devices, to study the chemical and physical processes in electrochemical systems, shoe the stability of material in electrolyte. These results show that pseudocapacitive negative MXene electrodes can potentially replace carbon-based materials in asymmetric electrochemical capacitors, leading to an increased energy density.

Keywords: MXene, MAX phase, Bare MXene, Delaminated MXene, Crumpled MXene, Supercapacitor, MnO_2

Acoustic Analog of Black Holes

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Abstract:

Black hole analogs have emerged as a significant tool for studying the properties of black holes in a controlled laboratory environment. Among these, acoustic analogs are particularly intriguing, as they replicate black hole-like phenomena using fluid dynamics and sound waves. These models utilize the principles of fluid flow through a constriction, such as a Venturi tube, to mimic event horizon-like behavior where sound waves are unable to propagate upstream due to high fluid velocity.

Our work focuses on constructing an acoustic analog of black holes using a Venturi tube as the primary apparatus. Airflow is generated using a controlled fan, and sound waves are introduced via a speaker. Microphones placed upstream and downstream of the Venturi tube capture the behavior of sound waves as they interact with the accelerating airflow. This setup allows us to study phenomena analogous to event horizons, such as the acoustic Doppler effect and changes in wave behavior at high flow speeds.

The use of such analog models provides a cost-effective and accessible way to simulate black hole physics. By varying airflow speeds, constriction geometry, and sound frequencies, we aim to explore a range of black hole-like phenomena. The findings from this study can contribute to understanding the dynamics of event horizons and the propagation of waves in extreme conditions, offering a unique perspective on black hole physics in the laboratory.

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Viscoelastic and Acoustic Properties of Iodine Doped PVA Solutions

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Abstract:

This study investigates the viscoelastic and acoustic properties of pristine and iodine-doped Polyvinyl Alcohol (PVA) solutions using various experimental techniques. Density measurements were conducted using a density bottle, while viscosity was determined via isometric analysis. The refractive index was measured using an Abbe refractometer, and ultrasonic velocity was determined using an ultrasonic interferometer to evaluate acoustic properties. From these values, parameters such as adiabatic compressibility, acoustic impedance, intermolecular free length, relative association, and relaxation time were derived to understand molecular interactions. The results indicate that increasing iodine concentration in PVA solutions leads to a rise in viscosity and density, affecting molecular packing and interactions. Additionally, changes in ultrasonic velocity suggest alterations in the medium's elasticity, indicating stronger molecular associations with higher iodine content. These findings highlight the potential of iodine-doped PVA in applications requiring tunable viscoelastic and acoustic properties, such as biomedical materials and industrial coatings.

Solution	**Ultrasonic Velocity (m/s)**	**Density (kg/m³)**	**Adiabatic Compressibility ($\times10^{-10}$ m²/N)**	**Acoustic Impedance ($\times10^{5}$ Pa.s/m³)**	**Intermolecular Free Length (Å)**	**Relative Association**
Water	1493	983.2	4.562	14.67	0.2205	1

3 g/100 ml PVA	1510	988.4	4.437	14.92	0.2174	1.0015
Iodine Solution 0.1 N	1498	1024.8	4.348	15.35	0.2152	1.0411
3g/100ml PVA + 1 ml iodine	1510	989.2	4.433	14.93	0.2173	1.0023
3 g/100 ml PVA + 2.5 ml iodine	1514	989.6	4.408	14.98	0.2167	1.0018
3 g/100 ml PVA + 5 ml iodine	1516	991.2	4.389	15.02	0.2163	1.0030

Table 1: Results

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Quantum to Classical: Exploring the Dynamics of Decoherence

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Abstract:

Quantum systems, characterized by the fundamental principles of quantum mechanics, offer a rich domain for exploration, this is especially relevant in the fields of quantum computing, quantum information processing, and basic physics. The study of open quantum systems i.e. systems that interact with their environment has gained significant attention due to its relevance in understanding quantum coherence, decoherence, and dissipation. In particular, the two-level quantum system is a foundational model for investigating quantum dynamics, allowing for a clear understanding of transitions between discrete energy states. Such transitions are crucial for studying quantum operations, quantum measurement, and quantum error correction. This study examines a two-level open quantum system that interacts with an external environment, specifically a reservoir of photons, by employing the provided Lindblad master equation. This framework captures both the coherent evolution of the system and its dissipative interactions with the surroundings, such as decoherence and dissipation. Numerical analysis is used to investigate the system's time evolution under different environmental conditions, including single-mode and double-mode frequencies of the photon reservoir. The expected outcome is to gain insight into how dissipation affects the system's coherence, population dynamics, and transition from pure to mixed states. This study seeks to enhance understanding of quantum decoherence and energy relaxation, with possible applications in quantum computing, communication, and other emerging technologies.

Keywords: open quantum systems, coherence, decoherence, quantum transition, two-level system, environmental interactions, Lindblad equation, photon reservoir.

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Optimum loading of surfactant for the effective spreading of pesticides

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Abstract:

Dispersion of pesticides, insecticides, etc. in aqueous medium may not stick to the plant leaves due to the water repellent or superhydrophobic property of plant leaves. This property of plant leaves arises due to the presence of microcrystalline epicuticular wax on the leaves surface. Addition of the surfactant to aqueous medium enhances adhesion as well as wetting properties of pesticides on plant leaves by lowering the surface tension of water. However, above the certain level of concentration i.e. critical micelle concentration (CMC), surfactant starts to aggregate in a bulk phase called micelle preventing the further reduction of liquid's surface tension. Thus, optimum loading of commercially used surfactants is crucial in order to prevents the overuse of pesticides which also leads to the contamination of soil as well as ground water.

In this study we characterize commercially used anionic surfactants Sodium dodecyl sulfate (SDS) and Aerosol OT (AOT), for their CMC value and evaluated their wetting property on the lotus leaves. Results show that CMC for SDS and AOT is 10 mM and 2.7 mM respectively. Anionic surfactant forms spherical shaped micelles above CMC that leads to saturation of surfactant molecule on the liquid surface. These micelles cause constant surface tension even in addition of more surfactant to the liquid. The minimum constant surface tension at above mentioned CMC is found to be 43mN/m for SDS and 31.45 mN/m for AOT which are in good agreement with the reported data. Aqueous SDS and AOT solution at CMC concentration shows the optimum wetting with excellent drop retention characteristics upon droplet impact to Webber number $W_b \sim 100$.

Keywords: surfactant, Critical Micelle Concentration (CMC), Sodium dodecyl sulphate (SDS)

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Unique Ferroelectric HfO_2: Synthesis and Structural Characterization

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Abstract:

Hafnium dioxide (HfO_2) nanoparticles have emerged as promising materials for energy harvesting applications due to their excellent dielectric properties, high thermal stability, and wide bandgap.[1–6]At the nanoscale, surface energy effects can stabilize metastable phases, enabling the discovery of new ferroelectrics in abundant, non-toxic, and cost-effective materials. Binary oxides HfO offers a diverse range of polymorphs with unique coordination structures, increasing the likelihood of finding novel ferroelectric properties. Additionally, this material hold promises for magnetoelectric coupling and multiferroic behaviour, with potential breakthroughs in applications.These characteristics make it also suitable for triboelectric nanogenerators (TENGs), which convert mechanical energy into electrical energy for self-powered devices.[7,8] The synthesis and structural characterization of HfO_2 nanoparticles are essential for understanding their role in enhancing the triboelectric performance of TENGs, paving the way for their integration into next-generation energy-harvesting systems.

This study explores the synthesis and structural characterization of HfO_2 nanoparticles and evaluates their potential application in triboelectric nanogenerators (TENGs). The nanoparticles were synthesized using sol-gel, and their structural and morphological properties were analyzed through X-ray diffraction (XRD), scanning electron microscopy (SEM) and, Raman spectroscopy. Hafnium oxide (HfO_2), were synthesized using a sol-gel method. Hafnium tetrachloride ($HfCl_4$) was used as precursors, were mixed in stoichiometric ratios, followed by the addition of citric acid. This led to metal citrate complex formation. The resulting solution was heated and annealed to form the desired compounds. [3]

The results confirm the formation of highly crystalline HfO_2. It is Baddeleyite structured and crystallizes in the monoclinic $P2_1/c$ space group. Hf^{4+} is bonded to seven O^{2-} atoms to form a mixture of distorted corner and edge-sharing HfO_7 pentagonal bipyramids.[4] The SEM confirms the uniform size distribution of about 45nm. EDAX confirms the presence of Hf and O in appropriate proportion. Raman spectra is in coherence with XRD data, confirming the monoclinic phase with Ag and Bg modes, confirmed with reported theoretical calculation.

The future work is planned to investigate the ferroelectricity, magnetism and magnetoelectric coupling for the triboelectric nanogenerator application.[6]

Graphical Abstract:

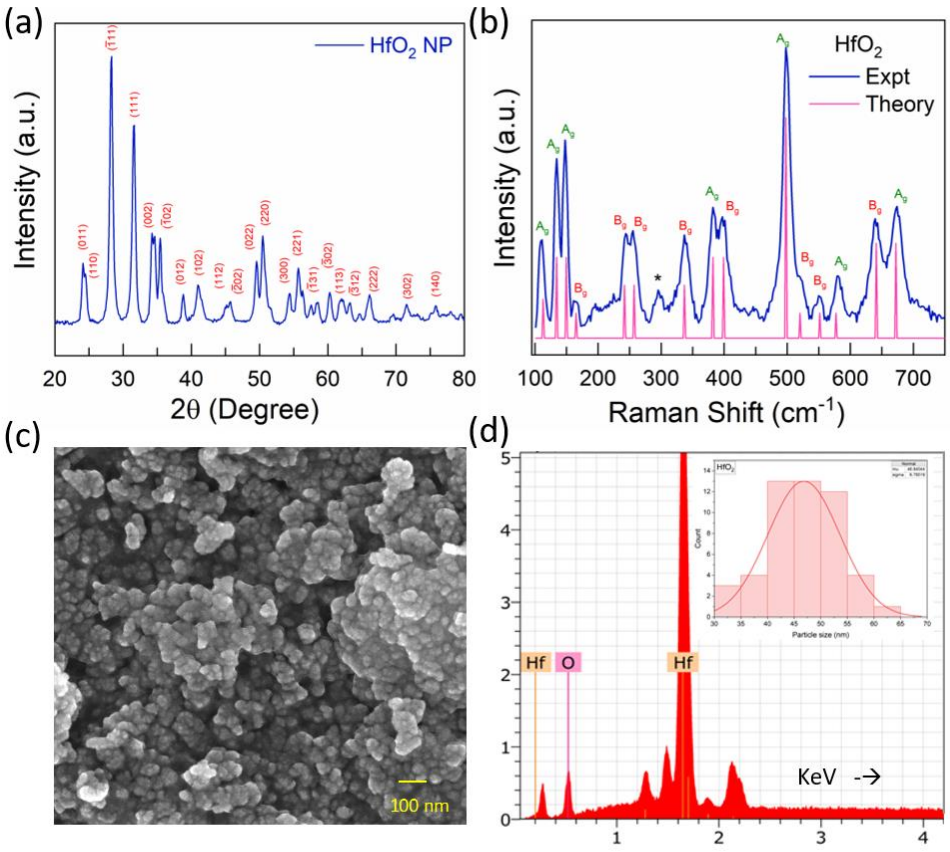

Figure 3 (a) XRD data confirm Monoclinic structure of (HfO with space group ($P2_1/c$), (b)Raman spectroscopy confirms the vibrational and rotational modes related to monoclinic structure in the (HfO_2), (c) FESEM images show spherical particle morphology with dominant size of ~ 48 nm) and, (d) EDAX confirms the

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Structural Synthesis of Mxene for Water Splitting Application

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Abstract:

MXenes, particularly $Ti_3C_2T_x$, have attracted significant attention due to their exceptional electrochemical properties, making them promising candidates for catalytic applications such as the hydrogen evolution reaction (HER) in water splitting.

This study investigates the structural changes and modifications of $Ti_3C_2T_x$ MXenes under various conditions to optimize their performance in water splitting. By analyzing the impact of surface terminations, layer exfoliation, and defect engineering on catalytic activity, we aim to understand how these changes enhance electron transfer kinetics, improve active sites, and reduce the overpotential required for hydrogen production.

The findings contribute to the development of cost-effective, efficient electrocatalysts for sustainable hydrogen production.

Synchrotron X-ray assisted Pd/MoS_2 nanostructure incorporated into PDMS for triboelectric nanogenerator fabrication

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Abstract:

In the new era defined by the growth of the Internet of Things and artificial intelligence, energy consumption patterns and structures are changing. The widespread use of non-renewable energy sources has led to environmental harm, encouraging researchers to look for alternative ways to harvest energy from the environment. This modification has led to advancements in developing nanogenerators, which offer promising sustainable energy source. Herein a one-step in-situ synthesis and simultaneous embedding of Pd nanoparticles on MoS_2 nanosheets using synchrotron x-ray irradiation method is reported. Further, high performance triboelectric nanogenerator (TENG) was fabricated using Pd embedded MoS_2 nanosheets within PDMS matrix. The electrical output performance of the fabricated TENG device was enhanced when compared with that of PDMS and MoS_2/PDMS TENGs. The synthesized Pd/MoS_2 nanostructures are notably significant due to increased contact surface area and charge distribution density, leading to high charge transfer rates, improved charge transport, and a higher density of charge trapping centres within the insulating matrix. An average peak to peak output voltage of 100 V and dc current of 4 μA at 5 Hz frequency were achieved. A peak power density of 2.76 W/m^2 was resulted during the contact separation process. Moreover, the practical applicability of the fabricated TENG was demonstrated by powering 104 LEDs by finger tapping.

Keywords: Triboelectric Nanogenerator, PDMS, Pd nanoparticles, MoS_2 nanosheets, synchrotron X-ray irradiation, energy harvesting, etc.

Carbon Dots Conjugated System as a Ratiometric Sensor for Detection of Mercury and Lead

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Abstract:

Heavy metal ions pose significant threats to both human health and the environment due to their toxicity, persistence and bio accumulative nature. Their detrimental effect highlights the urgent need for effective detection of these metal ions. This study presents a novel ratiometric sensor based on yellow emissive carbon dots conjugated with the blue emissive 2-amino terephthalic acid. The covalent conjugation between the -COOH group of carbon dots and -NH_2 of 2-amino terephthalic acid is achieved through carbodiimide bond formation via EDC-NHS reaction. The surface-functionalized carbon dots exhibited unique fluorescence properties and were evaluated for the selective detection of heavy metal ions, including lead (Pb^{2+}) and mercury (Hg^{2+}). The sensor demonstrated ratiometric sensing for Pb^{2+} and Hg^{2+}, with inverse fluorescence trends at 442 nm and 563 nm as metal concentrations varied. This approach offers a promising avenue for the development of sensitive and selective probes for environmental heavy metal monitoring.

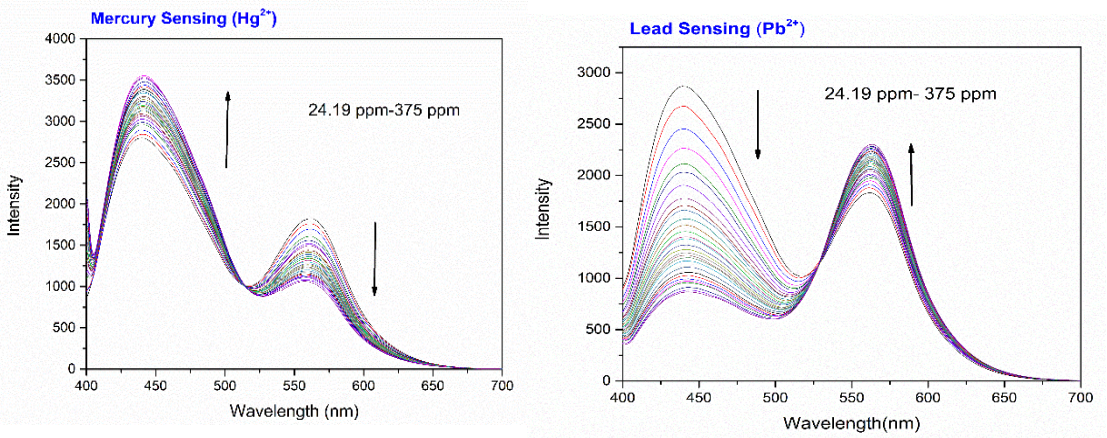

Fig- Ratiometric sensing of Mercury and Lead

Reference(s):

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Exploring Chaos: The Dynamics of Chua's Circuit

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(Ruchita T Khare[b]*, Email: ruchitaphysics@gmail.com)

Abstract:

Chua's Circuit, introduced by Leon O. Chua in 1983, is a nonlinear electrical circuit that exhibits chaotic behavior. Comprising resistors, capacitors, inductors, and a nonlinear element, it serves as a simple model for studying chaotic systems. The circuit's dynamics are governed by differential equations, and its behavior can range from periodic to chaotic depending on the parameters. The circuit serves as a useful model for studying chaos theory due to its simplicity and the richness of its dynamic behaviors.Chua's Circuit is widely used in chaos theory, nonlinear dynamics, and applications like secure communications and random number generation, offering insights into the complexity of deterministic chaos. Through numerical simulations and experimental implementations, Chua's Circuit continues to be an important tool for understanding complex systems and chaos theory, and it provides insights into the behavior of nonlinear oscillators and circuits.

Keywords: Chaos, Chua's circuit

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1 **I. Gomes, W. Korneta, S. G. Stavrinides, R. Picos, and L. O. Chua**, "Experimental observation of chaotic hysteresis in Chua's circuit driven by slow voltage forcing," *Chaos, Solitons & Fractals*, vol. 166, p. 112927, 2023.

2 **G. Sivaganesh, K. Srinivasan, T. Fonzin Fozin, and R. Gladwin Pradeep**, "Emergence of chaotic hysteresis in a second-order non-autonomous chaotic circuit," *arXiv preprint arXiv:2303.03158*, 2023.

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Synthesis and Characterization of TiO_2 Nanoparticles

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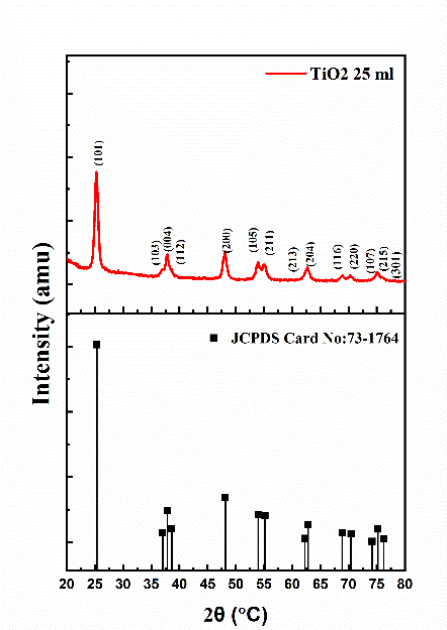
Abstract:

Titanium dioxide (TiO_2) nanoparticles have shown assurances for photocatalytic water treatment. We synthesized water dispersible (WD) TiO_2 Nanoparticles by hydrolysis method. In this process, titanium precursors are mixed with water and suitable solvent then giving heating treatment. The XRD and UV-Visible Spectroscopy results showed that product consisted of anatase phase of WD-TiO_2 having the band gap of approximately 3.2 eV as shown in fig.2. SEM technique is used to analyze the morphology and size of nanoparticles. To analyze vibrational modes raman spectroscopy was performed. The result shows formation of well dispersed WD-TiO_2 NPs with controlled size and morphology. Photocatalysis studies of methylene blue and rhodamine-B dyes are performed. As research in this field continues to advance, we can expect to see even more exciting application of WD-TiO_2 NPs in the near future.



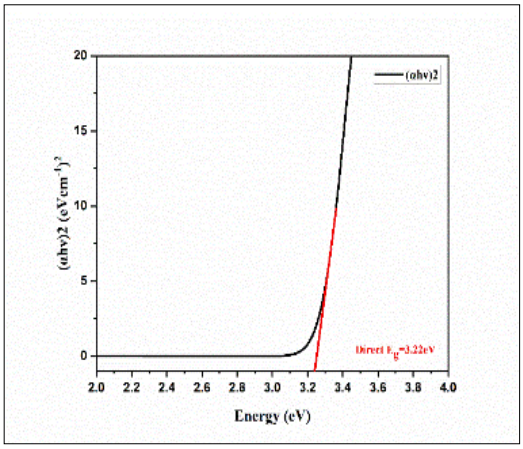


Fig.1 XRD Plot of TiO2 nanoparticles

Fig.2 UV-Visible Spectroscopy TiO_2 nanoparticles

Reference(s):

1. Padhye, P., Sadhu, S., Malik, M., Poddar, P., 2016. A broad spectrum photon responsive, paramagnetic β-$NaGdF_4$:Yb^{3+} ,Er^{3+} – mesoporous anatase titania nanocomposite. RSC Adv. 6, 53504–53518. https://doi.org/10.1039/C6RA06813H

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3. Sugapriya, S., Sriram, R., Lakshmi, S., 2013. Effect of annealing on TiO2 nanoparticles. Optik 124, 4971–4975. https://doi.org/10.1016/j.ijleo.2013.03.040

Effect of Frequency on Electrowetting Assisted Droplet Based Mixing

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Abstract:

In Electrowetting the contact angle of a conductive liquid is changed after applying an external electrical voltage. When an electric potential is applied between a liquid droplet and a solid electrode, the electric charges are redistributed at the liquid-dielectric interface modifying the surface energy of the liquid on the dielectric surface. This decreases the contact angle (θ) of the liquid. The contact angle returns to its original value after the removal of electric potential. Thus, the contact angle can be actively controlled using external voltage. The contact change in electrowetting is given by Young-Lippman Eq. (1) [1]

$$cos\theta(U) = cos\theta_Y + \frac{CU^2/_2}{\gamma_{LV}} \quad (1)$$

Electrowetting possesses many applications on account of tunable wetting properties. The applications encompass liquid lens, flowing liquids in microfluidic devices, lab on chip devices, droplet-based mixing, energy harvesting, display technology, tensiometer, etc.[2-5]

In the present study PMMA-Teflon AF polymeric bilayer is utilized as a dielectric for electrowetting experimentation. PMMA solution was prepared in n-Butyl acetate (7 wt %) and Teflon AF solution in Fluorinert FC 40 (1 wt %). PMMA was deposited on FTO glass by dip coating technique with a retracting speed of 7 cm/min. The film was then heat treated at 100 ^{O}C for 2 hrs. in vacuum oven. The film was then utilized for Teflon AF

coating by spin coating technique with a speed of 2000 rpm. The film was then cured at 100 ^{O}C for 2 hrs. in vacuum oven. The film was subjected for electrowetting study (for AC and DC voltages). The observed electrowetting response was hysteresis free showing good quality films. The electrowetting response was stable for many applied voltage cycles depicting the robustness of the sample. The film was then utilized to demonstrate electrowetting induced droplet-based mixing. For this study water: glycerol (70:30 %) with Fluorescein sodium salt was used. The applied AC frequency was varied from 5-40 Hz. We observed that the mixing time changes as the frequency changes. The least time for complete mixing was observed for the applied frequency of 20 Hz and voltage 115V. Fig. 1. Shows the mixing of droplet

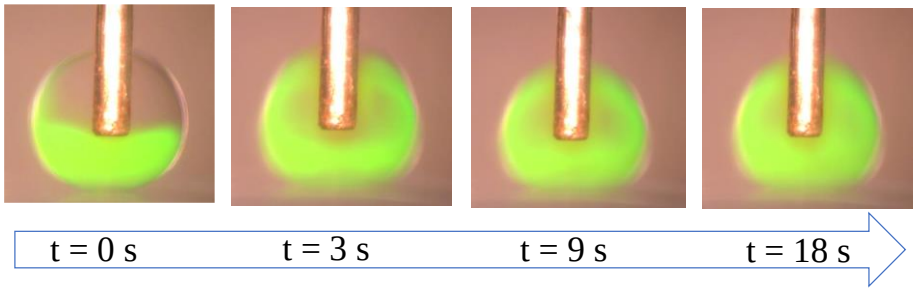

Fig. 1: Progress of mixing process for the applied voltage of 115 V and frequency 20 Hz.

When frequency was varied below and above the value of 20 Hz keeping voltage same, increase in mixing time was observed. Thus, PMMA Teflon AF bilayer dielectric is a potential dielectric for electrowetting based applications.

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Measurement of Electric Fields in the Ionosphere Using Space- Based Platforms

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Abstract:

The *Equatorial Electrojet (EEJ)* is a narrow band of eastward-flowing current in the ionosphere at ~105 km attitude, driven by an eastward electric field. The EEJ serves as a diagnostic tool for monitoring ionospheric processes that influence space weather. Observations reveal that plasma embedded in the EEJ can become turbulent at times, leading to density irregularities and affecting radio waves, leading to density irregularities and affecting radio wave propagation.

Ground-based magnetometers, radars, and rockets have provided significant insights into EEJ variability, ionospheric conductivity, and atmospheric tidal motions. The EEJ is an enhancement of the *Sq* current system over the magnetic equator, influenced by tidal winds from mid-latitudes. Plasma instabilities within the EEJ result from complex interactions between gradient-drift and modified two-stream instabilities, causing irregularities in current flow.

One way to study these electric fields is by using space - based platforms such as satellites or sounding rockets equipped with specialized instruments. The *Vector Electric Field (VEF) probes*; designed to extend long booms with sensors that detect the electric potential difference between two points in space. By placing sensors along different directions, the electric field can be measured in multiplied dimensions, providing valuable insights into ionospheric conditions. The VEF probes work by detecting the voltage difference between their sensor tips, which are placed far enough from the spacecraft to avoid interference from its structure. These measurements are then converted into electric field strength, allowing

scientists to study ionospheric dynamics and understand how electric fields interact with the Earth's magnetic field and solar wind.

Such measurements are essential for improving our understanding of space weather and its impact on modern technologies like satellite communication and GPS systems. Continuous advancements in probe technology are helping to gather more accurate data, furthering our knowledge of the ionosphere and its influence on the Earth's atmosphere.

Keywords: Equatorial Electrojet, Electric Field, Ionosphere, Sounding rocket

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Fourier Analysis In Music

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Abstract:

The Fast Fourier Transform (FFT) is a powerful mathematical algorithm used to analyse the frequency components of signals, and it plays a crucial role in the analysis and processing of musical signals in various devices. In musical devices, FFT is used to decompose complex audio signals into their constituent frequencies, enabling real-time analysis and manipulation of sound. This method allows for efficient identification of pitch, timbre, harmony, and other sonic characteristics, making it essential in applications such as digital audio effects, equalization, pitch correction, and sound synthesis. FFT aids in noise reduction, spectral analysis, and the creation of effects such as reverb and distortion. By providing a clearer understanding of the frequency spectrum, FFT enhances the design and performance of musical instruments and audio processing equipment, allowing for higher quality sound production and more precise control over audio content.

Keywords: Fast Fourier Transform (FFT),

References:

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2 G. Smith and R. Brown, "Application of FFT in Music Signal Processing for Timbre Analysis," *IEEE Transactions on Audio, Speech, and Language Processing*, vol. 28, no. 7, 2022.

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Synthesis and Characterization of TiO_2 Nanoparticles

Saniya Sayyad[1,] Prajakta Rayate[1], Dr.H.M.Gholap[1] ,Preeti Kulkarni[2], Sandhya Deshmukh[2], Dr.S.S.Dahiwale[2,*]

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Abstract:

Water dispersible Titanium dioxide nanoparticles (TiO_2) were synthesized via hydrolysis method, involving the mixing of titanium precursor with water and ethanol, followed by heating and annealing. This results in the formation of water dispersible titanium dioxide nanoparticles. Different characterization techniques were used to identify phase, crystallinity and morphology of the material. X-Ray Diffraction (XRD) confirmed the formation of pure rutile phase. Zeta potential analysis provides information about surface properties of TiO2 nanoparticles. The morphological study and average particle size analysis was performed by scanning electron microscopy (SEM). UV-Vis spectroscopy reveled optical properties of the sample. These synthesized nanoparticles exhibit water dispersibility and promising properties which makes them suitable for various applications.

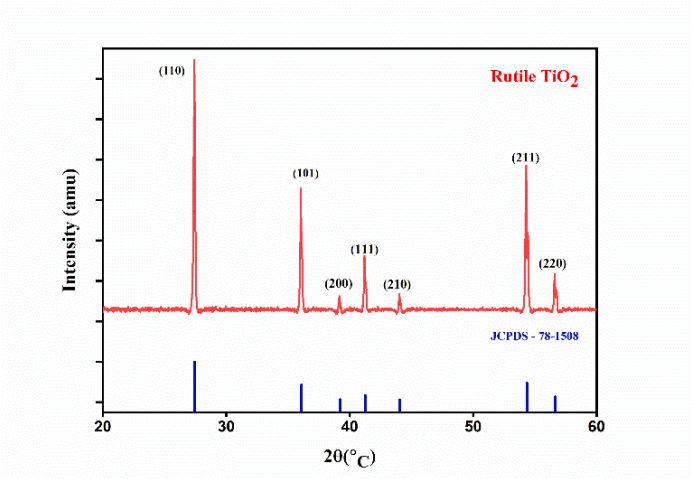

Fig.1 displays the XRD pattern for the TiO_2 nanoparticles

Reference(s):

1. Padhye, P., Sadhu, S., Malik, M., Poddar, P., 2016. A broad spectrum photon responsive, paramagnetic β-$NaGdF_4$:Yb^{3+} ,Er^{3+} – mesoporous anatase titania nanocomposite. RSC Adv. 6, 53504–53518. https://doi.org/10.1039/C6RA06813H
2. Santhi, K., Navaneethan, M., Harish, S., Ponnusamy, S., Muthamizhchelvan, C., 2020. Synthesis and characterization of TiO2 nanorods by hydrothermal method with different pH conditions and their photocatalytic activity. Applied Surface Science 500, 144058. https://doi.org/10.1016/j.apsusc.2019.144058
3. Sugapriya, S., Sriram, R., Lakshmi, S., 2013. Effect of annealing on TiO2 nanoparticles. Optik 124, 4971–4975. https://doi.org/10.1016/j.ijleo.2013.03.040

Development of graph-based ML techniques for optimized particle analysis at LHC

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Abstract:

Machine learning (ML) has a long history of applications in High Energy Physics (HEP) experiments, such as those at the Large Hadron Collider (LHC), which generates vast amounts of complex data. In this presentation, I will briefly introduce the CMS detector at the LHC, describe the nature of its data, and discuss the role of deep learning techniques including deep neural networks (DNNs), convolutional neural networks (CNNs), and graph neural networks (GNNs) in analyzing this data. I will mainly focus on the utility of graph-based ML techniques, particularly GNNs, in developing novel data interpretation methodologies for LHC data. Unlike conventional methods that rely on images or sequential data structures, GNNs offer greater flexibility by effectively handling unordered data as graph structures. The key challenge, then, lies in constructing the appropriate graph representations.

In my poster, I will present GNN-based approaches for two main tasks which address this challenge:

1. Event-level analysis – Representing entire LHC collision events as graphs to classify them into different HEP processes.

2. Object-level analysis – Utilizing graph structures for track-related problems, such as determining whether an event contains a high-transverse-momentum charged particle.

For the event classification task, I will explain how HEP data can be converted into various graph representations, how graph convolution models are applied to these datasets, and how different graph representations compare in performance. For the track-related task, I will demonstrate how tracker hit data can be transformed into graph representations using a toy

detector simulation and how events can be classified based on the presence of high-momentum tracks.

This work highlights the potential of GNNs to enhance data analysis strategies at the LHC.

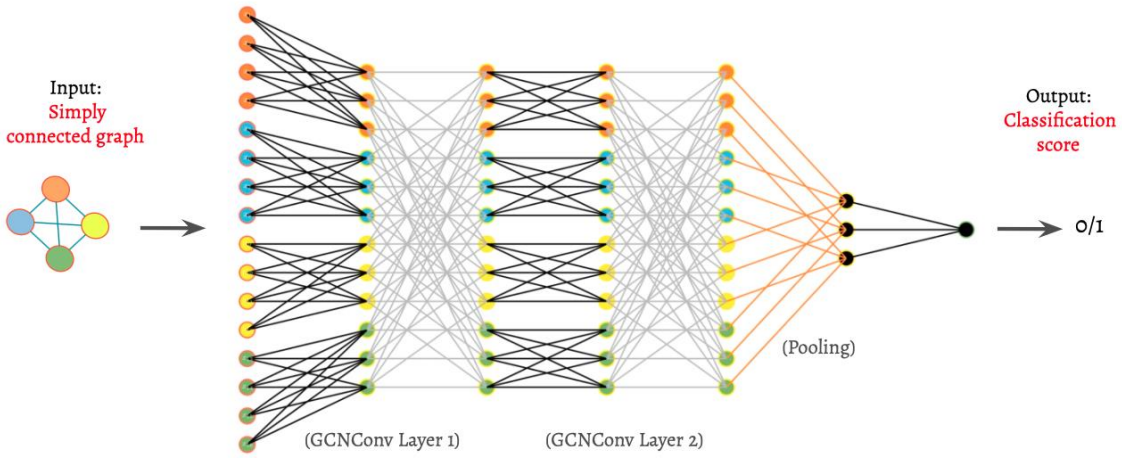

Fig. 1: Visualization of a graph neural network utilizing GCNConv layers for classifying a simply connected graph with four nodes, each having four features. The network architecture includes two hidden GCNConv layers followed by a pooling layer.

Reinterpretations in Experimental Particle Physics

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Abstract:

The standard model of particle physics has several shortcomings, such as neutrino masses, dark matter candidates and baryon asymmetry. In the quest to explore new particles and physics beyond the standard model, high-energy physics searches analyse vast amounts of data, usually costing a lot of money and manpower. While these analyses are typically designed to address specific questions, the results they produce can often be repurposed to test new theories and scenarios. This process, known as reinterpretation, is much more efficient than designing a new analysis and elevates the scientific value of existing data.

Through my poster, I will discuss the methodology of reinterpretation, from generating signals for the new model and implementing detector efficiencies to constructing the signal regions and calculating the final limits. I will also highlight the challenges involved, such as the complexities of detector effects and limit calculations. Finally, I will present my work in reinterpreting a model-independent search result on a new theoretical model. This poster will provide a comprehensive overview of how a reinterpretation is done, why it matters, and how it contributes to constraining new theories and models.

Keywords: Experimental high-energy physics, reinterpretation, repurpose, efficient

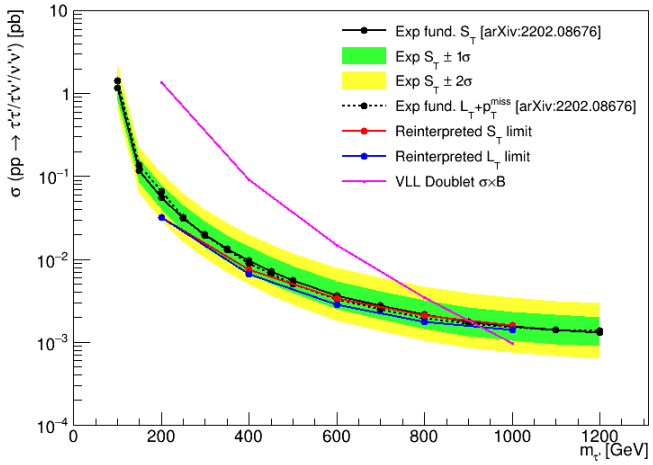

Fig. 1: Reinterpreted results compared to published results for validating the reinterpretation workflow.

To Study the Electron Dynamics in Dye-Sensitized Solar Cell

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Savitribai Phule Pune University, Pune - 411007, India

Abstract:

Dye-sensitized solar cells (DSSCs) represent promising photovoltaics due to their low-cost fabrication, high efficiency under diffuse light conditions, and tunable aesthetics. The dynamic properties of DSSCs, encompassing their photoelectric conversion efficiency, charge transport, and recombination dynamics play a critical role in determining their overall performance. This study delves into the fundamental mechanisms influencing these properties, including light absorption by the dye molecules, electron injection into the semiconductor, charge transport across the electrolyte, and the recombination kinetics at the interfaces. The molecular structure surface morphology, and electrolyte composition are examined in relation to their impact on the dynamic performance of DSSCs. By leveraging advanced characterization techniques. This work aims to provide a comprehensive understanding of the dynamic behavior of DSSCs, leading the way for advancements in next-generation solar energy technologies.

Keywords: photovoltaics, conversion efficiency, charge transport, recombination dynamics

Examining displaced multilepton final states in proton-proton collisions

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Abstract:

The Large Hadron Collider (LHC) in CERN collides proton beams at a center of mass energy of 13.6 TeV. Aside from measurements of standard model particles, the data can be used to probe for signs of beyond standard model (BSM) phenomena. The hypothesized BSM particles often decay into leptons, which can be used for characterizing the collisions. Most searches for BSM phenomena use prompt leptons; prompt implies that the leptons are produced at the point of collision (or very near it). Alternatively, searches also look for particles with significantly long lifetimes.

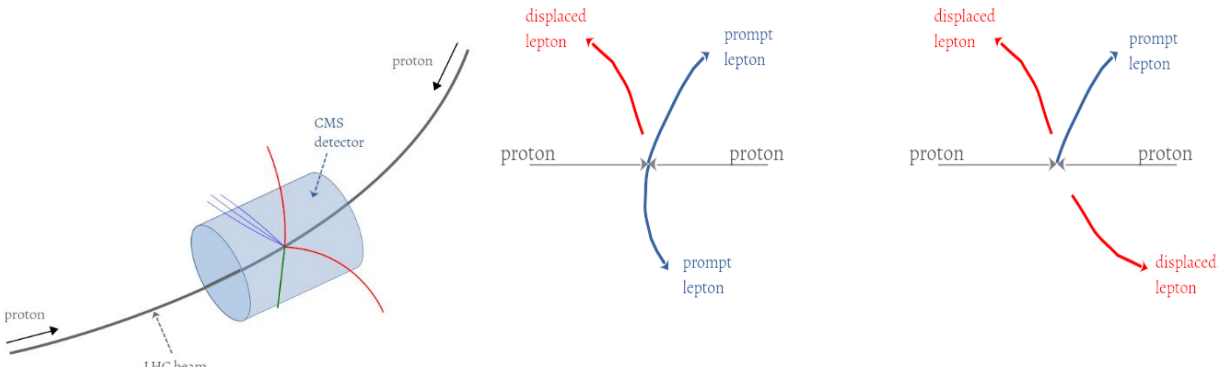

Figure 1: The figure shows the collision of protons in CMS Detector at LHC and the production of displaced and prompt leptons.

In this work, we study the production of leptons with intermediate displacement from the collision point. Such 'displaced' leptons can occur in many BSM models, and they can arise in the detector by themselves or in association with prompt leptons. We describe the construction of several overlapping final states which will span the available phase space for BSM models which can produce displaced leptons. We consider the various standard model

processes which may mimic the signatures of BSM phenomena, and we provide initial estimates of this background. We also present event yields in control selections to test the background estimation.

The analysis is a work in progress and uses the data collected by the CMS experiment in 2016.

Keywords: BSM phenomena, Displaced leptons, Multileptons

Catalytic methanolysis of sodium borohydride solution for hydrogen production using agricultural waste derived 3C-SiC nanostructures

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Abstract:

In this work, cubic silicon carbide (3C-SiC) nanoparticles were derived from rice husk, an abundant agricultural by product, via thermal plasma process. The crystal structure and surface morphology of the nanoparticles were verified using X-ray diffraction (XRD) and Field Emission Scanning Electron Microscopy (FE-SEM). These nanoparticles were subsequently utilized as catalysts for hydrogen generation through the methanolysis of sodium borohydride ($NaBH_4$).

Reaction parameters such as pH, $NaBH_4$ concentration, and temperature were also optimized. The volume of hydrogen produced was determined using a water displacement method, where the generated hydrogen gas displaced water in a conical flask, and the displaced volume was recorded over time.

The optimal catalytic performance was observed at pH 10 using 500 mg of $NaBH_4$. Additionally, an increase in reaction temperature led to a higher hydrogen generation rate, reaching a peak of 8.6 L/min/g catalyst at 47 °C. Notably, the hydrogen generation rate remained stable for nealy 2.5 hours, indicating strong catalytic activity and durability.

This study is the first to report the application of 3C-SiC nanoparticles as a catalyst for hydrogen production, highlighting their potential in sustainable energy solutions.

Visible-Light-Driven Photocatalysis Using graphitic carbon nitride (g-C_3N_4) for Effective Decomposition of Organic Dyes

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Abstract:

In this work, we report the synthesis of graphitic carbon nitride (g-C_3N_4) photocatalysts through simple calcination method utilizing melamine and thiourea as precursors and their structural, morphological, optical, and photocatalytic performance was investigated. As fabricated g-C_3N_4 photocatalysts were characterized by different analytical techniques like XRD, FT-IR, UV-Vis, BET, SEM, TGA and XPS. The XRD results revealed that, the crystallite size of T-gC_3N_4 is smaller (5.88 nm) than the M-gC_3N_4 (7.72 nm). The specific surface area for T-gC_3N_4 was observed to be 19.38 m^2 g^{-1}, which was nearly two times higher than that of M-gC_3N_4 (≈9.80 m^2 g^{-1}). Band gap energies using Tauc plot were estimated to be 2.99 eV for M-gC_3N_4, 2.86 eV for T-gC_3N_4. The difference in the band gap energies was due to the peak shift observed in UV-Vis spectra. SEM micrographs showed a significant change in the morphology of the g-C_3N_4. TGA analysis shows the good thermal stability of both the materials. FTIR reveled the confirmation of functional group of material. The presence of stoichiometric ratio of carbon and nitrogen in the EDS spectra confirms the formation of graphitic carbon nitride (g-C_3N_4). It was observed that the T-gC_3N_4 was observed to be more efficient (81.72% degradation in 60 min) than M-gC_3N_4 in the photo-degradation of crystal violet dye.

Keywords: photo catalyst; graphitic carbon nitride; calcination; crystal violet; photodegradation.

To study the Effect of incorporation of PbS nanocuboids on the performance of $CsPb_{0.6}Sn_{0.4}I_3$

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Abstract:

In this study, we improved the optoelectronic properties of $CsPb_{0.6}Sn_{0.4}I_3$ perovskite material by adding chemically grown PbS nanocuboids. The PbS nanocuboids were synthesized using different concentrations of CTAB complexing agent. Then, using slot die coating, thin films of $CsPb_{0.6}Sn_{0.4}I_3$:PbS nanocomposite were prepared with different-sized PbS nanocuboids. With the incorporation of PbS nanocuboids, significant improvement have been observed in the optoelectronic properties of $CsPb_{0.6}Sn_{0.4}I_3$ perovskite films. Finally, we fabricated pristine $CsPb_{0.6}Sn_{0.4}I_3$ and $CsPb_{0.6}Sn_{0.4}I_3$:PbS nanocomposite-based photodetectors using a slot die coating on a TiO_2-coated FTO substrate. The photodetector fabricated with the incorporation of PC3 in $CsPb_{0.6}Sn_{0.4}I_3$ has the shortest rise time of 0.23 s and decay time of 0.08 s. The fabricated photodetector has an external quantum efficiency of ~ 13.77 %. We believe the enhanced optical absorption and efficient charge collection between the perovskite and hole transport layer may be responsible for the improved photodetector performance. These results suggest that incorporating PbS in $CsPb_{0.6}Sn_{0.4}I_3$ perovskite holds promise for various optoelectronic applications.

Keywords: PbS nanocuboids; $CsPb_{0.6}Sn_{0.4}I_3$ perovskite nanocomposite; slot die; photodetector

Detection and Characterization of Biomass Burning Aerosols using High Resolution-Time of Flight-Aerosol Mass Spectrometer: A Mass Spectrometric Approach

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Abstract:

The High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-TOF-AMS) plays a crucial role in the real-time characterization of fine particulate matter (PM) and provides insights into the physio-chemical properties of aerosols during extreme pollution events. In this study, we investigate the physical and chemical characteristics of biomass-burning aerosols over Delhi from September to December 2024, with a specific focus on the peak biomass-burning event (12–19 November 2024). The HR-TOF-AMS was deployed at RASAGAM IMD Lab, Delhi, to identify the size-resolved chemical composition and key marker ions associated with biomass burning.

The instrument effectively detected tracer ions, such as $C_2H_4O_2^+$ (m/z 60) and $C_3H_5O_2^+$ (m/z 73), which are strong indicators of levoglucosan and other oxygenated organic species from biomass combustion. Additionally, K^+ (m/z 39, 41) and Cl^- (m/z 35, 37) were prominent, signifying potassium-rich combustion sources and particulate chloride. The temporal variation of these markers showed a substantial enhancement during the biomass-burning event, confirming the dominance of primary emissions.

Mass size distribution analysis revealed that the peak size mode of biomass burning aerosols during the event was larger compared to the pre- and post-event periods. Aging effects and secondary aerosol formation contributed to the size growth of aerosols through coagulation and condensation processes. Elemental ratio analysis indicated that the oxygen-to-carbon

(O:C) ratio decreased from 0.76 (pre-event) to 0.62 (post-event), suggesting reduced oxidation levels in freshly emitted aerosols. Additionally, the oxidation state of carbon (OSc) shifted from +0.10 to -0.34, emphasizing the presence of more reduced organic species during the event.

This study highlights the capability of HR-TOF-AMS in detecting and quantifying key biomass-burning markers, enabling an improved understanding of the physical evolution of aerosols during severe pollution episodes. These insights contribute to refining air quality models and mitigation strategies in urban environments.

Keywords: HR-TOF-AMS, Biomass Burning, Mass Spectrometry, Aerosol Size Distribution, Tracer Ions

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Assessing the Effects of Simulated Microgravity on Growth and Photosynthetic parameters in Wheat (*Triticum aestivum*)

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Abstract:

Microgravity or low gravity is a unique environment where system experiences a very less gravitational force, typically of the order of 10^{-5} to 10^{-6} times g, where g is acceleartion due to gravity. Recent studies on simulated microgravity treated plants showed changes in the seed germination, growth, morphological behaviour and biochemical parameters in many plants such as pea, soybean, maze, rice and potato etc. [1] [2]. The aim of the present study was to investigate the effects of simulated microgravity on growth and photosynthetic parameters in wheat. In present study, healthy wheat seeds were soaked for 24 hrs in D/W and exposed to simulated microgravity using 2-D clinostat and Random Positioning Machine (RPM) and its effect on growth and some photosynthetic parameters was studied. Seeds were sowed on a mixture of cocopeat and perlite at suitable ratio and exposed to simulated microgravity continuously for fifteen days under constant environmental conditions. The growth was monitored on each day and measurements were taken on fifteenth day.

Results of the present study showed changes in the orientation of shoots and roots under simulated microgravity as compared to control. The significant increase in shoot length as well as root length was observed in simulated microgravity treated plants. The increase in chlorophyll contents (Chl a, Chl b and Total Chl) was also observed when compared to control which could be the reason for enhancement of the photosynthetic efficiency of plants as

observed in the present study. Further, detail studies are being carried out to understand the effects of simulated microgravity in wheat by using Chlorophyll fluorescence, FTIR and Raman spectroscopic techniques.

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Investigating the photophysical, stability study and toxicity study aspects of favipiravir complexation with sulfonatocalix(4)arenes

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Abstract:

The complex interactions between the antiviral drug favipiravir and ρ-sulfonatocalix(4)arenes was investigated in this work, with particular focus given to the photophysical characteristics, stability study and toxicity study of their complexation. The structural features of ρ-sulfonatocalix (4) arenes, which are popular due to their molecular identification abilities, are explained and synthesised. UV-Vis and fluorescence spectroscopy was employed in photophysical studies to study how complexation affects the absorption and emission spectra of favipiravir and ρ-sulfonatocalix(4)arenes. The obtained information demonstrates the complex photophysical behaviour and offers attitudes into the nature of the interactions between molecules. To determine the safety appearance of the $FSCX_4$ complex, toxicity studies was carried out. To ensure a thorough understanding of the complex biological compatibility, potential cytotoxic effects was evaluated using cell culture models. The findings helped to determine suitable levels for use in medicine and contribute to the development of safe systems for drug delivery. A detailed investigation of the favipiravir ⊂ ρ-sulfonatocalix(4)arenes complexation was made easier by the combination of photophysical, enhance stability with drug safety and stability . By using an integrated strategy, valuable information could be obtained to optimise drug delivery strategies while maintaining safety and efficacy. The results of this study add to our understanding of host-guest interactions and may have effects on medication delivery, toxicity reduction, and design.

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Photolithographically Engineered Micro-Patterned Substrates for Geometric Alignment of Nematic Liquid Crystals: Influence of AuNPs on Optical and Dielectric Properties

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Abstract:

In this study, we investigated the alignment and optical switching behavior of nematic liquid crystals (NLCs) on photolithographically produced microgrooved substrates. The microgrooves, with dimensions of 2 µm × 10 µm, were fabricated using photoresist thin films on indium tin oxide (ITO) substrates. The alignment characteristics of NLCs were examined using polarized optical microscopy (POM) at room temperature, revealing that surface-induced alignment was significantly influenced by the groove orientation. To avoid the complexity of the lift-off process typically used in photolithography, we rapidly altered the groove direction, thereby inducing a controlled disturbance in the surface alignment of the NLCs. Furthermore, we explored the impact of trace amounts of gold nanorods on the electrical and dielectric properties of the system. The electrical conductivity (σ), dielectric constant (ε), and loss factor were systematically measured. Gold nanoparticles (AuNPs) were introduced into the microgroove substrates via a simple dip-coating technique, leading to a reduction in the dielectric loss factor (tan δ) and enhanced anisotropic stability of the material. The interaction between the liquid crystal and the embedded nanoparticles played a crucial role in optimizing the optical and electrical properties of the system. Our study confirms that microgroove substrates dominate NLC alignment over conventional rubbing techniques. With strong optical responsiveness and tunable switching behaviour, these systems hold great potential for optical switching, sensors, and photonic devices, paving the way for advanced liquid crystal technologies.

Keywords: 5CB, Photolithography, Gold Nanoparticles, Optical Switching, Dielectric Properties, Nematic Liquid Crystals

Solid State Annealing Method Synthesized S,O-GCN Photocatalyst for Efficient Photocatalytic Degradation of RB Dye

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Abstract:

This study investigates the potential of sulphur and oxygen-codoped graphitic carbon nitride (S,O-GCN) as a photocatalyst for degrading Rose Bengal (RB) dye in industrial wastewater. Using a straightforward solid-state annealing method, we synthesized S,O-GCN photocatalysts. The synthesized materials were characterized through various analytical techniques to evaluate their structural and compositional attributes. The S,O-GCN photocatalysts demonstrated significantly improved photocatalytic activity, which can be linked to their enhanced specific surface area. The photocatalytic performance demonstrated a remarkable degradation efficiency of 77.77% over 100 minutes, with a calculated rate constant of 0.032 min^{-1} and a half-life of 21 minutes. These findings highlight the potential of S,O-GCN as effective materials for the degradation of environmental pollutants.

Keywords: S,O-GCN, RB dye, photocatalyst, Solid state annealing method

Study of Electrochemical Performance of Cu_2FeSnS_4 (CFTS) for the Energy storage application

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Abstract:

Due to the huge demand for energy storage devices, advanced anode materials with higher lithium-ion battery capacities need to be explored [1-2]. Quaternary multi-metallic chalcogenides have gained keen attention as promising materials in the field of optoelectronics like energy conversion devices and in energy storage devices. The quaternary kesterite from the family of CXTS (where X=Zn, Fe, Co, Ni, etc.) such as Cu_2ZnSnS_4 (CZTS), Cu_2FeSnS_4 (CFTS), and Cu_2NiSnS_4 (CNTS) are employed as anode electrodes because Sn is efficiently alloyed with Lithium and offers high capacity [3].

In the current research work, the Cu_2FeSnS_4 (CFTS) nanoparticles were synthesized by using the simple and cost-effective hydrothermal method. The resultant nanoparticles were studied for the morphological, structural and elemental analysis confirms the nearly stoichiometric formation of CFTS nanoparticles, exhibiting significant crystallite agglomeration and size variations by using specific characterization tool. The Raman spectroscopy of CFTS nanoparticles was studied to confirm the tetragonal stannite structures of CFTS nanoparticles. The optical properties of the Cu_2FeSnS_4 (CFTS) nanoparticles were determined from the absorption and the reflectance spectra with the help of UV-VIS spectrometer. The as-prepared CFTS nanoparticles exhibits a significant enhancement in the electrochemical activity.

Electrochemical Impedance Spectroscopy (EIS) was employed to understand the charge transfer mechanism at the interface within the electrode and electrolyte of as-prepared CFTS NPs which shows that the charge transfer obstacles of CFTS electrode are less. This conclude that it has better electrical conductivity. The cyclic voltammetry (CV) was employed to study the redox behavior, electrochemical kinetics, and other electrochemical features of CFTS NPs.

The large area under the CV curve indicates the higher capacity of CFTS anode to store the Li-ions. These features make CFTS NPs a potential candidate for energy storage applications.

Keywords: Stannite, Li-ion battery, CFTS electrode, Electrochemical Impedance Spectroscopy, Cyclic Voltammetry.

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Green Synthesis of TiO_2 nanoparticles using Orange Peel Extract for Photocatalytic Application

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Abstract:

In current research era, eco-friendly nanoparticle synthesis using plant extracts, such as those from leaves, stems, roots, and fruits, has been synthesized for a variety of applications. Researchers have recently shown a strong interest in the production of titanium dioxide (TiO_2) nanoparticles due to their non-toxic and cost-effective strategies. This study reports, the synthesis of TiO_2 nanoparticles using orange peel extract. The green-synthesized titanium dioxide nanoparticles (O-TiO_2) were evaluated using a variety of analytical techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), and Ultraviolet-visible spectroscopy (UV-Vis). The XRD examination of the as-synthesized TiO_2 nanoparticles reveals an anatase tetragonal structure with an average particle size of 34 nm. UV-Vis spectroscopy revealed an optical band gap of 3.14 eV. The photocatalytic degradation efficiency was assessed using various dyes, including Methylene Blue (MB), Rhodamine B (RhB), Rose Bengal (RB), and Eosin Y (EY). The synthesized O-TiO_2 demonstrated the maximum degradation efficiency (99%) for Rose Bengal with 120 minutes of radiation. Similarly, the degradation efficiencies of MB, RhB, and EY were 81.27%, 73.79%, and 98.12% respectively. Moreover, the reaction rates were also calculated using the pseudo-first order kinetic model. This work emphasizes the importance of green synthesis TiO_2 and its potential for environmental remediation.

Keywords: Green Synthesis, Orange peel, Titanium-dioxide, Photocatalysis, Organic Dye,

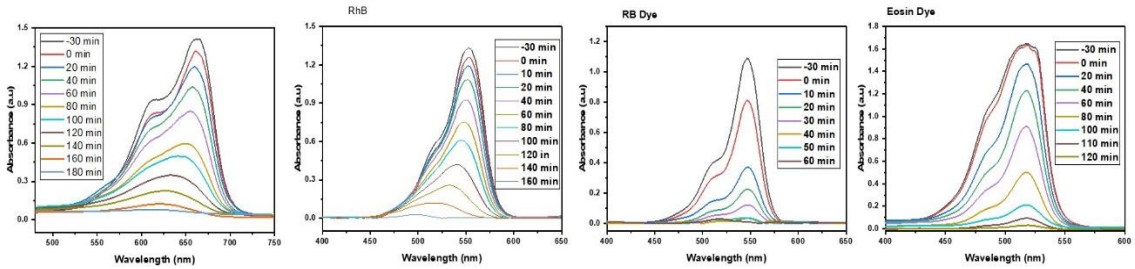

Fig 1. Time dependent absorption spectra of MB, RhB, RB and Eosin dye for photocatalytic degradation via O-TiO_2

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Boosting Cancer Therapy: β-Cyclodextrin-Imiquimod Nanoparticles for Enhanced 5-FU Delivery and Breast Cancer Treatment

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Abstract:

2.3 million women were diagnosed with breast cancer, resulting in 670,000 deaths worldwide (2023 statistics). Although the disease occurs in women of all ages after puberty, rates increase with age. Widely varying inequalities occur according to the Human Development Index (HDI), with high-HDI nations experiencing 1 in 12 women being diagnosed and 1 in 71 dying, while in low-HDI nations, 1 in 27 women are diagnosed but 1 in 48 dies, highlighting inequalities in early diagnosis, access to treatment, and health infrastructure. Beta-cyclodextrin (β-CD) is a cyclic oligosaccharide that is made up of seven glucose units. The combination of immunotherapy and chemotherapy presents a promising approach for the improvement of cancer treatment efficacy. In this study, we synthesized β-Cyclodextrin (β-CD) amine conjugated succinic acid functionalized imiquimod nanoparticles (β-CD-SA-IMQ NPs) and explored their potential as a dual-acting therapeutic system. The goal of this research is to develop β-Cyclodextrin (β-CD) amine conjugated succinic acid functionalized imiquimod nanoparticles (β-CD-SA-IMQ NPs) and explored their potential as a dual-acting therapeutic system. The nanoparticles were loaded with 5-fluorouracil (5-FU) and characterized for their drug loading and release kinetics. The cytotoxic effects of the 5-FU-loaded β-CD-SA-IMQ NPs were evaluated on MCF-7 breast cancer cells through MTT assay, demonstrating a significant reduction in IC50 value (5.78 µg/mL) compared to imiquimod alone (13.85 µg/mL). *In–vitro* investigations, including cell internalization, mitochondrial membrane potential (MMP) assay, reactive oxygen species (ROS) generation, apoptosis, and nuclear condensation assays, confirmed enhanced cellular uptake and apoptosis induction in treated cells. The results indicate that the β-CD-SA-IMQ NPs effectively potentiate the anticancer effects of 5-FU by leveraging both immune activation and cytotoxic mechanisms.

This study highlights the potential of β-CD-SA-IMQ NPs as a promising nano-immunochemotherapeutic strategy for breast cancer treatment.

Keywords: β-Cyclodextrin, imiquimod, nano-immunochemotherapeutic, breast cancer

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Exploring Binary Metal Chalcogenide Nanocrystals: Synthesis, Structural, and Optical Properties

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Abstract:

Silver sulfide (Ag_2S) has attracted significant attention for photovoltaic application due to its narrow bandgap, strong absorption in the infrared region, and excellent stability.[1,2] In this study, binary silver sulfide nanocrystals were synthesized by hydrothermal method using silver nitrate as the silver source and different sulfur sources. The structural properties of the synthesized nanocrystals were characterized by X-ray powder diffraction (XRD), confirming their monoclinic phase. Raman spectroscopy further validated the crystallinity and phase formation, Raman spectra shows two vibrational modes below 500cm^{-1}, it confirmed the alpha phase silver sulfide nanocrystal. while X – ray Photoelectron Spectroscopy Analysis (XPS) was used to analyse the elemental composition. Optical properties were examined using ultraviolet-visible (UV-Vis) spectroscopy, revealing a bandgap of ~ 0.90 eV. The Field emission scanning electron microscopy (FE-SEM) and energy – dispersive X-ray spectroscopy (EDS) analyses further revealed that the synthesized silver sulfide nanocrystals exhibit a monoclinic structure with irregularly round shapes. These morphological characteristics, combined with the observed structural and optical properties, highlight the potential of silver sulfide nanocrystals for photovoltaic application.

Keywords: Nanocrystals, Photovoltaic, Hydrothermal method.

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Synthesis of Ultrasmall TiO_2 Nanoparticles: Structural and Optical Characterization

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Abstract:

Titanium dioxide (TiO_2) nanostructures have unique properties that make them attractive for various applications such as hydrogen evolution, batteries, and photocatalysts. Novel synthesis methodologies have been developed in this work to synthesize ultrasmall TiO_2 nanoparticles (NPs). X-ray diffraction (XRD) analysis confirmed the formation of the anatase phase (101), which is known for its excellent stability. The crystallite size, calculated using the Debye-Scherrer equation ranged from 0.11 *nm* and 0.037 *nm* for different synthesis methodologies. Optical band-gap value was estimated to be from 3.13 *eV* and 3.4 *eV*. The morphological studies by Field Emission Scanning Electron Microscopy (FESEM) images shows the average agglomerate size was estimated to be 12 ± 3 *nm*. Efficient and cost-effective synthesis methods for TiO_2 NPs are crucial to develop practical and affordable solutions in various fields such as sensing, photocatalytic applications. Characterization and photocatalytic experiments are underway.

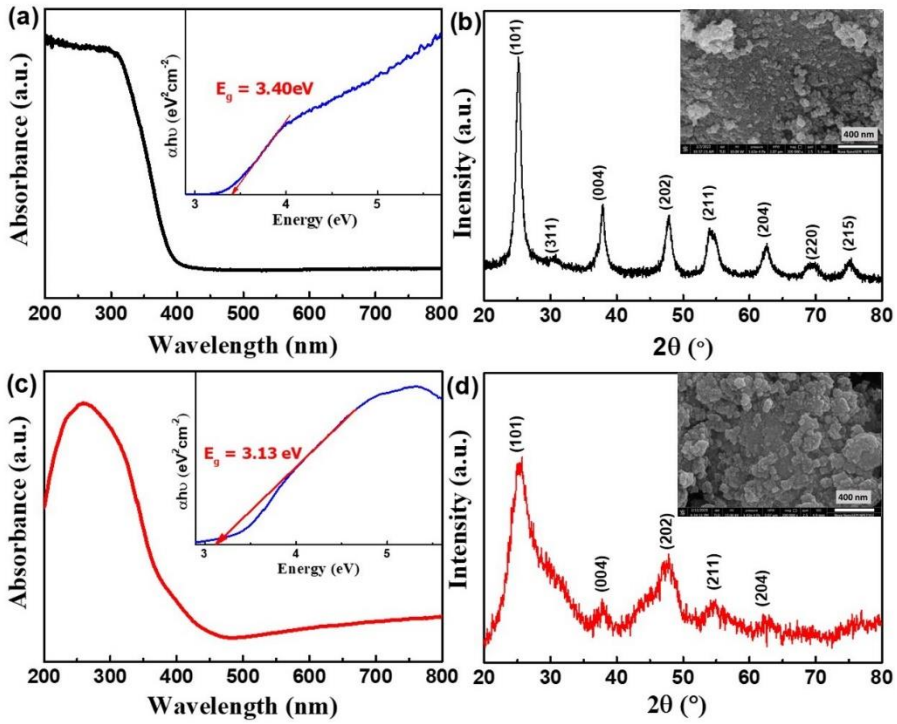

Fig. 1: (a), (b) and (c), (d) are UV spectra (inset Tauc's plot), XRD spectra (inset FESEM image) of synthesized by sol-gel and microwave irradiation method,

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Engineering MnO_2 Nanorod Morphology through Hydrothermal Synthesis for Enhanced Electrochemical Performance

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Abstract:

Manganese oxide nanostructures have gained significant attention due to their technological significance and have led to rigorous investigations as high-performance electrode materials for supercapacitors. [1-3] The increasing demand for efficient and sustainable energy storage has driven extensive research on MnO_2 nanostructures to enhance their performance. In this study, MnO_2 nanoparticles have been successfully synthesized by the hydrothermal method, which offers a simple, cost-effective, and scalable approach to obtaining well-defined nanostructures with enhanced electrochemical performance. The structural and morphological properties of the synthesized MnO_2 were thoroughly characterized using Powder X-ray Diffraction method (XRD), Scanning Electron Microscope (SEM) and Energy Dispersive X-ray Spectroscopy (EDX). The powder XRD analysis revealed that the synthesized MnO_2 exhibits a polycrystalline structure, with diffraction peaks corresponding to well-defined MnO_2 crystal phases. SEM imaging demonstrated the development of nanorod-like structures exhibiting variations in size, which play a crucial role in facilitating ion diffusion and charge storage. EDS analysis verified the elemental composition, confirming the presence of manganese and oxygen. The results indicate that the MnO_2 nanorods obtained when the reaction performed at 180°C for 24 hr. These findings highlight the potential of MnO_2 nanostructures as promising materials for high-performance supercapacitor electrodes.

Keywords: Manganese oxide, Nanorods, Hydrothermal, Supercapacitors, ion diffusion, nanostructures.

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Synthesis and Characterization of Copper Sulfide Counter Electrode for Enhanced Performance in Third-Generation Solar Cells

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Abstract:

This study presents the fabrication of a Copper Sulfide (CuS) counter electrode deposited by spray pyrolysis method for application in third-generation solar cells. Here we use an equimolar solution of copper (II) nitrate and thiourea (1:1) as precursors, films are deposited at various substrate temperature within the range of 350^0C to 380^0C. The characterization techniques, including UV-Vis spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM), were employed to analyze the optical, structural, and morphological properties of the the CuS counter electrode. Phase and Purity of CuS is also confirmed by Raman and XPS, The results demonstrate the successful synthesis of a CuS counter electrode with desirable properties for solar cell applications. The fabricated CuS counter electrode exhibited a conversion efficiency of 1.26%, which is significantly higher than that of carbon-based counter electrodes.

Keywords: Copper Sulfide (CuS); Third-generation solar cells; Ultraonic Spray Pyrolysis;; Counter electrode.

Desired Category: Poster Studies on Photosensing Performance of SnS thin films fabricated using RF magnetron sputtering technique: Effect of deposition pressure

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Abstract:

Tin sulfide (SnS) thin films were deposited on glass substrates using a radio-frequency (RF) magnetron sputtering technique at varying deposition pressures. The effect of deposition pressure on the structural, optical, morphological, and photosensing properties of deposited SnS films was characterized by field emission scanning electron microscopy (FE-SEM), electron dispersive spectroscopy (EDS), X-ray diffraction (XRD), Raman spectroscopy, UV-Visible spectroscopy (UV-Vis). The XRD pattern showed a polycrystalline nature with an orthorhombic crystal structure in the SnS films. FE-SEM micrographs revealed the compact and uniform nature of the synthesized SnS thin films. The EDS analysis showed an ideal stoichiometry of ~1:1 for all the synthesized SnS thin films. The direct energy band gap was observed to be decreased with the increase of deposition pressure. These synthesized SnS photodetectors show highly stable photo-response in terms of good photoresponsivity and photodetectivity, along with rapid rise and decay times.

Keywords: Tin sulfide; RF sputtering; Deposition pressure; Photodetector; Rise and decay time; Photoresponsivity; Photodetectivity.

Acknowledgements:

The authors thank to the Principal of the college, the Head, staff, and students of the department of Physics, Sangamner College, for their encouragement and support in carrying this work.

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Synthesis and characterization of $NiSe_2/CoSe_2$ hollow microspheres for Future Energy Storage Applications.

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Abstract:

Nickel selenide ($NiSe_2$) and cobalt selenide ($CoSe_2$) have emerged as promising materials for advanced energy storage systems due to their excellent electrical conductivity, redox activity, and structural stability. In this study, $NiSe_2/CoSe_2$ microspheres were successfully synthesized using a hydrothermal approach, resulting a uniform morphology with enhanced electrochemical properties. Comprehensive characterization techniques were employed to assess the structural and morphological features of the synthesized materials. X-ray diffraction (XRD) confirmed phase purity and crystallinity, while Raman spectroscopy provided insights into vibrational modes and possible defects. Scanning electron microscopy (SEM) revealed detailed surface morphology and particle distribution, whereas energy-dispersive X-ray spectroscopy (EDS) verified the elemental composition and stoichiometry.

The XRD pattern confirmed the presence of cubic $NiSe_2$ (JCPDS no. 11-0552) and cubic $CoSe_2$ (JCPDS no. 09-0234), with prominent diffraction peaks observed at (210), (211), (311), and (200). These findings validated the formation of well-defined crystalline $NiSe_2$ and $CoSe_2$ phases. Raman spectra displayed characteristic peaks associated with metal-selenium vibrations, indicating the coexistence of $NiSe_2$ (209.31 cm^{-1}) and $CoSe_2$ (184.33, 466.2, 510.84, and 674.01 cm^{-1}) within the heterostructured $NiSe_2/CoSe_2$ hollow microspheres. Notably, the $NiSe_2$ peak exhibited a slight blue shift, while the four $CoSe_2$ peaks showed red shifts in the heterostructured microspheres. SEM imaging confirmed the uniform distribution of hollow microspheres, and EDS mapping demonstrated the homogeneous incorporation of Ni, Co, and Se within the composite structure. These results highlight the potential of

$NiSe_2/CoSe_2$ microspheres as efficient electrode materials for next-generation batteries and supercapacitors, paving the way for high-performance energy storage technologies.

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Synthesis, Physico-Chemical Characterization and Field Electron Behaviour of 2D layered MoS_2-Ti_3C_2Tx (MXene) nanocomposites.

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Abstract:

Molybdenum disulfide (MoS_2) and its composite with MXene is of great interest for a various applications like electronics, sensors, energy storage, field emission etc because of its excellent properties. MoS_2 was synthesized by hydrothermal method while Ti_3C_2 was synthesized by chemical etching method. Furthermore the MoS_2/Ti_3C_2 nanocomposite was synthesized by hydrothermal method. The morphological and structural studies were done by using Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD). The XRD spectra confirms the formation of the MoS_2/Ti_3C_2 nanocomposite phase, with its unique diffraction signature at diffraction angle 9^0 and 14^0. Using FESEM-EDAX images clearly indicate the formation of petals-shaped MoS_2. The field electron emission studies of pristine MoS_2 and MoS_2/Ti_3C_2 nanocomposite has been analysed at a base pressure of ~$1x10^{-8}$ mbar. The turn-on field required for the emission current density of 10 mA/cm^2 has been observed at 2.67 V/μm for pristine MoS_2 and 1.80 V/μm for MoS_2-Ti_3C_2 nanocomposites. The maximum emission current density of ~390μA/cm^2 (~5V/μm) and ~270μA/cm^2 (~6 V/μm) has been observed for MoS_2/Ti_3C_2 nanocomosite and MoS_2, respectively. The FE current stability for the emitters was tested at pre-set values of ~ 1μA for pristine MoS_2, and MoS_2/Ti_3C_2 nanocomposite. The observed better FE results of nanocomosite are due to synergistic effect which enhances the electrical properties of nanocomposites.

Keywords: Molybdenum disulfide (MoS_2), Ti_3C_2, Field electron emission, X-ray diffraction, Nanocomposite.

MnO_2 nanostructure on TiO_2 nanotubes for H_2O_2 detection

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Abstract:

High concentration of H_2O_2 affect economic environment due to strong oxidizability. It also affects normal life activity of human body triggering many Chronic disease, Cardiovascular disease, Parkinson's disease and so on. Hence H_2O_2 detection is important. TiO_2 nanotubes (TNT) were grown on Ti foil by anodization technique. The MnO_2-TNT composite electrodes were obtained through depositing MnO_2 by Successive Ionic Layer Adsorption & Reaction (SILAR) method. Depending upon the strength of reducing agent the K or Na ions got preinserted in the MnO_2 matrix. Accordingly, we obtained K-MnO_2-TNT and Na-MnO_2-TNT composites. These nanocomposites were used as electrochemical sensors for detection of hydrogen peroxide (H_2O_2). Effects of SILAR growth cycles on electrochemical sensing performance is investigated. The sensitivity, stability and selectivity of the electrochemical sensors are thoroughly investigated. K-MnO_2-TNT composite found to show better electrochemical sensing performance than N-MnO_2-TNT composite.

Keywords- Anodization: TiO_2 nanotubes, SILAR: MnO_2 nanostructure, Electrochemical study.

Free-Free Gaunt Factors for a Hot Strongly Magnetized Plasma in Non-LTE Conditions: Including Anisotropic Effects

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Abstract:

Exploiting accreting X-ray pulsars as an astrophysical laboratory, Free-Free Gaunt factors – used in the studies of electrodynamics and radiative processes – are presented for 1-100 keV X-ray photon absorption in the anisotropic presence of a strong magnetic field of 10^{11}-10^{13} Gauss by a hot plasma at 8 keV in non-local thermodynamic equilibrium found in model pulsar atmospheres. The results recently reported in [4] in a space astrophysical context are presented in the alternate perspective of confined plasma physics.

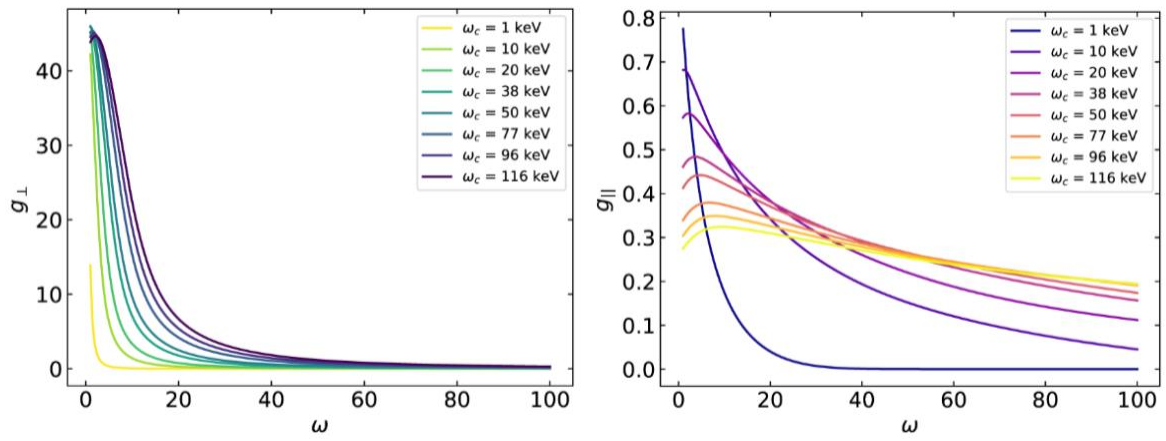

Fig. 1: Modified anisotropic Gaunt curves (left) $g_\perp(\omega)$ and (right) $g_{||}(\omega)$ for the full observing range of X-ray photons energies, ω=1−100 keV sampled at a fine spectral resolution of $\Delta\omega$=0.1 keV with (isochors) discrete sampling over the full span of accreting pulsar magnetic field strengths, B=10^{11}−10^{13} G for a plasma temperature of kT=8 keV.

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Contrasting features of haze and dense fog in different regions over IGP

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Abstract:

Winter Fog Experiment(WiFEx) is an extensive field observation program that has its observation sites located at Hissar [Haryana], Jewar[Noida], and Indira Gandhi International Airport (IGIA), New Delhi, during the winter months of 2023-2024. Using the state-of-the-art instrument Fog monitor-120 based on forward scattering optical spectroscopy, microphysical aspects of fog were investigated at different regions over the Indo-Gangetic Plain region(IGP). The current study was carried out in a rural region and a semi-urban region. In the rural region, early onset and late dissipation of fog was observed, unlike in the case of the semi-urban region. Two cases, each representing the haze and dense fog occurring at Hissar (Haryana) and Jewar(Noida), have been used for this study. It was found that the fog occurring in the rural region had more influence of Relative humidity(RH), with wind direction remaining Southeasterly with the least deviation. The dense fog in the semi-urban region was influenced by lower wind speed and nocturnal radiative cooling. Variations in microphysical characteristics were distinctly observed. The highest fog droplet number concentration (Nd_{max} haze, dense) was 16 cm^{-3} and 853 cm^{-3} for Jewar[semi-urban], and for Hissar, it was 22 cm^{-3} and 395 cm^{-3}. The highest liquid water content (LWC_{max} haze, dense) for Jewar was 0.01μgm^{-3} and 0.72 $\mu gm^{-3,}$ and Hissar was 0.009 μgm^{-3} and 0.22 μgm^{-3} and. The results suggest that higher anthropogenic activities in semi-urban regions resulted in higher fog droplet number concentration, thus ultimately resulting in poor visibility. Fog cases at both sites exhibited a bimodal size distribution with a dominance of smaller fog droplets in

3-7 μm range. It was also observed that Visibility(V_{is}) is inversely related to (LWC) and (N_d), thus highlighting the significance of this microphysical observation in different regions.

Keywords: Microphysics, Number concentration(Nd), Liquid water content (LWC), Visibility (V_{is}), Droplet size distribution(DSD).

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Synthesis of 2D Mn-MoS_2 using hydrothermal Method for supercapacitor

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Abstract:

Global warming and environmental damage caused by fossil fuels have created an urgent need for renewable energy sources as alternatives to fossil-fuel-based technologies. Supercapacitors (SCs) have emerged as promising candidates due to their high power density, rapid charge/discharge capability, and long cycle life. Among various materials, two-dimensional (2D) transition metal dichalcogenides (TMDs), particularly MoS_2, have gained attention as potential electrode materials. To enhance its electrochemical performance, we doped Mn into the MoS_2 lattice, which increased conductivity by introducing additional charge carriers, thereby improving electron mobility. The 5% Mn-doped MoS_2 exhibited an areal capacitance of 373.44 mF/cm^{-2} at 5 mV/s, nearly double that of pristine MoS_2 (177.83 mF/cm^{-2}), and further increased to 632.75 mF/cm^{-2} at 2 mV/s in a 2M NaCl electrolyte. Additionally, after 3000 CV cycles, Mn-doped MoS_2 retained 85.4% of its initial capacitance, while pristine MoS_2 retained 98.83%. The superior electrochemical performance of Mn-doped MoS_2 suggests its potential as an efficient electrode material for supercapacitors. In this study, we report the synthesis of Mn-doped MoS_2 using a simple one-step hydrothermal method and evaluate its structural, morphological, and chemical characteristics using Raman spectroscopy, XRD, SEM, XPS, and HRTEM.

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Tetragonal- $BaTiO_3$ NP Synthesis Using Wet-Chemical Method

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Abstract:

$BaTiO_3$ (BTO) is a ferroelectric material with applications in infrared detectors, H_2 production, electro-optic devices, ferroelectric memories, photocatalysis, and solar technology [1]. BTO stabilizes in cubic, tetragonal, orthorhombic, rhombohedral symmetries [2].

This work aims to synthesis of tetragonal-$BaTiO_3$ (t-BTO) nanoparticles (NP) with acetylacetone (acac) at different annealing temperature in order to study the effect of temperature on crystal structure. The characterization is done using X-ray diffraction (XRD), Raman spectroscopy, and field-emission scanning electron microscopy (FESEM).

BTO nanoparticles were synthesized using a sol-gel method. Ba-based precursors were dissolved in water, while Ti-based precursors were dissolved in acetylacetone (acac). Obtained gel was heated followed by annealing the samples at 900°C (BTO-1) and 1200°C (BTO-2).

Pure tetragonal phase is obtained for BTO-2 (1200°C), while for BTO-1(900°C) beginning of the transition from cubic to tetragonal phase is observed, which is evident by the splitting of (200), (220) and (300) peaks (fig.1 a1-a4). The tetragonal phase of BTO-2 was also confirmed by Raman spectroscopy (fig.1 b) [3]. The particle size from FESEM image (fig.1 c1-c3) obtained an average particle size of 127 nm for BTO-2.

Graphical Abstract:

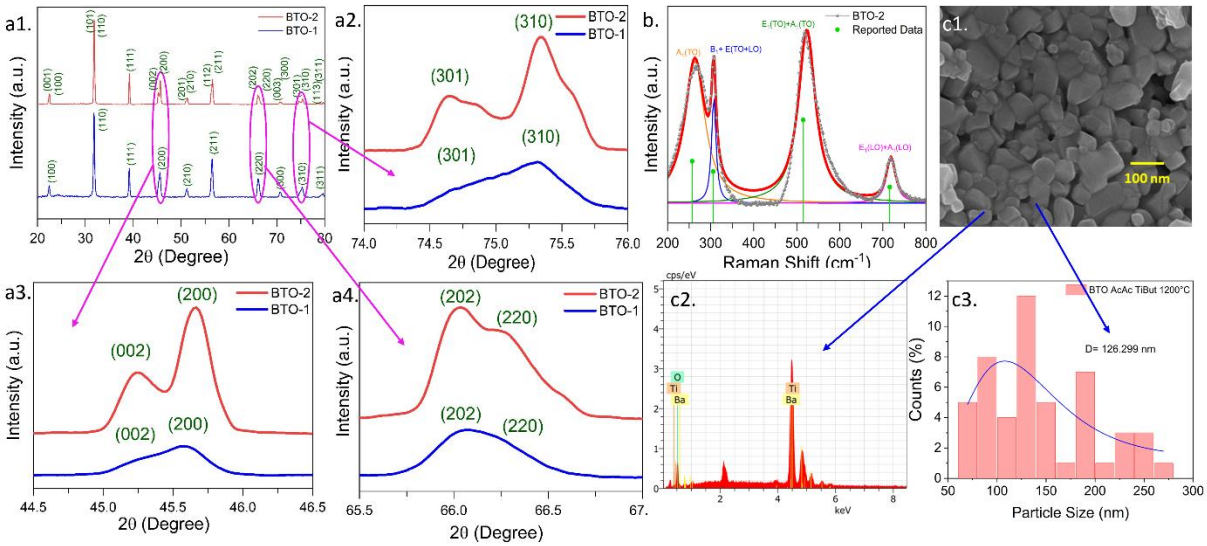

Figure 4: a1.-a4.- XRD image of BTO annealed at 900°C and 1200°C, b.- Raman Spectroscopy of BTO-2, c1.-c3.- FESEM image of BTO-2

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Cu-doped TiO2 spheres: enhanced solar-driven photocatalysis for hydrogen generation and degradation of methylene blue and Congo red

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Abstract:

Efficient photocatalysts are crucial for sustainable energy and environmental applications. In this study, Cu-doped TiO2 microporous spheres with varying Cu concentrations (1–5 wt%) were synthesized via hydrothermal techniques for enhanced photocatalytic activity under natural sunlight. Physio-chemical characterization using UV–Vis, XRD, PL, FESEM, and XPS techniques revealed a pure anatase structure with small crystallite sizes (10–15 nm) forming porous spheres. Copper doping induced a decrease in photoluminescence intensity, suggesting improved electron–hole pair separation. Among the samples, CT-2 exhibited superior photocatalytic performance, achieving efficient hydrogen generation (1860 μmol/g/h) and degradation of cationic (methylene blue degradation of 94% in 75 min) and anionic (Congo red degradation of 97% in 14 min) dye under sunlight. However, higher Cu concentrations led to diminished photocatalytic activity, likely due to increased charge trapping and recombination. This study underscores the crucial impact of fine-tuned copper

doping concentrations within the TiO2 lattice, highlighting their crucial contribution to enhancing photocatalytic efficiency.

Assessing the Impact of Spot Size Errors on Clinical IMPT Plans in Proton Therapy using a Monte Carlo Approach.

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Background and Purpose: This study investigates the impact of spot size deviations up to ±0.6 mm for proton beams with energy ranges between 70.18 and 226.2 MeV across different clinical sites. Monte Carlo simulations using the TOPAS platform were employed to model spot size errors in a treatment planning system (TPS) and evaluate their effects on dose distributions compared to a reference model.

Materials and Methods: The analysis focused on the clinical implications of spot size deviations (±0.3 mm and ±0.6 mm) in proton therapy plans, using TOPAS Monte Carlo simulations. Five variable spot size models were developed in the RayStation TPS by incorporating spot size shift errors simulated in TOPAS for 33 distinct proton energies (70.18–226.2 MeV). These models were applied to heterogeneous treatment fields targeting the pelvis, brain, and prostate. To assess the clinical impact, 2D gamma analysis was conducted with tolerance levels of 1%/1 mm, 2%/2 mm, and 3%/2 mm.

Results: Gamma analysis of 2D dose distributions for pelvis, brain, and prostate treatments revealed that the ±0.3 mm spot size model consistently delivered superior performance, achieving gamma passing rates exceeding 98% under 2%/2 mm and 3%/2 mm criteria.

Prostate cases exhibited the highest sensitivity to spot size deviations, particularly under the strict 1%/1 mm tolerance. While all models demonstrated robustness at higher tolerance levels, the ±0.3 mm model proved most reliable for ensuring accurate dose delivery across all anatomical regions studied.

Conclusion: Spot size variations significantly affect the precision of dose delivery in proton therapy. A tolerance of ±0.3 mm was found to provide optimal results, ensuring accurate beam matching and treatment delivery across various clinical scenarios. These findings underscore the importance of maintaining tight spot size tolerances to enhance the reliability and consistency of multiroom proton therapy systems.

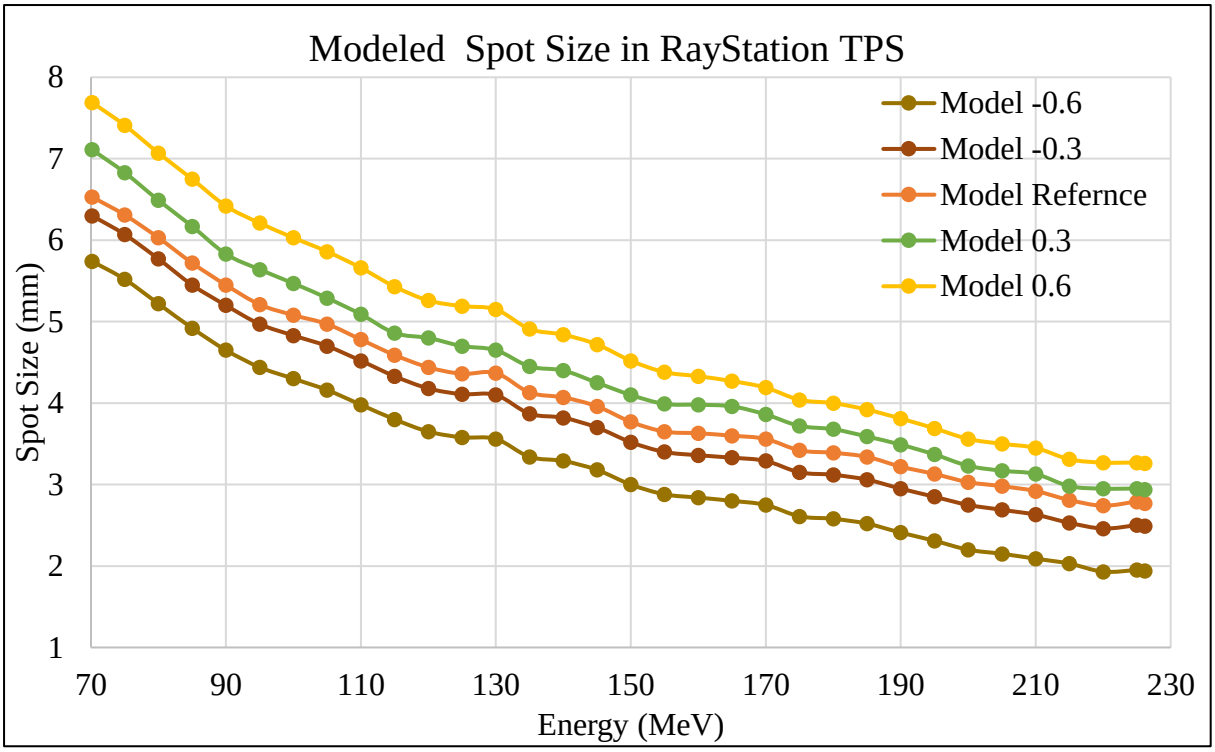

Figure 1. Modeled spot sizes with respect to energies in the raystation TPS.

Patient Group	**Spot Size**	**1%/1mm**	**2%/2mm**	**3%/2mm**

	Model	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**
Pelvis	Model -0.6	98.60 ± 1.68	99.93 ± 0.23	99.89 ± 0.31
	Model -0.3	99.18 ± 1.25	99.97 ± 0.12	99.99 ± 0.03
	Model 0.3	99.88 ± 0.22	100.00 ± 0.00	100.00 ± 0.00
	Model 0.6	99.08 ± 1.38	100.00 ± 0.00	100.00 ± 0.00
Brain	Model -0.6	94.62 ± 2.15	99.45 ± 0.62	99.91 ± 0.12
	Model -0.3	98.59 ± 1.32	99.98 ± 0.09	99.99 ± 0.03
	Model 0.3	98.71 ± 0.91	99.89 ± 0.15	99.98 ± 0.05
	Model 0.6	92.74 ± 4.52	99.28 ± 1.29	99.94 ± 0.12
Prostate	Model -0.6	72.01 ± 8.62	93.44 ± 4.62	96.28 ± 2.93
	Model -0.3	95.69 ± 3.28	99.89 ± 0.26	100.00 ± 0.00
	Model 0.3	92.80 ± 3.61	99.33 ± 0.86	99.88 ± 0.37
	Model 0.6	89.36 ± 4.15	98.27 ± 1.36	99.73 ± 0.59

Table 2: Model-to-model comparison of gamma passing results for pelvis, brain, and prostate cases.

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Water-based Li-ion storage devices using Manganese ferrite as anode material

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Abstract:

Because of the benefits over organic Li-ion batteries, such as non-toxicity and safety, the field of aqueous Li-ion batteries has attracted interest recently. The limited electrochemical stability window of water, which causes the hydrogen evolution reaction (HER), limits the selection of anode materials. Ferrites are stable in water and can be used as an anode material in organic Li-ion batteries. As such, it may be a difficult material to use as anode of aqueous Li-ion battery.

Manganese ferrite ($MnFe_2O_4$) is synthesized via a hydrothermal process in this work. The successful phase development and cubical morphology of $MnFe_2O_4$ (MFO) are confirmed by the structural and morphological characterizations. Aqueous Li-ion half-cells are evaluated using a standard, inexpensive $LiNO_3$ electrolyte. The specific capacity of an aqueous Li-ion half-cell is lower because of the high particle size and intrinsic low conductivity of $MnFe_2O_4$. By greatly increasing the surface area, the ball milling technology can improve battery performance by up to ten times. The surface area significantly increases from 14 to 395 m^2/g, as demonstrated by Brunauer-Emmett-Teller (BET) research. Carbonaceous compounds such as graphite (G) and graphene oxide (GO) can be used to further boost the capacity. By doing this, direct contact with the aqueous electrolyte will be avoided, and ion dissolution will be prevented. The specific discharge capacity for the first few cycles of the optimized sample is determined to be 70 mAh/g. This is, as far as we know, the first time ferrite material has been used as an anode for hybrid capacitors and aqueous Li-ion batteries

Synthesis of Morphological-based Novel Ternary Composite of TiO_2/g-C_3N_4/$CuFe_2O_4$ Heterojunction for Supercapacitor Application

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Abstract:

This work explains the synthesis of TiO_2, $CuFe_2O_4$, Exfoliated g-C_3N_4 (Ex.g-C_3N_4), and their novel ternary composite by hydrothermal method, facile calcination, and chemical method respectively. In this study, the optimized 2D/2D/0D TiO_2/Ex.g-C_3N_4/$CuFe_2O_4$ (CuFCNT) ternary composite was characterized by optical, morphological, and electrochemical analysis. UV-DRS and PL spectra investigations of CuFCNT indicate the red shift towards the visible wavelength region and effective separation of photo-generated electron-hole pairs in the catalyst. The analysis of TEM images not only confirms the morphology of TiO_2, Ex.g-C_3N_4, and $CuFe_2O_4$ and explains the formation of p-n heterojunction between semiconductors in the ternary composite. Further Characterization XPS analysis was performed to determine the chemistry of the atoms in the CuFCNT composite. The BET isotherm of the composite interprets the mesoporous structure formation in CuFCNT composite and the specific surface area (SSA) was found to be increased from 25.7 m^2/g to 32.2 m^2/g. The magnetic behavior of material explained by VSM analysis explained the diamagnetic behavior of TiO_2 and CuFCNT composite, which showed paramagnetic behavior measured at 2.59 emu/g in between -20K (Oe) to +20K (Oe) at room temperature. The Electrochemical Impedance studies were also conducted for fabricated nanomaterials which showed enhanced conductance. These results demonstrate that it is an excellent material for energy storage applications.

	Specific Surface Area (m^2/g)	**Average Pore Diameter (nm)**	**Pore Volume (cm^3/g)**
TiO_2	25.7	36.317	0.2333
5CuF3CNT	32.2	27.768	0.2232

Table 1. BET-specific surface area, pore size diameter, and pore volume of CuFCNT Composite and Synthesized TiO_2

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Review on Secondary Mineral Potential of Chhatrapati Sambhajinagar District, Maharashtra: A Special Case of Quartz & Zeolite Varieties of Gemstones

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Abstract:

This review paper explores the geological, mineralogical, and physicochemical characteristics of gem-quality zeolites and quartz group minerals found in the many blocks of the Chhatrapati Sambhajinagar (Aurangabad) district, Maharashtra. Various silicate minerals are known to occur as secondary cavity-filling deposits, especially in the volcanic basaltic terrains. The minerals found in Maharashtra are mostly zeolites some of which appear as tiny tube fillings, spherules, nodules & patches of zeolitic material in basalt. The part of the extensive Deccan Traps, hosts minerals such as Stilbite, Scolecite, Amethyst, Citrine, Apophyllite Agate, and Banded Agate, which are products of complex hydrothermal processes. These minerals are not only of significant geological interest but also hold substantial economic and gemmological value. The review highlights the critical role of temperature, pressure, and fluid composition in the crystallization of these minerals, as well as their implications for local and global markets. Furthermore, the paper discusses the potential for sustainable gemmological exploitation of these resources and suggests areas for future research, particularly in geochemistry and mineral physics. This will also highlight the importance of environmental sustainability in mining practices. To explore advanced technological methods for mineral characterization, such as geochemical analysis & also the comparative studies with other regions, the integration of local knowledge and community involvement in mineral research and management will be emphasized. The findings provide valuable insights into the gemmological and geological communities importance of responsible mineral exploitation in enhancing the region's economic potential.

Review on: Synthesis, Applications and Future perspective of Yttrium Oxide Nanoparticles

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Abstract:

Yttrium oxide (Y_2O_3) nanoparticles have emerged as a promising material in the field of gas sensing due to their excellent thermal stability, chemical inertness, and high surface area, which enhance their sensitivity and selectivity in detecting various gases. This review provides an in-depth overview of the recent advancements in the synthesis of Y_2O_3 nanoparticles, including methods such as sol-gel, hydrothermal, and chemical vapor deposition, which allow for precise control over nanoparticle morphology and size. The applications of Y_2O_3 nanoparticles in gas sensing are highlighted, focusing on their effectiveness in detecting toxic and flammable gases, such as CO, NO_2, and H_2S, which are crucial for environmental and industrial monitoring. Recent innovations in surface modification and doping techniques that enhance the gas-sensing properties of Y_2O_3 nanoparticles are also discussed. Finally, the review explores future perspectives, including challenges in achieving reproducibility, stability, and selectivity in real-world applications. This work aims to provide valuable insights for researchers and engineers working on the development of advanced gas sensors utilizing yttrium oxide nanomaterials.

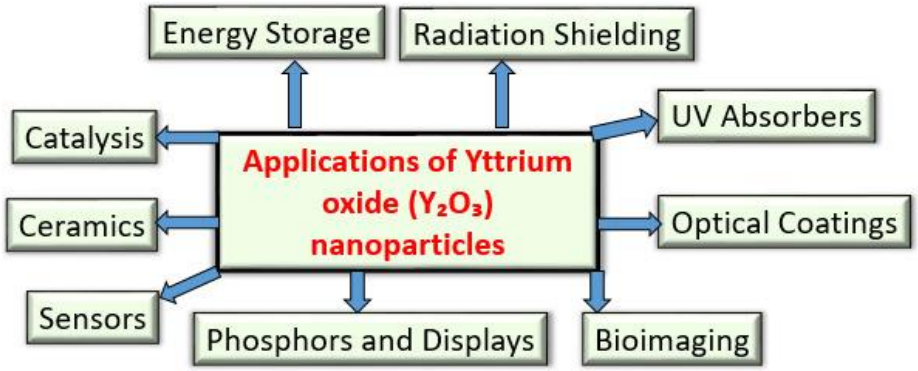

Fig. 1: Various applications of Y2O3 NPs.

Keywords: Yttrium oxide, high surface area, flammable gases, doping, nanomaterials.

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Particle size-dependent dosimetric properties of CaF_2:Dy phosphor.

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Abstract:

High Energy Planetary Ball milling method was used to create CaF_2:Dy phosphor with particle sizes varying from 140 nm to 35 nm. Irradiation with ^{60}Co gamma rays was used to examine the thermoluminescence characteristics of the material. The crystallite size of the pristine, 10 and 50-hour ball-milled phosphor samples was approximately 45 nm, 19.1 nm, and 9.99 nm, respectively, and also confirmed by FESEM. The corresponding thermoluminescence response was examined after CaF_2:Dy particles of various sizes were exposed to gamma doses ranging from 1 Gy to 20 kGy. The phosphor with a particle size of around 65 nm was shown to respond linearly to gamma doses ranging from 1 Gy to 12 kGy. These findings demonstrate the potential of the CaF_2:Dy phosphor for food irradiation dosimetry and high gamma radiation measurement.

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NiO Nanostructures for the Application of Dye-Sensitized Solar Cell

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Abstract

Dye-sensitized solar cells (DSSCs) have received great attention because of their low cost, simple manufacturing process, and recent high-power conversion efficiency. NiO (Nickel oxide) is a transition metal oxide with a wide band gap commonly observed in a range of 3.6-4.0 eV. This band gap energy is relatively narrower than that of TiO_2. NiO itself is an extremely stable material that can survive commercial nanoparticles with a size of approximately 25 nm are used as the photoelectrode in DSSC and investigate the effect of various parameters on the cell performance. Here we report the fabrication of NiO photoelectrode for DSSC, here Mercury Chrome (MC) dye is used as a sensitizer. Various characterization techniques are used for the analysis of NiO photoelectrode. IV performance of the NiO/MC-based photoelectrode was measured under a solar simulator.

Keywords: Solar Cell, NiO, DSSC, Nanostructures

Gamma-Irradiation as a Versatile Tool for Tailoring the Properties of Metallic Nanoparticle

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Background: With increasing environmental concerns and the need for sustainable solutions, there is a pressing demand in order to advance ecological friendly methods to synthesize versatile nanomaterials. In particular, the treatment of wastewater has emerged as a critical issue, necessitating innovative approaches to address contamination effectively. ZVI NPs, or zero valent iron nanoparticles, have shown promise in various applications, including wastewater treatment, due to their special qualities.

Methodology: ZVI NPs were created utilizing aqueous tea extract in a single process that is safe for the environment. The produced NPs were then exposed to radiation at a ^{60}Co gamma radiation source at a dosage of 100 kGy. XRD, FT-IR, particle size analysis techniques used to characterize the materials, both before and after they were exposed to radiation. ZVI NPs' antibacterial activity and efficacy as adsorbents for the elimination of Cu2+ ions was evaluated in a range of experimental settings, including changes in pH, dosage, and starting metal ion concentration. In addition, thermodynamic parameters were computed and examined, and examined was how temperature impacted the process of adsorption.

Findings: The findings showed that gamma irradiation significantly altered the structural and morphological properties of ZVI NPs, resulting in increased crystallinity and the development of sheet-like morphologies. Cu2+ ions were effectively removed from aqueous solutions by ZVI NPs, with clearance efficiencies of 81.67% and 97%, prior to and following radiation, respectively. Moreover, after several adsorption/desorption cycles, the nano-adsorbents

showed stable recyclability. The assessment of ZVI NPs' antibacterial activity revealed encouraging outcomes, as they demonstrated significant reduction of bacterial growth. ZVI NPs therapy was found to be safely used in vivo by safety assessment.

A Novel Hybrid Solvothermal and Thermal Evaporation Method for Producing Highly Crystalline CZTS/Se Thin Films for solar cell application

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Abstract:

$Cu_2ZnSn(S/Se)_4$ (CZTS/CZTSe) has attracted considerable interest as a promising absorber material for thin-film solar cells due to its high absorption coefficient, tunable direct bandgap, low toxicity, and the abundance of its constituent elements. It serves as a viable alternative to conventional absorber materials such as CdTe and $Cu(In,Ga)Se_2$ (CIGS), offering the potential for high photovoltaic conversion efficiency.

In this study, CZTS and CZTSe nanoparticles were synthesized using a cost-effective hydrothermal method. The resulting powders were further processed via thermal evaporation to fabricate thin films. The structural, morphological, and optical properties of both the synthesized nanostructures and the thermally evaporated films were characterized using X-ray diffraction (XRD), Raman spectroscopy, scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDS), UV–Vis absorption spectroscopy, and transmission electron microscopy (TEM).

XRD and Raman spectroscopy confirmed the presence of wurtzite and kesterite phases in both the powder and thin films, with no detectable secondary phases. Elemental analysis via EDS indicated good stoichiometric composition in select samples. TEM analysis revealed nanostructured particles with sizes below 10 nm. The thermally evaporated films exhibited a compact and uniform morphology. UV–Vis absorption spectra analysis determined that the optical bandgap of CZTS is approximately 1.4 eV, while CZTSe has a bandgap of around 1.1 eV, confirming their suitability as absorber layers for photovoltaic applications.These findings highlight the potential of CZTS and CZTSe as efficient and sustainable absorber materials for next-generation thin-film solar cells.

Keywords: CZTS, CZTSe, Nanoparticles, Hydrothermal, Thermal evaporation

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