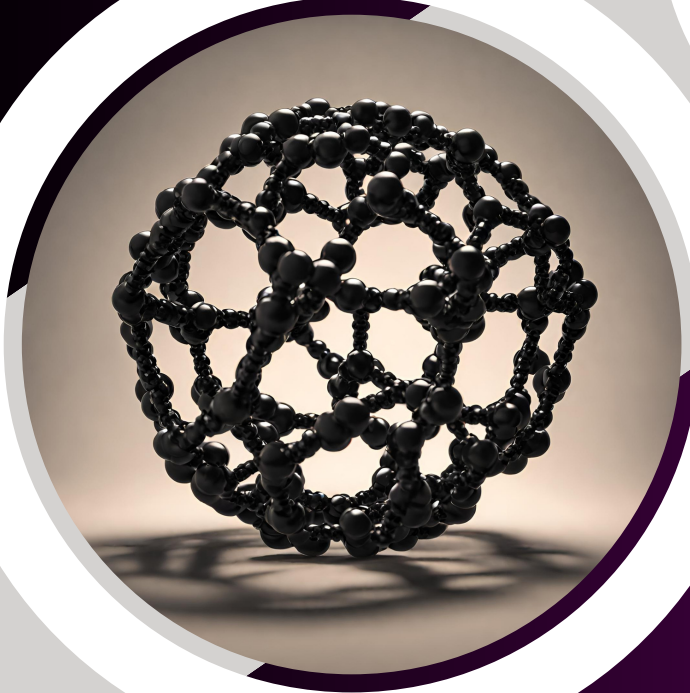
INTERNATIONAL SYMPOSIUM ON ADVANCED MATERIALS AND THEIR APPLICATIONS 2023



In collaboration with

KAGAWA UNIVERSITY

宝鸡文理学院

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
UNIVERSITY OF MORATUWA, SRI LANKA

International Symposium on Advanced Materials and their Applications 2023

14th December 2023, at Faculty Board Room, University of Moratuwa.

AGENDA

08.30 am	Arrival of Guests
09.00 am	Lighting of the Oil Lamp
09.10 am	Welcome Address *Prof. A.S.Galhenage - Programme Chair*
09.20 am	Speech by Dean, Faculty of Engineering
09.30 am	Keynote Speech *Prof. Qi Feng – Kagawa University, Japan*
10.15 am	Cultural Event & Morning Tea
10.45 am	Invited Speech 1 *Prof. Dengwei Hu – Baoji University of Arts and Sciences, China*
11.15 am	Technical Session 1
12.15 pm	Lunch
01.15 pm	Invited Speech 2 *Dr. Imalka Jayawardena – University of Surrey, England*
01.45 pm	Invited Speech 3 *Dr. Han Yu – Baoji University of Arts and Sciences, China*
02.15 pm	Cultural Event
02.30 pm	Invited Speech 4 *Dr Ruixuan Xue - Baoji University of Arts and Sciences, China*
03.00 pm	Technical Session 2
03.45 pm	Closing Ceremony
04.15 pm	Evening Tea

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Message from the Programme Chair

It is with great pleasure that I welcome you to the International Symposium on Advanced Materials and Their Applications-2023 at the University of Moratuwa, Sri Lanka. This symposium is a collaborative effort between Kagawa University in Japan and Baoji University of Arts and Sciences in China. Notably, this annual symposium, initiated by Prof. Dengwei Hu, was first held in China in 2021.

This year, we are proud to announce that the symposium is sponsored by The Faculty of Graduate Studies, University of Moratuwa, and hosted by the Department of Materials Science and Engineering, University of Moratuwa.

The symposium reflects our commitment to exploring and advancing cutting-edge research, innovation, and collaborative initiatives within our community. The program we have meticulously prepared is designed to foster meaningful discussions, share valuable insights, and establish connections that will contribute to the growth and development of our field.

Our program includes a keynote speech by the renowned expert Prof. Qi Feng, thought-provoking invited presentations by Prof. Dengwei Hu, Dr. Imalka Jayawardena, Dr. Han Yu, and Dr. Ruixuan Xue, as well as a rich array of presentations covering a wide spectrum of topics. We are honored to have such a distinguished group of researchers, scholars, and professionals joining us from around the world. I am confident that the exchange of ideas and experiences during this symposium will not only deepen our understanding of current challenges but also inspire novel solutions and avenues for future research.

As the Program Chair, I would like to express my sincere gratitude to our keynote speaker, invited speakers, all authors and presenters of the technical sessions, session chairs, the Faculty of Graduate Studies, all staff supporting the event, and the dedicated members of the organizing committee.

I look forward to meeting each of you and engaging in insightful discussions during the symposium. May this event be a source of inspiration, learning, and lasting connections.

Prof. (Mrs.) Galhenage A. Sewvandi

Program Chair

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Keynote Address

Development of Functional Nanomaterials Using Soft Chemical Process

Qi Feng

Faculty of Engineering and Design, Kagawa University, Japan.

Soft chemical process is an inorganic material synthesis process using host-guest reactions, such as intercalation/deintercalation reactions and ion-exchange reactions which can be carried under mild reaction conditions. This process is unique and powerful for development of functional nanomaterials. Fig. 1 gives an overview of our research on the soft chemical process.

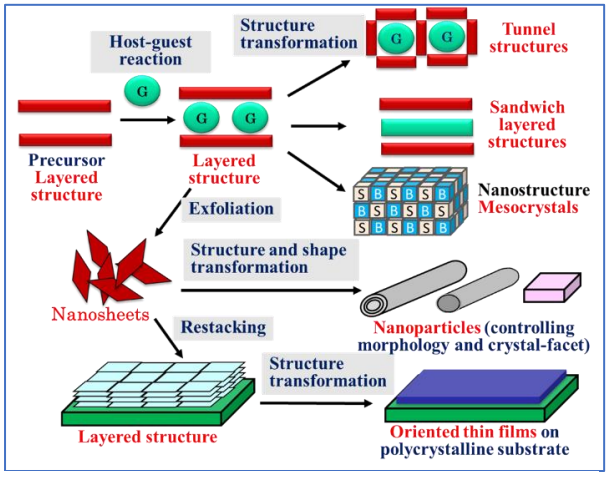

Fig. 1. Overview of soft chemical process for synthesis of functional inorganic materials

We use a layered compound as starting material and intercalate guest ions or molecules into its interlayer, then transform the layered structure to other structures. When the layered structure is transformed to a tunnel structure, the tunnel size is dependent on the size of guest ion or molecule, namely the tunnel structure can be controlled by the size of ion or molecule. If the guests polymerize in 2 dimensions, a sandwich layered structure is constructed. A mesocrystalline material constructed from nanocrystals with the same crystal-axis orientation can be obtain easily by a topochemical structural transformation reaction from the layered compound. In this case, the chemical composition of the mesocrystalline material can be regulated by host-guest reaction of the starting layered compound. The layered compound can be exfoliated into this structural unit nanosheets. The nanosheets have wide applications to prepare nanomaterials and nanocomposites, such as nanotubes, nanofibers, and nanocrystals, nanosheet thin film, and mesocrystalline thin films.

In this presentation, we will show some our research on the development of functional nanomaterials and their applications, including four topics. (1) Soft chemical synthesis of mesocrystalline materials for enhanced performance of piezoelectric materials and lithium-ion batteries. (2) Soft chemical synthesis of TiO_2 nanocrystal with specific crystal facet for development of high performance photocatalysts and solar cells. (3) Fabrication of high-performance reverse osmosis (RO) membranes using porous layered titanate nanosheets. (4) Ion-sieve adsorbents for selective removal of Sr^{2+} in radiation-contaminated water of Fukushima No. 1 nuclear power plant accident.

Invited Speeches

Fluorinated Polyimide/Barium Titanate/Polyimide/Fluorinated Polyimide Sandwich Film for High Temperature Energy Storage

Peimei Yuan[1], Dengwei Hu[2]

[1]*Faculty of Chemistry and Chemical Engineering, Engineering Research Center for Titanium Based Functional Materials and Devices in Universities of Shaanxi Province, China.*

[2]*Baoji University of Arts and Sciences, 1 Hi-Tech Avenue, Baoji 721013, China.*

Polymer-based composite materials, as crucial components of advanced dielectric capacitors, have broad prospects due to their simultaneous utilization of the high dielectric constant of ceramic fillers and the strong dielectric breakdown strength of polymer matrices. Because many dielectric film capacitors operate under harsh conditions, they have been developed to possess high-temperature resistance, outstanding energy storage performance, and excellent efficiency. Barium titanate (BT), as an inorganic nanofiller, was prepared using a solid-state hydrothermal method. Subsequently, polyimide (PI) with a higher glass transition temperature was prepared as the polymer matrix using an in-situ polymerization method; and fluorinated polyimide (FPI) was prepared by modifying PI. FPI/BT/PI/FPI sandwich nanocomposite films were prepared using a layer-by-layer spinning coating process. By adding BT to adjust the dielectric constant (k) of the intermediate layer, a low-k/high-k/low-k three-layer structure was formed, and according to the characteristics of serial capacitors, the dielectric constant was moderate. The clever design of the low-k/high-k/low-k sandwich polymer combines the advantages of the high-k layer of BT/PI with the low dielectric loss and high dielectric strength of the low dielectric constant layer. Meanwhile, after fluorination treatment, the bandgap width of FPI increases. This means a larger energy gap exists in the material, aiding in restricting the transport of charge carriers, thereby enhancing insulation performance. Additionally, FPI has a greater transmittance compared to non-fluorinated polyimide, exhibiting excellent optical performance, and is suitable for applications requiring high transparency and optical properties. Compared to single-layer BT/PI and FPI, the energy density and effective polarization of FPI/BT/PI/FPI have been greatly improved. When 3 wt% BT is added to the intermediate layer, the energy density and effective polarization of the composite film increase by 6.7 and 4.67 times, respectively. This work provides a meaningful and effective method for achieving excellent energy storage performance in PI-based polymers.

Engineering the Next Generation of High Efficiency Solar Cells: Materials and Device Concepts

K. D. G. Imalka Jayawardena, W. Hashini K. Perera, S. Ravi P. Silva

Advanced Technology Institute, School of Computer Science and Electronic Engineering, University of Surrey, Guildford, Surrey, GU2 7XH, United Kingdom.

The growing concerns on the dependance of fossil fuels as a source of energy has led to increased attention on the development of renewable energy technologies. Of the energy mix that is likely to contribute towards the net zero targets set by a majority of countries globally, photovoltaics is anticipated to play a key role. Prior to the last decade, photovoltaics based on silicon as the absorber was considered to be a costly solution as a renewable energy technology. However, scaling up of manufacturing compared with other practices has resulted in a dramatic drop in prices leading to a growth in the uptake of photovoltaics.

The last decade has also seen a tremendous growth in terms of research at both academic and pilot level studies of thin film photovoltaic technologies. Of the materials widely investigated, metal halide perovskites have rapidly emerged in terms of performances that are arguably becoming comparable with silicon. With champion power conversion efficiencies having risen from 3.8% in 2009 to 26.1% in 2023, these are anticipated to further increase the deployment of high efficiency photovoltaics.

Within this talk, I will cover the historical developments of this fascinating material, including the materials science behind the improvements in perovskite solar cell efficiency. This will include materials that passivate defects of the perovskite semiconductor and new contact modifiers that reduce parasitic optical and electronic losses. The role of perovskites as an absorber that can be combined with silicon providing a first point of entry to the market based on tandem architectures will also be discussed together with potential avenues for subsequent generations based on all perovskite multijunction solar cells.

Development of Titania-Supported Iridium Catalysts for the Green Synthesis of Nitrogen-Containing Chemicals

Han Yu[1], Qi Feng[2], Kenji Wada[3]

[1]*Faculty of Chemistry and Chemical Engineering, Engineering Research Center for Titanium Based Functional Materials and Devices in Universities of Shaanxi Province, Baoji University of Arts and Sciences, 1 Hi-Tech Avenue, Baoji 721013, China.*

[2]*Faculty of Engineering and Design, Kagawa University, Takamatsu 761–0396, Japan.*

[3]*Faculty of Medicine, Kagawa University, Kagawa 761-0793, Japan.*

At the end of last century, human beings' living environment is facing serious challenges with the developing of industry. In particular, the chemical industry, while bringing people great benefit, has also brought severe environmental pollution problems. In this context, green chemistry had become important issues to achieve sustainable development. Nitrogen-containing chemicals are important building blocks in pharmaceuticals, agrochemicals and organic synthesis. The green synthesis of nitrogen-containing chemicals from amines with alcohols has attracted much attention on account of its clean output. On the other hand, heterogeneous catalysis has advantages from both practical and environmental viewpoints, such as easy recovery and reuse of the catalysts, prevention of contamination of the products by heavy metallic species, and other factors. In the present study, we focus on the development of titania supported iridium catalysts, which enable the catalytic synthesis of nitrogen-containing chemicals from ammonia/amines with alcohols. The catalysts showed excellent activities and the byproduct are pollution free. The main contents of this dissertation are summarized as follows.

In the first study, we demonstrate the synthesis of tertiary and secondary amines from aqueous ammonia and benzylic alcohols by titania-supported iridium catalyst. It is a successful example of heterogeneous systems at moderate temperature without either additional solvent or high pressure. The catalytic system showed good tolerance to the atmosphere condition and performed rapidly to give tribenzylamine a yield of over 99% within 6 hours in argon, and well applicable with various primary and secondary benzylic alcohols. The crystal structure of titania supports for iridium catalysts strongly affected their activity. The catalysis smoothly proceeded on larger scales. The catalyst could be easily reused and run at least for 5 cycles without significant loss of activity.

In the second study, we report the modification of titania supports for iridium catalysts by phosphorus species, which greatly enhanced the activity of catalyst for the synthesis of benzimidazoles via hydrogen transfer. Two series of phosphorus-modified titanias were used: The phosphorus-doped rutile supported iridium catalysts showed nearly 5 times higher activity than the catalysts supported on unmodified rutile. XPS depth profile study substantiated that the dopant was present mainly on the surface of the rutile support. Therefore, a facile wet impregnation method was applied to modify the surface of anatase titania with phosphoric acid. The use of thus-modified titania enhanced the activity of the iridium catalysts by more than 2.7 times based on a higher yield baseline.

In summary, an environmentally friendly and cost-effective catalytic system based on titania support has been initially developed. It successfully achieved the green conversion of inorganic ammonia to organic amines as well as organic amines to nitrogenous heterocyclic compounds.

DLP Printing of BT/HA Nanocomposite Ceramic Scaffolds Using Low Refractive Index BT Crystals

Ruixuan Xue, Dengwei Hu

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The piezoelectricity in natural bone is a key factor for bone regeneration. Biological piezoelectric materials have significant potential for bone repair and energy harvesting owing to their excellent biocompatibility and piezoelectric effect. The $BaTiO_3/Ca_{10}(PO_4)_6(OH)_2$ (BT/HA) composite material is an outstanding representative of biological piezoelectric materials, which has not been individually designed using digital light processing (DLP) 3D printing because of the large difference in the refractive index of its components. Therefore, in this work, double-sided-tooth plate-like BT crystals with high curvature were prepared via a hydrothermal process, and BT/HA nanocomposite ceramic scaffolds were fabricated by DLP 3D printing technology. The nanostructure, dielectric properties, and piezoelectric energy harvesting performance of the BT/HA nanocomposite ceramic scaffolds were evaluated. The influences of different morphologies and contents for BT on the piezoelectric potential and stress distribution were analyzed based on a multi-physics coupling finite element simulation. The cell proliferation and adhesion abilities were investigated also. The BT/HA nanocomposite ceramic scaffolds present excellent dielectric properties, cell proliferation and adhesion abilities, and an open circuit voltage of 8 V during piezoelectric energy harvesting. The material properties and multi-physics coupling finite element analysis imply that the double-sided-tooth plate-like BT plays an important role for the fastness structure and electric filed distribution in the BT/HA nanocomposite. Thus, this work provides a strategy for the application of the customized BT/HA nanocomposite ceramic scaffolds in new-generation orthopedic implants and biological energy harvesting.