SCO-Young Scientist Profile

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Details of research work carried out in S&T –

Higher dependence on non-renewable energy sources has resulted in serious global concerns and hence the development of clean & abundant substitutive energy resources is the need of the hour to overcome the obsession with fossil fuels. In this context, my work focuses on the development of nanoengineered lead-free inorganic halide perovskites (LF-IHP) as highly active, selective, and stable photochemical catalysts mimicking natural photosynthesis reduction of CO_2 to usable energies. The major novelty lies in real-time testing of nanocatalysts integrated as regenerative sun ink on handheld prototypes. Through the work, my team is making concerted efforts to provide solutions to many of the concerns mentioned below:

1.) The high recombination rate of photogenerated charge carriers in LF-IHP leads to a low solar-to-fuel conversion rate and rapid deterioration.
2.) Additionally, aggregation and structure distortion due to low stability of LF-IHP in polar protic solvents compared to nonaqueous medium hinders its usage, although water is a far better medium for CO_2 reduction and/or photocatalysis processes.
3.) Further, usually, CO and CH_4 evolve from nonpolar solvents employed as reaction medium instead of catalysis reaction leading to errors in efficiency calculation. Interestingly, to date, none of the reported IHP materials can be dispersed effectively in the water, and despite remarkable photophysical properties and PCE, IHP integrated devices are yet to be commercialized. This is primarily accredited to the use of lead, known to cause hazards to the ecosystem.

Despite, the urgency to overcome the kinetic limitation of the initial CO_2 conversion step, which is a determining factor across the different techniques, great success lies in the efficiency to reduce CO_2 to value-added products without increasing anthropogenic CO_2 emissions, which is very well possible using LF-IHP as shown by our preliminary studies.

Associated SCO-YSC Theme: Sustainable Energy and Energy Storage

Statement of Innovation –

Portable devices integrated with photocatalytically active ink based on solar simulated LF-IHP colloidal nanocrystals for CO_2 conversion to value added fuels will be fabricated. Development of sun ink-based prototypes without employing expensive inert material as electrodes and its testing at real sites will help not only in validating experiments but also to gauge economics involved during the commercialization of products achieved as a result of research done in the laboratory. The high quality outcomes in terms of improved process conversion efficiency will help in commercializing the technology even at grass root levels. It is also foreseen that the sun ink synthesized using a gram scalable process using earth-abundant elements is bound to lower the production costs drastically thereby lowering India's greater dependence on non-renewable energy sources. LF–IHP sun ink may become an attractive substitute due to its unique optoelectronic features and simplicity, and hence the work is expected to stimulate further innovation within carbon-neutral, that is CCUS technologies.

Major awards/ Achievements –

1. "Excellence in Teaching" prize jointly awarded by Lion's Club and Woman Doctor's Wing, Indian Medical Association, India, Sep 2020.
2. Overseas Travel Grant for Young Faculty from Gramaudyogik Shikshan Mandal Trust, India, Nov 2019 **(Amount – 1,00,000 INR)**.
3. "Young Scientist Encouragement Award" from ATA Scientific Instruments, NSW Australia, Nov 2017 **(Amount – 1500 AUD)**.

Possible collaboration with SCO countries –

My group is actively engaged in proposal submission, knowledge transfer, development of prototypes for energy conversion, chemical sensors & medical diagnostics, engineered nanomaterials synthesis and so on through collaborations. Last year, we had collaborated with Prof. Tamara Morgaleva, Centre for Biotesting the Safety of Nanotechnology and Nanomaterials, Tomsk State University, Russia as well as Prof. Xuehua Zhang, currently based at Alberta University, Canada. Dr. Wei Li (presently at Aston University, UK) is the current collaborator through DST Carbon Capture Challenge project. We welcome partnership in mutually interested research areas and more specifically in CCUS technologies and hydrogen economy at all levels.

Key words –

Hierarchical Nanomaterials, Heterogeneous Catalysis, Green Chemistry, CO_2 Conversion, Defect Engineering and Piezocatalysis.