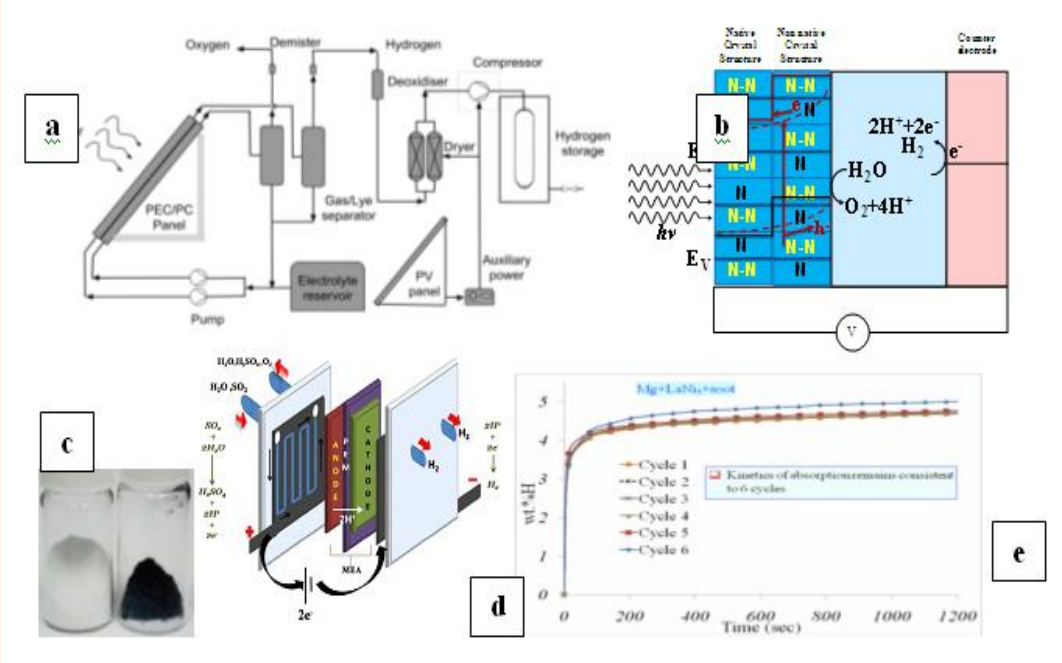
Technology Systems Programme

2.) Generation of Solar Hydrogen

This is a multi-institutional research project undertaken by a consortium comprising IIT Kanpur, IIT Madras, Dayalbagh Educational Institute Agra, IIT Jodhpur, CECRI, Karaikudi and BARC, Mumbai. The effort was initiated and supported by the Technology Systems Development Program of DST, New Delhi. The project aims at developing scalable designs of solar hydrogen generation systems using multiple technologies. Besides bridging the technical challenges that exists at multiple lengths scales in the development of a solar energy conversion technology, the initiative was planned to bridge the complementary strengths of universities and national laboratories so as to map the laboratory-scale prototype to the corresponding field-scale device.

As a result of the collaboration, modular prototypes have been fabricated into which functional materials have been integrated. These prototypes are also being replicated for large area solar energy conversion to hydrogen. The central emphasis of the project has been to design, synthesize and characterize the best possible solar-chemical-materials combination suitable for large scale applications. The goal is to integrate these materials into a photoreactor to generate hydrogen and oxygen with water as the feed. Materials close to international standards and general heuristics for material design have been developed. Apart from the photocatalytic and photo-electrocatalytic route, an electrolyzer integrated to photovoltaic modules has also been fabricated. Catalyst materials for sulfuric acid decomposition and electrode materials for aqueous SO2 electrolysis that serve to complete the solar-thermochemical route for hydrogen generation have been identified.



R & D output at multiple-length scales: (a) Solar-H2 process flowsheet; (b) Material design involving native/non-native heterostructures to promote electron-hole separation; (c) Functionalization of material to make a "white" transition metal oxide to "black" thereby increasing the photon absorption cross-section; (d) Sulphuric acid electrolyzer; and (e) Hybrid-organic-metallic alloy for H2 storage.

Scientists participating in the project are listed below

Name	Organization/ Contact Information	Focus area
Dr. Malay Das Dr. Raj Pala Dr. S. Sivakumar Dr. A. Subramaniam Dr. K. Muralidhar	**Indian Institute of Technology Kanpur** mkdas@iitk.ac.in rpala@iitk.ac.in srisiva@iitk.ac.in anandh@iitk.ac.in kmurli@iitk.ac.in (coordinator)	Process design; photoreactor design and fabrication; Design and synthesis of photocatalysts and their integration into photoreactors; Hydrogen storage materials
Dr.S.Srinivasa Murthy Dr. M. P. Maiya Dr. P. Selvam Dr. B. Viswanathan	**Indian Institute of Technology Madras** ssmurthy@iitm.ac.in mpmaiya@iitm.ac.in selvam@iitm.ac.in bvnathan@iitm.ac.in	Hydrogen storage devices; photocatalyst design, synthesis and characterization
Dr. Sahab Dass Dr. Vibha R	**Dayalbagh Educational Institute, Agra** drsahabdas@gmail.com vibhasatsangi@gmail.com, rohitshrivastav.doi@yahoo.co.in	Synthesis and characterization of photo-electro-chemical

Satsangi Dr.Rohit Shrivastav		catalysts
Dr. R. Sharma	**Indian Institute of Technology Jodhpur** rakeshiisc@gmail.com	Synthesis and characterization of photocatalysts
Dr. S. Bharadwaj Dr. A.K. Tripathi Dr. M. R. Pai Shri. A.B. Banerjee Dr. H. S. Sodaye Dr. T. K. Dey	**Bhabha Atomic Energy Research Center, Mumbai** shyamala@barc.gov.in catal@barc.gov.in mrinalr@barc.gov.in atinmb@barc.gov.in hemant@barc.gov.in tkdey@barc.gov.in	Development of polymer exchange membrane; photocatalyst development, material development for SO2 electrolysis
Dr.S. Ravichandran	**Central Electrochemical Research**Institute,Karaikudi sravi371@gmail.com	Electrocatalyst development

Publications arising from the project are listed below. These publications can be seen in the accompanying document.

Dayalbagh Educational Institute, Agra:

- Nirupama Singh, Surbhi Choudhary, Sumant Upadhyay, Vibha R. Satsangi, Sahab Dass, Rohit Shrivastav (2014). Nanocrystalline Zn1−xAgxOy thin films evolved through electrodeposition for photoelectrochemical splitting of water. J Solid State Electrochem. 39, 11860–11866.
- Sumant Upadhyay, Dipika Sharma,Nirupama Singh, Vibha R. Satsangi, Rohit Shrivastav, Umesh V. Waghmare, Sahab Dass (2014). Experimental and first-principles theoretical studies on Ag-doped cuprous oxide as photocathode in photoelectrochemical splitting of water. J Mater Sci. 49 (2), 868-876.
- Surbhi Choudhary, Anjana Solanki, Sumant Upadhyay, Nirupama Singh, Vibha R. Satsangi, Rohit Shrivastav, Sahab Dass (2013). Nanostructured CuO/SrTiO3 bilayered thin films for photoelectrochemical water splitting. J Solid State Electrochem., 013, 2139-2147.
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Central Electro-Chemical Research Institute, Karaikudi:

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Bhabha Atomic Research Center, Mumbai:

- A. M. Banerjee, M. R. Pai, R. Tewari, Naina Raje, A. K. Tripathi, S. R. Bharadwaj and D. Das, A Comprehensive Study on Pt/Al2O3 Granular Catalyst used for Sulfuric Acid Decomposition Step in Sulfur-Iodine Thermochemical Cycle: Changes in Catalyst Structure, Morphology and Metal-Support Interaction, Applied Catalysis B: Environmental, 162 (2015) 327-337. I.F. (PDF attached) (Impact factor: 6)
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- Sushma A. Rawool, Mrinal R. Pai, A. M. Banerjee and S. R. Bharadwaj, Photocatalytic H2 Generation over P-N Junctions of NiO-TiO2 and Ternary Cuo-NiO-TiO2 Composites under Sunlight" presented in the 5th Interdisciplinary Symposium on Materials Chemistry (ISMC-2014) held on 9-13th December 2014 at TSH, Anushakti Nagar, Mumbai p. 398.
- Ashish Nadar, A. M. Banerjee, M. R. Pai, R. V. Pai, A. K. Tripathi and S.R. Bharadwaj, Preparation, Characterization and Catalytic activity Evaluation of Fe2O3/SiO2 Catalyst for Sulfuric Acid Decomposition Reaction, presented in the 5th Interdisciplinary Symposium on Materials Chemistry (ISMC-2014) held on 9-13th December 2014 at TSH, Anushakti Nagar, Mumbai p. 400.
- Mrinal R. Pai, Atindra M. Banerjee, S. R. Bharadwaj, "Sunlight Driven photocatalytic hydrogen generation over CuO- TiO2 Nanocomposites" in the 4th Interdisciplinary Symposium on Materials Chemistry (ISMC-2012) held on 11-15th Dec. 2012 at TSH, Anushakti Nagar, Mumbai. p. 353.
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Indian Institute of Technology Jodhpur:

- Nanocatalyst for Hydrogen production via water splitting, Pratibha Mittal and Rakesh K Sharma CATSYMP21 Indian Institute of Chemical Technology (CSIR-IICT) Hyderabad, India, February 11-13,**2013**
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