Annexure – IX

UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

NEW DELHI – 110 002

PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. TITLE OF THE PROJECT... **Synthesis, Characterization and Optical Properties of Metal-Metal and Metal-Dielectric Core-Shell Nanoparticles**

2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR: Dr. Kuntal Chatterjee

3. NAME AND ADDRESS OF THE INSTITUTION: Dept. of Physics,
Vidyasagar University, Midnapore

4. UGC APPROVAL LETTER NO. AND DATE: File No. 42-1069/2013 (SR)__dated 22/03/2013

5. DATE OF IMPLEMENTATION .....15th May 2013

6. TENURE OF THE PROJECT .....2 years

7. TOTAL GRANT ALLOCATED .....Rs. 2,00,000/-

8. TOTAL GRANT RECEIVED .....Rs. 1,62,500/-

9. FINAL EXPENDITURE .....Rs. 1,57,077/-

10. TITLE OF THE PROJECT ..... Synthesis, Characterization and Optical Properties of Metal-Metal and Metal-Dielectric Core-Shell Nanoparticles

11. OBJECTIVES OF THE PROJECT:

This project involves an experimental approach to study optical properties of bimetallic and metal-dielectric heterogeneous C/S-NPs, identifying as a main objectives:

a) To establish a lucid synthesis procedure of by chemical intuition and empirical synthetic approaches.
b) Implementation of experimental techniques to study the structural, chemical and morphological details of the prepared C/S-NPs.
c) To investigate experimentally and theoretically the optical properties of the samples with different materials and dimensions of the core and shell.

d) Publicize the obtained results through meeting presentations and articles submitted to international journals.

12. WHETHER OBJECTIVES WERE ACHIEVED .....

Project was initiated with the aim to synthesize metal –metal and metal dielectric core-shell structures for optical properties which can be utilized for the benefit of society. The metal-metal core shell structures were prepared, analysed but found that they are not that much impressive for practical applications. But novel studies on Metal dielectric structures showed immense practical applications in dye sensitized solar cell. Ag-TiO2 and Au TiO2 core shell structures have been reported for enhanced performance of DSSC. Apart from the initial goal the project further extended to study the effect of dielectric –dielectric heterostructures and their optical response in environmental application. It was found that silica supported tiO2 nanostructures shows excellent photocatalytic dye degradation under visible light irradiation. Photocatalytic and antibacterial activity of cadmium sulphide/zinc oxide nanocomposite with varied morphology has been studied with magnificent results. It was also seen that morphology variation of Fe2O3 plays crucial role in Photocatalytic and antibacterial applications. All together the project has achieved the goal and with the help of the project further scientific goals had been set and pursued.

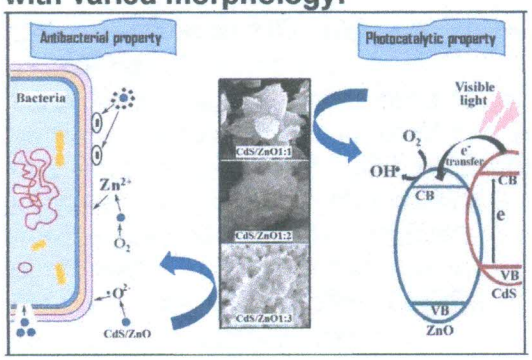
13. ACHIEVEMENTS FROM THE PROJECT .....

Fabrication of efficient dye-sensitized solar cells with photoanode containing TiO2– Au and TiO2–Ag plasmonic nanocomposites:

Herein, we established the effect of incorporation of two types of plasmonic nanocomposites, TiO2–Au and TiO2–Ag in different ratios, in the TiO2 photoanode of dye-sensitized solar cells DSSCs). Electrophoretic deposition technique (EPD) has been utilized for the deposition of these nanocomposite photoanodes. The high-resolution transmission electron microscopy reveals that the nanocomposites, TiO2–Au and TiO2–Ag, have a wide size distribution of Au (5–60 nm) and Ag (20–130 nm) nanoparticles embedded in the TiO2 matrix. The UV–Visible absorption spectra of these nanocomposite films reveal the enhancement in the optical density due to the plasmonic effect. The DSSC based on photoanode consists of plasmonic nanocomposite TiO2–Au:TiO2–Ag (3:1 ratio) showed power conversion efficiency (PCE) of 10.9% which is 187% higher than that pristine TiO2 counterpart. The enhancement in the PCE has been confirmed by the photoluminescence and electroimpedance spectroscopy indicating that both Au and Ag play an important role in enhancing the PCE of DSSCs due to the plasmonic effect.

[Journal of Materials Science: Materials in Electronics (2018) 29:18209–18220]

Photocatalytic and antibacterial activity of cadmium sulphide/zinc oxide nanocomposite with varied morphology:



Nanocomposites with multifunctional application prospects have already dragged accelerating interests of materials scientists. Here we present CdS/ZnO nanocomposites with different morphology engineering the precursor molar ratio in a facile wet chemical synthesis route. The materials were structurally and morphologically characterized by X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), energy dispersive X-ray analysis (EDX) and high-resolution transmission electron microscopy (HRTEM). The growth mechanism of the composite structure with varying molar ratio is delineated with oriented attachment self assemble techniques. Photocatalytic activity of CdS/ZnO nanocomposites with varying morphology were explored for the degradation of rhodamine B (RhB) dye in presence of visible light irradiation and the results reveal that the best catalytic performance arises in CdS/ZnO composite with 1: 1 ratio. The antibacterial efficiency of all nanocomposites were investigated on Escherichia coli, Staphylococcus aureus and Klebsiella pneumonia without light irradiation. Antibacterial activity of CdS/ZnO nanocomposites were studied using the bacteriological test-well diffusion agar method and results showed significant antibacterial activity in CdS/ZnO composite with 1:3 ratio. Overall, CdS/ZnO nanocomposites excel in different potential applications, such as visible light photocatalysis and antimicrobial activity with their tuneable structure.

[Journal of Colloid and Interface Science 480 (2016) 9–16]

Photocatalytic and Antibacterial Performance of a-Fe2O3 Nanostructures:

Morphology engineered a-Fe2O3 nanostructures with magnificent antibacterial property and excellent photocatalytic activity have been presented to address the long-standing environment issue. After tuning the morphology via solvothermalroute the products were characterized by morphological,structural and elemental analysis. The visible-light photocatalytic activity of a-Fe2O3 nanostructures was evaluated by using them to degrade methylene blue (MB) dye under visible light irradiation in the presence of H2O2. Amidst the series, nano bead-like structure exhibited the greatest activity toward MB degradation with 90% degradation efficiency. Unique bead-like structure having fluctuant diameter is thought to play a key role in the enhanced separation of electron-hole pairs of a-Fe2 O3 and results superior photocatalytic activity. On the other hand all the shape variants of a-Fe2O3 nanostructures showed brilliant antibacterial effect against Gram negative (Escherichia coli) bacterium. Based on the current findings, the presented a-Fe2O3 nanostructures with their superb photocatalysis andantibacterial activity can be a promising candidate for industry to abate the ever rising environmental threat.

[ChemistrySelect 2017, 2, 3068 – 3077]

Silica supported TiO2 nanostructures for highly efficient photocatalytic application under visible light irradiation:
Titanium dioxide decorated silica nanospheres have been synthesized by a simple wet chemical approach. X-ray diffraction, electron microscopy and energy dispersive X-ray analysis revealed that anatase phase of TiO2 nanostructures, with exposed {0 0 1} and {10 1} facets, are anchored onto the amorphous silica spheres of _60 nm diameter. The photocatalytic activity of the sample under visible light irradiation was examined. It is found that photocatalytic efficiency of the material is better than commercial P25 TiO2 photocatalyst and the result is attributed to the unique synergistic effect of SiO2– TiO2 nanocomposite structure resulting enhanced charge separation and charge transfer.

[Materials Research Bulletin 76 (2016) 353–357]

Morphology dependent magnetic properties of α-Fe2O3 nanostructures:

Well crystalline α-Fe2O3 nanomaterials with a wide range of morphology variation have been successfully synthesized by solvothermal route. The synthesized products have been characterized for structural and morphological details by employing x-ray diffraction patterns, transmission electron microscopy, field emission scanning electron microscopy and energy dispersive x-ray spectroscopy. Various unique shapes of α-Fe2O3 nanocrystal have been modelled on the basis of their growth evolution. The effect of morphology of α-Fe2O3 nanocrystals on their magnetic behaviour has been studied by investigating temperature and field dependence of magnetization. The results are analyzed considering all the possible surface anisotropy and lattice strain evolved due to their surface structure. This comprehensive study of morphology dependent magnetic behaviour of α-Fe2O3 nanomaterials offers a better opportunity to tune the materials in the desired technological applications.

[Mater. Res. Express 1 (2014) 046104]

14. SUMMARY OF THE FINDINGS (IN 500 WORDS)

The project enabled our lab to gather in depth knowledge on synthesis, analysis and application for energy and environmental issues of different metal –dielectric and dielectric – dielectric heterostructured systems. Various human resources have involved in this project and got themselves trained in this research direction. Collaborative scientific network has been established with this project activities.
Summarily the following research outcome have been evolved out of this project:

- Fabrication of efficient dye-sensitized solar cells with photoanode containing TiO2– Au and TiO2–Ag plasmonic nanocomposites
- Photocatalytic and antibacterial activity of cadmium sulphide/zinc oxide nanocomposite with varied morphology
- Photocatalytic and Antibacterial Performance of a-Fe2O3 Nanostructures
- Silica supported TiO2 nanostructures for highly efficient photocatalytic application under visible light irradiation
- Morphology dependent magnetic properties of α-Fe2O3 nanostructures

15. CONTRIBUTION TO THE SOCIETY :

Two burning issues of our society are energy and environment. The research on these direction is utmost important for the society. Here in this project we have addressed the energy issue by developing high performance dye sensitized solar cell. We have also shown the apt materials for photocatalytic dye degradation which actually contributes in environment pollution control. Our study also focused on the antibacterial property investigation of some heterostructured materials which address the health & environment issues. In a nutshell the outcome from this project has an appreciable impact on societal needs.

16. WHETHER ANY PH.D. ENROLLED/PRODUCED OUT OF THE PROJECT.....

Sankalpita Chakrabarty, Tushar Kanti Jana and Arnab Pal, these three scholars from Vidyasagar University, West Bengal and Swati Bhardwaj from The LNM Institute of Information Technology, Jaipur, mainly contributed in this project and they published their findings in reputed international journals. Their research findings, in this project, are included in their Ph.D. works and eventually all these four scholars have awarded Ph.D. degree from the Dept. of Physics, Vidyasagar University and The LNM Institute of Information Technology, Jaipur respectively.

17. NO. OF PUBLICATIONS OUT OF THE PROJECT : 6 (International Journal)

(PLEASE ATTACH) Attached herewith.

Kuntal Chatterjee 8.11.23

(PRINCIPAL INVESTIGATOR)

(Seal)

Dr. Kuntal Chatterjee
Associate Professor
Department of Physics
Vidyasagar University
Midnapore - 721102, W.B.

21/11/23

(REGISTRAR/PRINCIPAL)

Registrar
Vidyasagar University
Midnapore - 721102
West Bengal, India