Quantum dots impregnated-mesoporous TiO_2 nanospheres for environmental remediation

S. Harish[(1,2)*], J. Archana[(2)], M. Navaneethan[(2)], M. Shimomura[(3)], Y. Hayakawa[(1,3)]

[(1)] *Research Institute of Electronics, Shizuoka University, 3-5-1 Johoku, Naka-Ku, Hamamatsu, Shizuoka 432-8011, Japan.*
[(2)] *Functional Materials and Energy Devices Laboratory, Department of Physics and Nanotechnology, SRM Institute of Science and Technology, Kattankulathur-603 203, India*
[(3)] *Graduate School of Science and Technology, Shizuoka University, 3-5-1 Johoku, Naka-Ku, Hamamatsu, Shizuoka 432-8011, Japan*
e-mail: aravindharri@gmail.com

1. Introduction – Treatment of organic and inorganic pollutants using semiconductor oxide as photocatalyst has been extensively studied [1]. To enhance the energy conversion efficiency, coupling of different photocatalyst semiconductor is a promising method that enhances photocatalytic response to visible light and increases the charge separation and extends the energy range of photoexcitation [2]. The present study describes a soft template route to synthesize ZnS nanoparticles impregnated mesoporous TiO_2 spheres with enhanced photocatalytic activity. The effect of metal sulphide concentration on the phase and morphology was investigated. The photostability and photocatalytic mechanism of mesoporous TiO_2 is proposed.

2. Experimental –The mesoporous TiO_2 spheres were dispersed in 50 mL of water and different mole concentration of zinc acetate (0.025, 0.050, 0.075 and 0.1 M) and thioacetamide (0.025, 0.050, 0.075 and 0.1 M) were added. Pyridine was added as a capping ligand. The reaction was allowed to stir for 12 h. The white solution was transferred to a 100 mL Teflon-lined stainless steel autoclave, and heated at 150 °C for 15 h. The resulting product was collected and dried at 100 °C for 10 h. The samples were termed as Ti for pure mesoporous TiO_2, TiZ-1 for 0.025 M of ZnS, TiZ-2 for 0.050 M of ZnS, TiZ-3 for 0.075 M of ZnS and TiZ-4 for 0.1 M of ZnS,

3. Results and Discussion - Image 1 shows the FESEM images of (a) TiO_2 and (b), (c) TiO_2/ZnS composites. The impregnation of ZnS nanoparticles (3-5 nm) on the surface of TiO_2 mesospheres was achieved by soft template assisted solvothermal approach. XRD and elemental analysis confirmed the presence of ZnS in TiO_2 nanostructures. The morphological analysis showed that ZnS nanoparticles were firmly immobilized on the TiO_2 mesospheres, which improved electron and hole pair separation at the TiO_2/ZnS interface. The photocatalytic activity of the mesoporous nanostructures was assessed by the photodegradation of methylene blue (MB) as a model pollutant. It was found that mesoporous TiO_2 impregnated with ZnS nanoparticles remarkably enhanced reaction activity compared with the mesoporous TiO_2. The maximum degradation efficiency was observed for 0.025 M of ZnS impregnated on TiO_2. The MB related absorption peak completely disappeared after 32 min of irradiation (Image.1(d)). Photo-charge scavenger analysis indicated that hydroxyl radicals played a pivotal role in the photodegradation mechanism. The mesoporous photocatalyst was stable and could be used repeatedly under light irradiation.

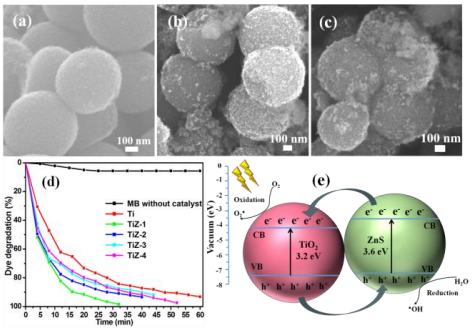

Image 1. FESEM of (a) TiO2, (b), (c) TiO_2/ZnS, (d) photocatalytic degradation and (e) mechanism.

4. Conclusions - The assessment of photocatalytic degradation of organic compound using the TiO_2/ZnS composite revealed a higher reaction rate compared with that of pure mesoporous TiO_2. The maximum degradation efficiency was observed for 0.025 M of ZnS, where the MB related absorption peak completely disappeared after 32 min of irradiation. After four cycles of reuse, the catalyst showed significant capacity for dye degradation

5. References

[1] S. Harish, et al., *Dalton Trans.*, **44**, (2015) p. 10390.