ABSTRACT

Recently, a great attention has been focusing to convert the solar energy into electric or thermal energy. Photocatalysts are able to convert the solar energy to chemical energy while oxidizing or reducing the materials, which allows the removal of toxic organic compounds and harmful materials and its widely used in various applications includes purification of air/water in the environment. Titanium dioxide (TiO₂) in both anatase and rutile phase has great importance in energy and environment concern mainly due to its promising use in cost-effective photovoltaic and photocatalytic applications. Mesoporous TiO₂ hollow spheres with tunable shell and cavity shown an enhanced photocatalytic activity under UV irradiation. In view of the literature, many methods have been developed to prepare a TiO₂ hollow sphere. Graphene is another exciting material for fundamental and applied solid-state physics research. Hitherto, chemically derived GO has been receiving more attention for large-scale electronics, because its solubility in a variety of solvents that allows ease of wafer-scale deposition. It has been reported that the graphene can act as an efficient electron acceptor in TiO₂/graphene composite. It is found that when combining TiO₂ with graphene, electrons at interface will transfer from TiO₂ to graphene owing to the energy level structure of the two materials and the heterojunction formed
at the interface which separates the photoexcited electron–hole pairs, thus hindering the charge recombination. Based on the unique properties of graphene, considerable efforts have been made to incorporate a graphene into TiO$_2$-based composite materials.

Electrospinning technique was employed to synthesize tubular TiO$_2$ nanofibers. The as-spun fibers were subjected to heat treatment at 800 °C for 1 h in air. By controlling the polymer concentration, pores of 30 - 60 nm were found on the side walls of the tubular nanofibers. During annealing, the average nanofiber diameter shrank from 150 nm to 120 nm. The structural properties were characterized by XRD analysis and Raman spectroscopy. Further, porous and tubular structure of the nanofibers was confirmed by SEM and HRTEM. The specific surface area of porous tubular nanofibers (PTNFs) was measured using Brunauer-Emmett-Teller (BET) method, which revealed a high surface area of 63 m$^2$ g$^{-1}$. Photodegradation of methyl orange demonstrated that the PTNFs have higher photocatalytic activity than nonporous nanofibers. The enhanced photocatalytic activity was attributed to high surface area of the porous and tubular structures.

Reduced graphene oxide (rGO) wrapped anatase mesoporous TiO$_2$ nanofibers (TNFs) were synthesized by using electrospinning technique along with soft chemical route. Structural and morphological results demonstrate the successful wrapping of nanofibers by rGO. Control over the composition of the composites leads to an efficient photogenerated charge carrier separation
across the interface of rGO and TNFs. As a result the photocatalytic activity of the composites enhanced greatly compared to TNFs.

Rutile TiO$_2$/rGO composite nanofibers with tubular and porous structure were synthesized by electrospinning technique with the help of soft chemical route. Structural and morphological results demonstrate the successful wrapping of nanofibers by rGO. The specific surface area of the composite nanofibers was measured using BET method, which revealed a high surface area of 210 m$^2$ g$^{-1}$. Control over the composition of the composites leads to an efficient photogenerated charge carrier separation, owing to electron injection from the conduction band of TiO$_2$ to rGO. TiO$_2$/rGO composite fiber can effectively reduces the electron hole recombination rate compared to bare TiO$_2$ which leads to enhanced photocatalytic activity can be attributed to the high surface area of rGO and the porous and tubular structure of TiO$_2$ nanofibers.

The enhanced photocatalytic performance of anatase/rutile mixed-phase TiO$_2$ nanofibers (MPTNFs)/ rGO composites were synthesized by an efficient electrospinning technique together with the help of soft chemical route. The mixed-phase nanofiber composites were characterized by XRD, SEM, TEM, XPS and Raman spectroscopy. A nanofibers wrapping onto rGO were conformed through structural and morphological analysis. The photocatalytic activity was evaluated by the degradation of methyl orange (MO); a significant increase in the reaction rate was observed in the mixed
phase composite materials under UV light irradiation. The synergistic effect of 1D anatase/rutile mixed phase and the electronic interaction of TiO$_2$ with rGO provide the subsequent improvement of adsorption capacity and further enhancement of the photocatalytic efficiency.