

Preparation of Graphene-ZnO Nanocomposites Using a Facile, Green Antisolvent Method

Wei-Chen Hu and Yung-Jung Hsu*

*E-mail: yhsu@cc.nctu.edu.twDepartment of Materials Science and Engineering,
National Chiao Tung University
1001 University Road, Hsinchu, Taiwan 30010, Republic
of China

Graphene is a single atomic layer of graphite and possesses 2D structure of sp²-bonded carbon network that is different from 1D carbon nanotubes and 3D ball-like C₆₀. Since it became experimentally accessible in 2004, graphene has attracted intense scientific interest due to its unique properties such as extremely high electron mobility (>15000 m²V⁻¹s⁻¹), large surface area and high chemical stability. It has been demonstrated that assembling semiconductor nanocrystals on graphene sheets can enhance the overall photoconversion efficiency. This enhancement results from the high electron mobility of graphene which can suppress the recombination of electron-hole pairs to improve the carrier utilization efficiency [1]. Till now, various kinds of graphene-semiconductor nanocomposites have been proposed and fabricated to further the advancement of photoconversion technology.

In this work, we developed a facile, environmentally benign antisolvent approach to prepare graphene-ZnO nanocomposites. Note that graphene was first obtained with the modified Hummers method [2], which was essentially composed of reduced graphene oxide (RGO). The antisolvent process involved the dissolution of ZnO powders in a deep eutectic solvent (DES), followed by the precipitation and growth of ZnO from DES upon injection into a bad solvent [3]. The DES used here was prepared by mixing urea with choline chloride at a 2:1 molar ratio, which is environmentally friendly and shows high solvency for many metal oxides, especially ZnO [4,5]. When ZnO-containing DES solution was injected into a bad solvent (water) showing no solvation ability toward ZnO, ZnO would be precipitated from the solution owing to the dramatic decrease in its solubility. With the addition of RGO sheets in the bad solvent, growth of ZnO in antisolvent process was accompanied with RGO decoration, resulting in the formation of RGO-ZnO nanocomposites. By modulating the amount of RGO employed, the content of RGO in the resultant RGO-ZnO nanocomposites can be readily controlled.

Figure 1 displays the typical SEM images of the as-obtained RGO-ZnO nanocomposites. Evidently, free-standing RGO sheets were rarely observed in the products, demonstrating the advantage of the current antisolvent approach to obtain graphene-semiconductor nanocomposites. Because of the high electrical conductivity of RGO, the photoexcited electrons of ZnO would preferentially transfer to RGO, leaving positively charged holes in ZnO to achieve charge carrier separation. This significant charge separation may further enhance the performance of RGO-ZnO nanocomposites when applied in photoconversion processes such as photocatalysis. Figure 2 compares the photocatalysis results of different samples in the photodegradation of rhodamine B (RhB). It is clearly seen that with the decoration of RGO, ZnO performed better in RhB photodegradation. This is mainly a result of the introduced RGO that can facilitate charge separation by

attracting the photoexcited electrons of ZnO, thus providing more charge carriers for RhB degradation. Among the three RGO-ZnO samples tested, RGO-ZnO with 5.0 wt% RGO showed the highest photocatalytic activity, suggesting that there is an optimal RGO content for improving the photoconversion efficiency of RGO-ZnO. To further highlight the structural importance of RGO-ZnO in enhancing the photocatalytic efficiency, a physical mixture of RGO and ZnO (RGO@ZnO) was also prepared and compared. As revealed in Figure 2, the RGO@ZnO sample did not perform as well as RGO-ZnO did, presumably owing to less contact of ZnO with RGO in RGO@ZnO. The limited contact of ZnO with RGO in RGO@ZnO may further retard charge carrier separation, leading to a poor photocatalytic performance as observed. The current study provides a facile yet efficient synthetic strategy for preparation of graphene-semiconductor nanocomposites that can effectively produce chemical energy from light.

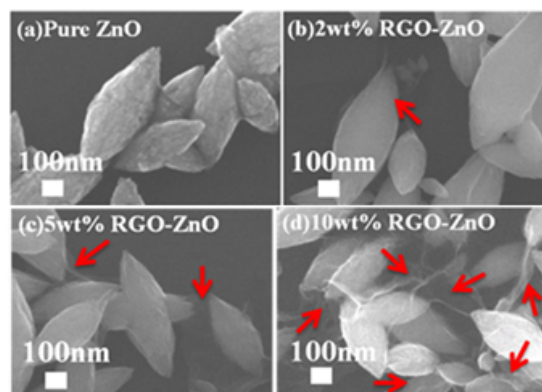


Figure 1. Typical SEM images of (a) pure ZnO nanocrystals, and (b)-(d) RGO-ZnO nanocomposites with different RGO contents.

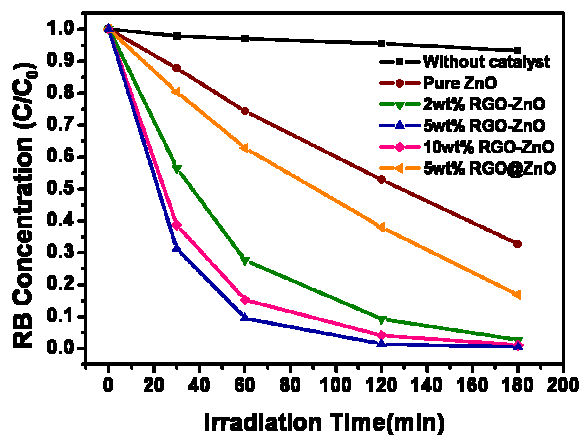


Figure 2. Results of RhB photodegradation by using different samples.

References

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