Enhanced Photocatalytic Performance of ZnO Nanorods Coupled by Two-Dimensional α-MoO3 Nanoflakes under UV and Visible Light Irradiation

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Abstract

We exploit the utilization of two-dimensional (2D) molybdenum oxide nanoflakes as a co-catalyst for ZnO nanorods (NRs) to enhance their photocatalytic performance. The 2D nanoflakes of orthorhombic α-MoO3 were synthesized through a sonication-aided exfoliation technique. The 2D MoO3 nanoflakes can be further converted to substoichiometric quasi-metallic MoO3-x by using UV irradiation. Subsequently, 1D-2D MoO3 /ZnO NR and MoO3-x /ZnO NR composite photocatalysts have been successfully synthesized. The photocatalytic performances of the novel nanosystems in the decomposition of methylene blue are studied by using UV- and visible-illumination setup. The incorporated 2D nanoflakes show a positive influence on the photocatalytic activity of the ZnO. The obtained rate constant values follow the order of pristine ZnO NR<MoO3 /ZnO NR<MoO3-x /ZnO NR composites. The enhancement of the photocatalytic efficiency can be ascribed to a fast charge carrier separation and transport within the heterojunctions of the MoO3 /ZnO NRs. In particular, the best photocatalytic performance of the MoO3-x /ZnO NR composite can be additionally attributed to a quasi-metallic conductivity and substoichiometry-induced mid-gap states, which extend the light absorption range. A tentative photocatalytic degradation mechanism was proposed. The strategy presented in this work not only demonstrates that coupling with nanoscale molybdenum oxide nanoflakes is a promising approach to significantly enhance the photocatalytic activity of ZnO but also hints at new type of composite catalyst with extended applications in energy conversion and environmental purification.

References


Figure 1: a) Representative TEM image of a MoO3 nanoflake. b) HRTEM image of a 2D nanoflake and c) the corresponding SAED pattern.

Figure 2: a) AFM image of MoO3 nanoflakes and section height profile along the black line overlaid on the image. SEM images of composite samples b) MoO3/ZnO and c) MoO3-x/ZnO.