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Ternary Nanostructured Photocatalysts for Photoelectrochemical Water Splitting

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Abstract

The world's population is growing continuously and in close proportionality to thedemand on fossil fuels, which may lead to its depletion in the coming decades. Theability to harness energy from renewable resources is highly desirable for sustainableenergy economy. In recent years, photoelectrochemical (PEC) water splitting processbased on Earth-abundant semiconductor photocatalysts has gained considerable research interests for resolving energy and environmental issues. The PEC watersplitting that mimics the natural photosynthesis process can convert solar energy intostorable form of hydrogen (H_2) energy, which is a good energy vector to meet theescalating energy demand. To date, however, almost all singular semiconductor photocatalysts used demonstrated poor PEC performance for solar-to-H_2 energy conversion. In this study, two different novel ternary nanostructured hematite-based photocatalysts of eRGO/C60/α-Fe_2O_3 and eRGO/NiO/α-Fe_2O_3 were synthesized, characterised and tested as photoanodes toward PEC water splitting application. Theternary nanostructured hematite-based photoanodes were characterised using FE-SEM, EDX, XRD, XPS, as well as Raman, UV-Vis and EIS spectroscopic methods. It wasfound that the ternary nanostructured photoanodes of eRGO/C60/α-Fe_2O_3 andeRGO/NiO/α-Fe_2O_3 showed 5-fold and 9-fold enhancement in current density andsignificant reduction in charge transfer resistance when compared to the pristinehematite photoanode. In this instance, the enhancement in PEC performance of ternary nanostructured eRGO/C60/α-Fe_2O_3 photoanode was attributed to the electrons cavenging property of C60 as well as the highly conducting eRGO property that have mitigated the high interfacial recombination rate of photogenerated electron-hole pairs. Whilst for the ternary nanostructured eRGO/NiO/α-Fe_2O_3 photoanode, eRGO transferred the electrons efficiently in the p-n heterojunction without causing substantial bulk recombination. Additionally, the internal electrostatic field in eRGO/NiO/α-Fe_2O_3 could facilitate the effective separation of photogenerated electron-hole pairs so that more holes could participate in the water oxidation reaction instead of recombination process. It is anticipated that the fundamental understanding gained through this study is helpful to design and construct high-performance photoelectrodes for the application in PEC water splitting in the near future.

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