Z-scheme photocatalysts for CO_2 conversion into fuels and chemicals

Gianguido Ramis[1], Simge Naz Degerli[2], Alice Gramegna[2], Matteo Tommasi[3], Ilenia Rossetti[2,3]
1 Dip. Ing. Chimica, Civile ed Ambientale, Università degli Studi di Genova and INSTM Unit Genova, Genoa, Italy
2 INSTM Unit Milano-Università, Milan, Italy
3 Chemical Plants and Industrial Chemistry Group, Dip. Chimica, Università degli Studi di Milano

Abstract

Solar driven CO_2 photoreduction is promising, albeit challenging due to low quantum efficiency and limited solar light absorption. Layered two-dimensional materials like graphitic carbon nitride (g-C_3N_4) can pave the way thanks to their intriguing properties. However, an additional post-synthesis step of exfoliation is needed to enhance surface area and optoelectronic properties of such materials, after their synthesis in bulk form. Herein, we demonstrate exfoliation of graphitic carbon nitride g-C_3N_4 by means of UltraSound (US) treatment using water as a solvent at varying input power. Different strategies for the functionalization of graphitic carbon nitride have been also employed. The aim is to obtain direct Z-Scheme photocatalysts, able to be excited by the sunlight. This is a type of junction between two different semiconductors: their connection allows to increase the difference of potential between the redox sites of the material, without requiring absorption of a radiation with shorter wavelength. This is possible because the two semiconductors which constitute the junction absorb the light independently and, thanks to the valence and conduction band position, the effect is an extension of the redox potentials.

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The functionalization of the g-C_3N_4 exfoliated was performed using different types of metal oxides with various loadings. In particular, the chosen co-semiconductors for the modifications were iron oxide, zinc oxide and tin oxide. All the three types of Z-schemes have been characterized with XRD, BET and DRS analysis. Testing has been carried out at high pressure (18 bar) and temperature (85°C).
The graphitic carbon nitride with a loading of hematite equal to 8% in weight showed the best performances among this series, with an increase of the productivity of formic acid (the main product of the photoreduction process) of 26.1% respect to the bare graphitic carbon nitride.

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