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Self-assembling reduced graphene oxide and TiO_2-based materials for photocatalytic wastewater treatment

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Abstract

Improvement of wastewater treatment is an urgent necessity of our times, as stated in the United Nations SDG 6. For this purpose, photocatalysis presents multiple advantages over traditional treatment methods (e.g. adsorption), such as mineralization of organic contaminants and reusability of the catalyst. However, its application is limited by the 3.2 eV bandgap of TiO_2, the most common photocatalyst, which requires high-energy photons. Moreover, TiO_2 used in slurry form tends to agglomerate, reducing the specific surface area available for photocatalysis [1]. Coupling TiO_2 with graphene oxide (GO), particularly in its reduced form (rGO), represents a valid strategy to enhance applicability of photocatalysis. Having a smaller bandgap, rGO/TiO_2 nanocomposites result particularly promising for visible and solar light-driven photocatalysis [2]. However, their investigation is currently limited mainly to slurry or supported systems.
To the best of our knowledge, the self-assembling rGO-TiO_2 membrane recently developed by our research group is the first and only self-standing membrane of rGO and TiO_2 reported in the literature [3]. The preparation method is simple and environmental-friendly. Briefly, being reduced with L-ascorbic acid, rGO is mechanically mixed with TiO_2 nanopowder in 1:1 mass ratio. Upon vacuum filtration and mild drying, a self-standing composite membrane (rGO-TiO_2) is obtained. Following a circular economy approach, we also investigated the replacement of TiO_2 with tionite (TIO), a waste-derived TiO_2-containing material, obtaining a rGO-TIO membrane.
In this research, we tested rGO-TiO_2, rGO-TIO, rGO and GO membranes for photodegradation of organic molecules in water, namely the pesticide Imidacloprid and the drug paracetamol. Experiments were carried out under UV-A, visible and simulated solar light irradiation, in static and dynamic conditions. Adsorption tests in dark were also performed. Irradiated for 5 h with UV-A light, both composite membranes showed a pollutants photodegradation between 10% and 20%. Despite limited, the photocatalytic activity of these membranes is notable, considering the small amount of TiO_2 and TIO contained. Moreover, the anatase content of tionite is as low as 1/6 of the one of commercial TiO_2. Under simulated solar light, instead, an Imidacloprid photodegradation of 25% after 5 h in static conditions was achieved with rGO-TiO_2 and with the membrane consisting of only rGO.
In order to maximize the surface interaction between photocatalyst and wastewater, we also developed rGO/TiO_2-coated open cell flexible foams. In particular, we dip-coated polyurethane foams with coatings having the same composition of the above-mentioned membranes (GO, rGO, rGO-TiO_2 and rGO-TIO). Having blown away the excess coating inside pores, they were dried at just 40 °C. Such coated foams are going to be tested as floating photocatalysts and related results will be shown during the conference.

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