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Self-standing membranes of reduced graphene oxide, TiO_2 and waste-derived TiO_2 for water treatment through adsorption and photocatalysis

C. Membranes for energy and the environment

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Abstract

As stated in United Nations SDG 6, improvement of wastewater treatment and reuse is an urgent necessity. In this context, titanium dioxide (TiO_2) and reduced graphene oxide (rGO) deserve a particular attention. The former is a well-known photocatalytic material, the latter shows a significant capture ability toward metal ions and organic molecules. Compared to pure TiO_2, rGO-TiO_2 composites are proved to have a reduced bandgap, which allows to exploit lower-energy photons for photocatalysis.

In this work, we developed composite self-assembling membranes of rGO and TiO_2. Our purpose is to obtain a self-standing material having the double functionality of adsorbent and photocatalyst, able to decontaminate wastewater from both inorganic and organic pollutants. To the best of our knowledge, no other self-standing membranes of rGO and TiO_2 have been reported in literature yet. Fulfilling a circular economy approach, we also investigated the replacement of TiO_2 with tionite (TIO), a waste-derived TiO_2-containing material.

Composite rGO-TiO_2 and rGO-TIO membranes, with 2:1, 1:1 or 1:2 mass ratio, were simply prepared by mixing of an rGO aqueous suspension with commercial TiO_2 nanopowder or tionite, followed by vacuum filtration and mild drying. The resulting self-assembling membranes were extensively characterized through XRD, SEM-EDX, thermogravimetry, Raman and UV-Vis spectroscopy.

Their water remediation properties were evaluated toward contaminants of different nature. Membranes were employed as filters for aqueous solutions of Fe^{3+} and Cu^{2+}, representative of heavy metals contaminated wastewater. Then, membranes were tested for adsorption and photodegradation of organic molecules, namely the pesticide Imidacloprid, the dye methylene blue and the analgesic drug paracetamol. Experiments were carried out in dynamic and static conditions for 5 h, irradiating the membranes with UV-A, visible and simulated solar light. All the membranes exhibited a significant adsorption capacity (75%) toward the three molecules. In addition, composite membranes were responsible for pollutants photodegradation. Despite being limited (between 10% and 20%), 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.