Development of novel graphene-titanium oxide photocatalytic adsorbent for organics removal from water and wastewater

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A B S T R A C T

Over the past decades degradation of organic pollutants using titanium dioxide has attracted increasing attention for the purification of water. One of the newest methods is combining titanium dioxide and an adsorbent material to create integrated photocatalytic adsorbents (IPCA) which overcome some of the limitations of TiO2 nano-particles such as low photocatalytic efficiency at low pollutant concentrations and complicated separation after purification. In this paper, it is proposed to develop a facile and reproducible route to obtain a chemically bonded TiO2 nanoparticle-graphene composite and evaluate its ability to purify water and wastewater. The combination of TiO2 and graphene nanosheets promises to simultaneously possess excellent adsorption, transparency, conductivity and controllability due to its very large planar structure, which would enhance pollutant adsorption and charge transportation to facilitate photodegradation of the pollutants. This results will be compared to the photocatalytic performance of other absorbent-TiO2 (e.g. zeolite-TiO2 and activated carbon-TiO2 composites) composite's ability to absorb and degrade pollutants under the same experimental conditions.

I N T R O D U C T I O N

Conventional wastewater treatment technologies are often not sufficient for the purification and disinfection of polluted waters [1]. The development and implementation of alternative technologies are of both scientific and social importance. In this decade TiO2 has aroused much interest as an advanced oxidative treatment technology in the water/wastewater industry to remove persistent organic compounds and microorganisms from water. However, problems are associated to specifically: (1) the difficulty in separating the powder from the solution after reaction is complete, (2) aggregation of particles in suspension and (3) difficulty in application to continuous flow systems [2]. The use of carbonaceous nano-materials to enhance TiO2 performance has attracted considerable attention because of their unique and controllable structural and electrical properties. New opportunities are offered by novel nanostructured carbons such as carbon nanotubes, fullerens and graphene [3]. Among carbonaceous nano-materials, graphene has been realized recently.

W H A T I S G R A P H E N E ?

Graphene, the latest member of the carbon family is one of the most interesting materials of this century composed of individual sheets of sp² hybridized carbon bond in two dimensions [4]. It has emerged into one of the most exciting new materials. Exfoliated graphene sheets theoretical surface area of 2600m² g⁻¹ and high electron mobilities make it a highly attractive material as a photocatalyst support [5]. The one-atom-thick structure provides high transparency. Features like large surface area, presence of surface functional groups, excellent adsorptivity, transparency, conductivity, and controllability, make single sheets of graphene and its composites an attractive adsorbent candidate for photodegradation of pollutants in water purification process [6].

M A T E R I A L S & M E T H O D S

Expandable flaked graphite and Activated carbon are provided by Asbury Carbon, Titanium(IV) isopropoxide, Isopropyl alcohol, H2O2, Hydrazine solution, Potassium permanganate, sodium Hydroxide, Nitric acid. Sulphuric acid and Hydrochloric acid were purchased from Sigma-Aldrich. Zeolite ZSM5 and Y and P25 TiO2 Degussa were purchased form Zeolyst International and Lawrence Industry respectively. In present work, two simple strategy has been proposed to synthesize TiO2 nano-particles on the surfaces of RGO, direct mixing of GO with TiO2, P25 Degussa powder and in-situ sol-gel synthesis of TiO2 nano-particles (Fig 3 and Fig 4) on the surface of Graphene sheets, followed by calcination at different temperatures. Graphene sheets have been synthesised by thermal induced exfoliation of graphite followed by chemical oxidation and UV and chemical reduction. Activated carbon-TiO2 composite and Zeolite-TiO2 have been in-synthesised in a same process to compare the results.

A N A L Y S I S & D E V I C E S

Graphene and Graphene-TiO2 composite will be characterised by Transmission and Scanning electron microscopes, Atomic force microscopy, X-ray diffraction, FT-IR and Raman spectroscopy and Contact angle technique. Photodegradation experiments were conducted in a borosilicate glass photocatalytic reactor (Fig 6) manufactured by Ace Glass with a 1 L capacity and an immersion well with water cooling. A 125 W medium pressure mercury lamp (λmax= 366 nm) inserted in the middle of the reactor was used as the light source. The TiO2-Graphene, TiO2-Activated carbon and TiO2-Zeolite composite at different concentration with dye solutions as degradable model will be tested. HPLC and UV spectrophotometer will be used to measure pollutant concentrations at regular intervals.

R E F E R E N C E S