Dark and light mediated NO_2 abatement by TiO_2- and WO_3-polyaniline nanocomposites

Ermelinda Falletta[a,b,c], Claudia L. Bianchi[a,b], Marta Sartirana[a], Marcela Frias Ordonez[a], Carolina Cionti[a,b], Daniela Meroni[a,b]

[a] Dipartimento di Chimica, Università degli Studi di Milano, via C. Golgi 19, 20133, Milano, Italy; [b] Consorzio INSTM, Firenze, Italy; [c] ISTM-CNR, Milano, Italy

Abstract

Nitrogen oxides are serious primary air pollutants generated by human activities and are responsible for acid rains, photochemical smog, and health diseases. TiO_2 is one of the most investigated semiconductors to reduce NOx emissions. However, its activity is high under UV light irradiation, very low under sunlight, and in the dark it is completely inactive. Thanks to its redox properties PANI can contribute to the NOx abatement even in the dark and improve the TiO_2 activity in the visible region. Here, PANI/TiO_2 and PANI/WO_3 nanocomposites were synthesized by an innovative green procedure and applied to the NO2 abatement both under light irradiation and in dark conditions.

Experimental section

The composites were prepared by an innovative UV-assisted eco-friendly approach (Fig. A) (C. Cionti et al., *Chem. Commun.* 54, **2018**, 107021, 2; C. Cionti et al., *Nanomaterials*, 10, **2020**, 441).

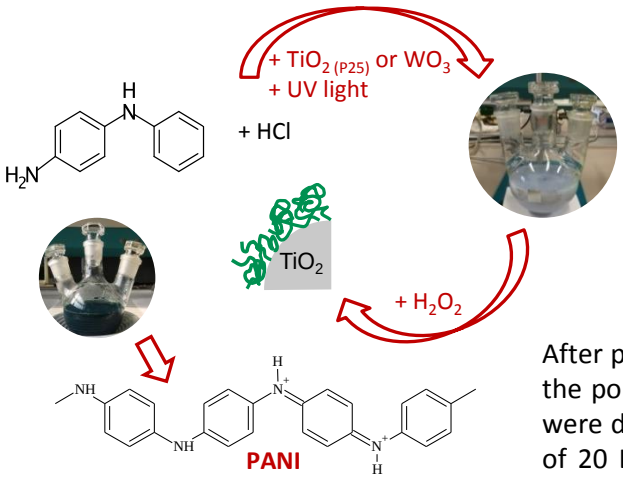


Fig. A) Reaction scheme of PANI composites

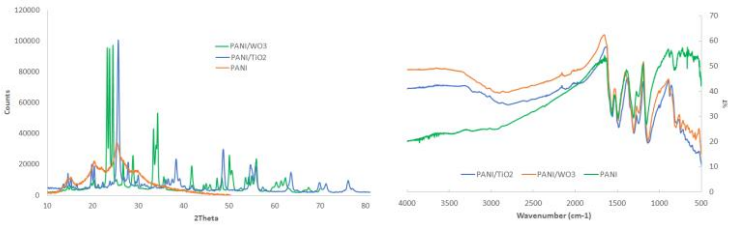
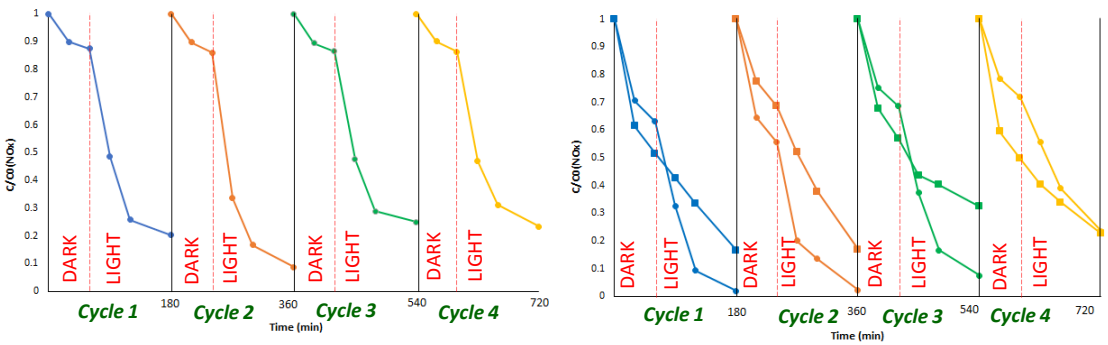


Fig. B) XRPD patterns (left) and FT-IR spectra (right) of PANI/TiO_2, PANI/WO_3 and PANI

After proper characterization (Fig. B) that confirmed the structure pf the polymer and the presence of the oxides, 50 mg of each sample were deposited on a glass support and introduced in a batch reactor of 20 L for the degradation tests. The initial concentration of NO_2 was 500 ppb and the reaction time 3 hours (1 h dark, 2 hrs UV light).

Results

TiO_2 is extraordinary active to degrade NO_2 under UV light irradiation (Fig. C), but it is completely not active in the absence of light. On the contrary, both PANI/TiO_2 and PANI/WO_3 composites can remove NO_2 completely both under dark and light irradiation. In fact, the presence of the alternating benzoid–quinoid segments in its structure (Fig. A) makes PANI able to participate to the NO_2 abatement by reducing it to its less toxic reduced form (NO) that subsequently under light irradiation is completely degraded (Fig. C).



C) Photodegradation of NO_2 by TiO_2 (left) and by PANI composites (right, dots = PANI/TiO_2, square = PANI/WO_3

PANI/TiO_2 is more active than the corresponding WO_3 composite both in the dark and under UV irradiation. If for the results obtained under light irradiation, the different behaviour can be related to the higher photoactivity of TiO_2, the different behaviour of PANI matrix could be a consequence of different oxidation level of the polymeric chains.

Conclusions and perspectives

PANI/TiO_2 and PANI/WO_3 composites resulted highly active towards NO_2 removal both under dark and UV irradiation. Future studies will focus on replacing UV light with solar light and on the demonstrating the polymer structure modification during the degradation process.