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Turning point of Catalysis: new raw materials, new approaches and new technologies

Investigation on Titania Synthesis for Photocatalytic NOx Oxidation

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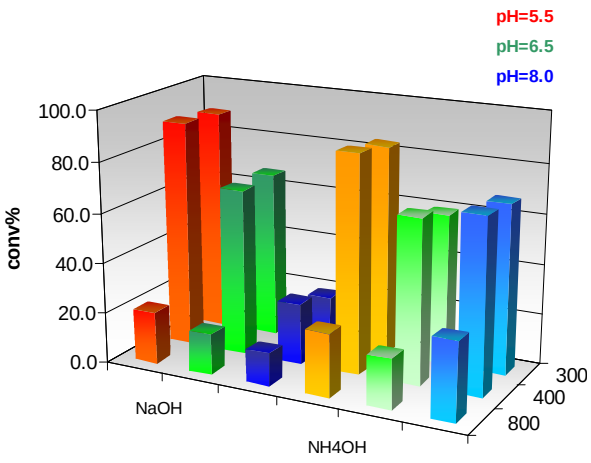
Heterogeneous photocatalysis has shown a high efficiency in the photooxidation of many organic pollutants present in the air or in liquid effluents. It allows pollution abatement under mild conditions (room temperature and pressure) and avoids the use of noxious metal species that are often present in the classic catalytic depollution processes.

Among various materials, semiconductors are the best choice and in particular TiO_2 is the most used photocatalyst because of its high photocatalytic activity, non-toxicity, good availability, low cost and photochemical stability in the reaction conditions. Apart from its unique properties, TiO_2 has been extensively studied because of wide variety of applications, as for example: semiconductor electrodes, gas sensors, cosmetics and foodstuff, purification of water and air and recently as pigments in paints with enhanced photodegradation activity[1, 2].

However, its photocatalytic activity strongly depends on its physical properties, such as surface area, crystal structure, crystallite size, surface hydroxyl groups and so on. In fact, a good photocatalyst should possess a high specific surface area available for the adsorption and decomposition of the organic and inorganic pollutants.

Many efforts have been devoted to the preparation of TiO_2 nanopowders with high surface area and presence of anatase phase, including sol–gel synthesis using titanium tetra-alkoxides, ultrasonic nebulization of $TiCl_4$, homogenous precipitation, hydrothermal methods, flame synthesis, and relatively new molten salts method.

In the present work we have synthesized various TiO_2 by hydrolysis from $TiOSO_4$ using different precipitation agent such as NaOH or NH_4OH and pH of aging (acid, neutral or basic) and a range of calcination temperature. Thermal hydrolysis of titanyl sulphate solution, which can give highly pure TiO_2 (anatase) with good crystallinity, is a widely used commercial process; it allows to tune some preparation parameters and synthesis conditions in order to obtain different materials with various physical properties and therefore with different photocatalytic properties.



The catalysts were characterized by N_2 physisorption measurements and by XRD analyses. The photocatalytic activity of TiO_2 samples were analysed by NO oxidation reaction in both the UV and visible region, using a lab made plant equipped with a chemiluminescence analyzer.

A close correlation between photoactivity and physical properties has been found. The samples chacterized by high surface area (>100m^2/g) and a sole anatase crystal phase present the best performances. In particular, a significant increase has been obtained for materials synthesized in acid condition and calcined at lower temperature.

The differences in the activity will be discussed in relationship with the physical properties of the various samples.

[1] M.Signoretto, E. Ghedini, V. Trevisan, C.L. Bianchi, M. Ongaro, G. Cruciani, Appl. Cat. B: Environmental, 95 (2010) 130-136
[2] T. Kasuga, M. Hiramatsu, M. Hirano, A. Hoson, J. Mater. Res. 12 (1997) 607