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ORIGINAL PAPER

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Ti-montmorillonite as photocatalyst to remove 4-chlorophenol in water and methanol in air

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Abstract We studied the photocatalytic activity of Ti-montmorillonite. The highest activity was found for a Ti/bentonite ratio of 10 mmol/g, prepared using HCl and calcined by microwaves. This mixture is less active than TiO_2 P-25 for 4-chlorophenol removal in water, but more active for methanol removal in air.

Keywords Photocatalysis · Pillared clays · 4-Chlorophenol · Methanol

Introduction

The uncontrolled release by human activities of chemical substances in the atmosphere or in aquatic receptors leads to water and air quality degradation. In the aqueous environment, the presence of recalcitrant organic micropollutants such as chlorinated compounds, pesticides, and dyes, is of great concern. Moreover, disinfection by chlorine of water containing phenol derivatives or humic acid forms chlorophenols, which are considered harmful and carcinogenic. Until now, the main methods used for the removal of organic pollutants, apart from biological treatment, are based on adsorption or chemical oxidation. However, these processes have major drawbacks: adsorption transforms pollutants and chemical oxidation in homogeneous phase is not economically favourable except for high concentrations of pollutants.

Air is contaminated by many organic compounds emitted by combustion and all kinds of industries, particularly those using solvents. The most widely used method for treating these noxious and malodorous gaseous emissions is adsorption (Zhao and Yang 2003). But this process raises the same problem as water treatment, since contaminants are transferred to another phase. Heterogeneous photocatalysis can be an alternative remediation technology and has attracted attention of many research groups throughout the world during the last two decades (Pichat 2003) since (1) it does not need the addition of chemicals; (2) it is suitable for treating water and air with low concentrations of organic pollutants, (3) it is not specific, and (4) it can lead to total mineralization of organic compounds, although in most cases in a non-cost-effective manner. Some TiO_2 samples are the most active photocatalysts.

Research on photocatalysis applied to cleaning water and air, inter alia, aims at improving the photocatalytic activity. This can be achieved, for instance, by using nanoparticles of photocatalyst to increase the surface area. On the other hand, reducing the overall process cost requires immobilizing the photocatalyst on a support to avoid filtration. This immobilization should be carried out in such a way as to limit a decline of the photocatalytic activity.

Progress realized in clay pillaring processes by various metallic species points to the application of Ti-pillared clays as photocatalysts (Awate and Suzuki 2001; Ding et al. 1999; Ilisz et al. 2002, 2004; Ooka et al. 1999, 2003). TiO_2, intercalated in the interlayer spaces of clays, could have high photocatalytic activity because of its dispersion. In addition, the adsorption capacity, due to the high surface area of clay, could facilitate the retention of the pollutants and the intermediate products of their photocatalytic degradation. Finally, clays easily flocculate (Khalaf et al. 1997). On the other hand, organophilic clays can also be used for adsorbing poorly soluble pollutants,

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