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Iron (2,3) oxides based nano-particles as catalysts in advanced organic aqueous oxidation

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1. Introduction

Contamination of water with organic pollutions presented significant ecological problem. For water purification from organic pollutions biological and chemical oxidation processes are suitable. Biological treatment process is usually slow and limited when the dissolved organic matter is toxic, inhibitory or recalcitrant to microorganisms. The degradation and mineralization of organic pollutants in wastewater by advanced oxidation processes (AOPs) is useful for purifying drinking water, groundwater and for cleaning industrial wastewater has been reported recently [1–3]. It may also be useful as pretreatment for RO and NF water purification. The degradation and mineralization of organic pollutants in contaminated water by AOPs is based on the generation of a very reactive free hydroxyl radical (OH^*). The hydroxyl radicals are highly reactive, non-selective and may be used to degrade a wide range of organic pollutants. It reacts with most organic compounds by adding to a double bond or by abstracting hydrogen atoms from organic molecules [4,5].

Nanoparticles of metal oxides and semiconductors are of great attention due to novel properties compared to their bulk materials. Iron (3) oxide-based nanocatalyst efficiently destroyed organic contamination by the Fenton-like reaction in the presence of hydrogen peroxide at room temperature without the need for ultraviolet light (UV) or visible radiation sources. A strong effect of nanocatalyst concentration on reaction rate was shown. The kinetic reaction was found and the reaction rate coefficient k was calculated [6].

The objective of this research work is to continue the efforts of investigation catalytic behavior of the different iron oxide-based nanocatalyst by degradation and mineralization organic pollutants in wastewaters as a possible mean of treatment for contaminated groundwater and industrial wastewater. Typical organic contaminant: ethylene glycol was chosen for this study as simulating pollutants.

2. Results

Fig. 1 shows an example of a TEM image of nanoparticles. The average size of iron (2,3) oxide-based nanoparticles was 22 nm with a standard deviation of 11 nm. The corresponding electron diffraction reveals that the iron (2,3) oxide-based nano-particles are nano-particles of magnetite, syn, iron oxide, $FeFe_2O_4$, based on Card 19-0629 – JCPDS-International Center for Diffraction data ICDD.

The catalytic behavior of the iron (2,3) oxide-based nanocatalyst was investigated by changing the concentrations of the dissolved matter, the catalyst and the

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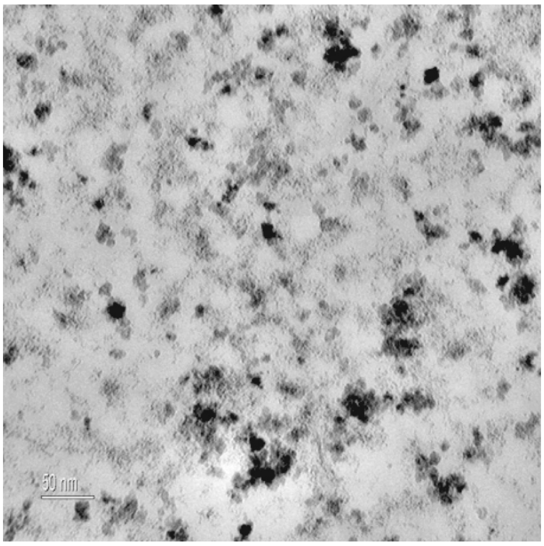

Fig. 1. TEM image of iron (2,3) nanoparticles.

peroxide. The experiments were carried out at room temperature without UV radiation, at visible room light, and in some cases in a darkened vessel with no light in the reaction (the latter did not differ from regular light). The initial concentration of ethylene glycol solution C_0 was varied the nanocatalyst concentration changed from 75 to 3000 ppm and the concentration of hydrogen peroxide varied between 0.65% and 4.3%. The pH values in these experiments ranged from 2 to 3.5.

Fig. 2 demonstrates the influence of peroxide concentration on the degradation rate of the organic matter. The results are shown on semi-logarithmic scale in order to demonstrate the low total organic content (TOC) level obtained in the experiments. Concentration presentation as TOC was chosen to represent the data. This is important since the target is to remove all organic compounds and not only the ethylene glycol, as by-products may be even more harmful than the original matter. The straight lines on semi-logarithmic scale confirm the assumption of first-order reaction degradation of the dissolved material. The by-products degrade also as first order reaction, demonstrating the non-selectivity nature of the catalytic reaction.

3. Conclusions

This study presents information about the catalytic properties iron (2,3) oxide-based nanoparticles for the degradation and mineralization of organic pollutants

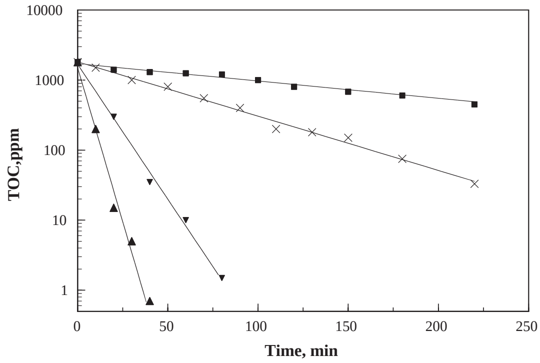

Fig. 2. Degradation of ethylene glycol in Fenton like process at different concentrations of hydrogen peroxide. Concentration of iron (2,3) oxide-based nanocatalyst: 1000 ppm. Concentration of H_2O_2, %: ▲, 4.3; ▼, 3; ×, 1.2; and ■, 0.65.

in wastewaters by AOPs. The main conclusions are as follows:

Ethylene glycol is efficiently destroyed by the Fenton-like reaction with iron (2,3) oxide-based nanocatalysts in the presence of hydrogen peroxide without UV or any radiation sources.

Catalytic reaction ethylene glycol degradation with iron (2,3) oxide-based nanocatalyst demonstrates the first order reaction kinetics.

No effect of nanocatalyst aging was observed.

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