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Phenol degradation by powdered metal ion modified titanium dioxide photocatalysts

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HIGHLIGHTS

- Removal of phenol by the application of TiO_2 based photocatalysts was explored.
- Undoped TiO_2 and Cu doped TiO_2 showed considerable phenol degradation.
- The efficiency of photocatalytic reaction depends on the methods of preparation.
- Photocatalytic decomposition of phenol follows pseudo zero order reaction kinetics.
- Direct sunlight can be a substitute for the UV lamps.

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ABSTRACT

Conventional water purification and disinfection generally involve potentially hazardous substances, some of which known to be carcinogenic in nature. Titanium dioxide photocatalytic processes provide an effective route to destroy hazardous organic contaminants. This present work explores the possibility of the removal of organic pollutants (phenol) by the application of TiO_2 based photocatalysts. The production of series of metal ions doped or undoped TiO_2 were carried out via a sol–gel method and a wet impregnation method. Undoped TiO_2 and Cu doped TiO_2 showed considerable phenol degradation. The efficiency of photocatalytic reaction largely depends on the photocatalysts and the methods of preparation the photocatalysts. The doping of Fe, Mn, and humic acid at 1.0 M% via sol–gel methods were detrimental for phenol degradation. The inhibitory effect of initial phenol concentration on initial phenol degradation rate reveals that photocatalytic decomposition of phenol follows pseudo zero order reaction kinetics. A concentration of > 1 g/L TiO_2 and Cu doped TiO_2 is required for the effective degradation of 50 mg/L of phenol at neutral pH. The rise in OH^- at a higher pH values provides more hydroxyl radicals which are beneficial of phenol degradation. However, the competition among phenoxide ion, Cl^- and OH^- for the limited number of reactive sites on TiO_2 will be a negative influence in the generation of hydroxyl radical. The dependence of phenol degradation rate on the light intensity was observed, which also implies that direct sunlight can be a substitute for the UV lamps and that photocatalytic treatment of organic pollutants using this technique shows some promise.

1. Introduction

While the world's population tripled in the 20th century, the use of renewable water resources has grown six fold. Poor access to good quality drinking water increases the risk of waterborne diseases, which result in more than 10 million deaths. Diarrhoea alone is responsible for 2.2 million deaths each year, mostly among children under the age of five. This represents a significant global problem, however a number of options available today for water disinfection include chlorination, ozonation, iodine treatment, UV treatment, and boiling [1]. The ideal solution would offer complete and full sterilization, without harming other forms of life; it should also be inexpensive as well as non-corrosive [2].

The last 20 years has seen the development of two of the most interesting disinfection alternatives: solar disinfection and TiO_2

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