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ORIGINAL PAPER

Removal of 4-chloro-2-nitrophenol occurring in drug and pesticide waste by adsorption onto nano-titanium dioxide

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Abstract The present study deals with removal of 4-chloro-2-nitrophenol (4C2NP) as a model contaminant from pharmaceutical and pesticide industries using titanium dioxide nanoparticles as an adsorbent. 4C2NP is recalcitrant and persistent toward biodegradation and its generation in aqueous environment during formulation, distribution and field application of pesticides is often unavoidable. Batch experiments were carried out to investigate the effect of contact time, nano-titanium dioxide dosage, initial pH, initial 4C2NP concentration and temperature on adsorption efficiency. The results showed that the adsorption capacity was increased with increasing 4C2NP concentration and temperature. Optimum conditions for 4C2NP adsorption were found to be initial pH $\approx$ 2, nano-titanium dioxide dosage $\approx$ 0.01 g/250 mL and equilibrium time $\approx$ 1 h. Titanium dioxide nanoparticles recorded a maximum capacity of 86.3 mg/g at optimal conditions. The linear correlation coefficients of Langmuir, Freundlich and Temkin isotherms were obtained. The results revealed that the Freundlich isotherm fitted the experimental data better than the other isotherm models.

Keywords Nanoparticle · Phenolic compounds · Adsorption isotherm · Wastewater

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Introduction

Environmental pollution due to technological developments is one of the most important problems of this century. Industrial use of phenol and its derivatives over the past decades has led to serve environmental pollution. These compounds are toxic and carcinogenic, and they can persist for many years in the environment because of their resistance to microbiological degradation (Khan and Anjaneyulu 2005; Chen et al. 2009). Owing to their toxicity, their polluting effects on our echo-system provide possible human health risk. Chronic toxic effects due to phenols reported in humans include vomiting, difficulty in swallowing, anorexia, liver and kidney damages, headache, fainting and other mental disturbances (Calace et al. 2002). While the World Health Organization (WHO) has recommended the permissible phenolic concentration of 0.001 mg/L in potable waters, the European Union (EU) has set a maximum concentration level of 0.5 μg/dm^3 of total phenols in drinking water (WHO 1963; Dursun and Tepe 2005). Moreover, the maximum permitted concentration level of phenols being 0.5–1 mg/L for industrial wastewaters (Sokol and Korpal 2004). Thus, the removal of phenolic compounds from wastewater before its discharge, is necessary to reduce their side effects on the environment and human health. In the last decade, various methods have been proposed to remove phenols, including advanced oxidation process (Samarghandi et al. 2007; Saritha et al. 2007), biological degradation (Agarry and Solomon, 2008), ultrafiltration (Acero et al. 2005), ozonation (Benitez et al. 2000; Gharbani et al. 2010) and adsorption (Hashizume 2004; Roostaei and Tezel 2004; Mahvi 2008; Dabhade et al. 2009; Subramanyam and Das 2009; Belarbi and Al-Malack 2010). Since the other methods need special process requirements or special catalysts, adsorption seems