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Thermodynamics and Kinetics Studies of Pentachlorophenol Adsorption from Aqueous Solutions by Multi-Walled Carbon Nanotubes

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Abstract The adsorption of pentachlorophenol (PCP) from aqueous solutions using pristine multi-walled carbon nanotubes (MWCNTs) was studied kinetically and thermodynamically. The results showed that MWCNTs are good adsorbents for the elimination of PCP from aqueous solutions in a very short time compared with activated charcoal. The kinetics study showed that the adsorption of PCP is mainly due to the diffusion of PCP from the aqueous phase to the solid phase beside intra-particle diffusion. This intra-particle diffusion was more significant for activated charcoal compared with MWCNTs. The equilibrium adsorption of PCP at different temperatures was studied, and the adsorption isotherms were well described using different adsorption models. Thermodynamics study showed that the adsorption process was product-favored (enhanced) as the temperature decreased.

Keywords Multi-walled carbon nanotubes · Water treatment · Kinetics · Thermodynamics · Pentachlorophenol adsorption

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1 Introduction

Pentachlorophenol (PCP) is widely used as a textile and wood preservative as well as a microbiocide, fungicide, insecticide, and herbicide. It is well known to be toxic to living organisms, and its bioaccumulation, persistence, and toxicity pose environmental problems. Knowledge of PCP adsorption characteristics is necessary for predicting its mobility and fate in aquatic ecosystems. PCP is sparingly soluble in water but the removal of this toxic compound from aqueous systems represents a problem especially when it is at very low concentrations. The conventional treatment methods for wastewater include biological treatment (Jianlong et al. 2000), adsorption by porous solids such as granulated activated carbon (Liu et al. 2004), photocatalytic degradation (Hanna et al. 2004), and solvent extraction (Khodadoust et al. 1999). Among these methods, adsorption is regarded as a promising method for the removal of PCP. By adsorption–desorption processes, the water and adsorbent could be recycled. For an analytical process, efficient adsorption and desorption are needed. Hence, it is important to look for new types of adsorbents and to develop new efficient analytical methods. Multi-walled carbon nanotubes (MWCNTs) have become the focus of wide ranging of research for their intrinsic properties and their possible applications. It has been reported that MWCNTs have very strong adsorption capability for many different compounds. This may be attributed to their unique size distributions, novel hollow-tube structures, and high specific surface