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Synthesis of polyelectrolyte-modified ordered nanoporous carbon for removal of aromatic organic acids from purified terephthalic acid wastewater

Mansoor Anbia, Samira Salehi*

Research Laboratory of Nanoporou Materials, Department of Chemistry, Iran University of Science and Technology, Narmak, Tehran 16846, Iran

A B S T R A C T

In this work polyelectrolyte (polydiallyldimethylammonium chloride) modified ordered mesoporous carbon (CMK-1/PDDA) has been synthesized and has been employed in removal of major aromatic compounds present in purified terephthalic acid wastewater, such as p-toluic acid, benzoic acid, 4-carboxybenzaldehyde, phthalic acid and terephthalic. The adsorption behavior of these acidic impurities has been studied through batch experiments and using UV-spectrophotometric technique. The results show that CMK-1/PDDA is very effective in selective removal of acidic compounds from PTA-waste aqueous solutions. The electrostatic interaction was considered to be the main mechanism for the adsorption of acidic compounds. The effects of chemical modification, contact time, initial concentrations, adsorbent dose, agitation speed, solution pH and reaction temperature have been optimized. The sorption equilibrium was reached within 5 min. The sorption of acidic compounds on the CMK-1/PDDA slightly decreases with increasing pH, and temperature, indicating an exothermic process. The experimental isotherm data were analyzed using the Langmuir and Freundlich equations. The equilibrium data were best represented by the Langmuir isotherm.

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Keywords: Adsorption; Purified terephthalic acid; Polyelectrolyte; Mesoporous carbon

1. Introduction

Purified terephthalic acid (PTA) is widely used as a starting material for production of synthetic products such as polyethylene terephthalate bottles, polyester textile fibers, polyester films, etc. (Joung et al., 2009; Moraes et al., 2004). Macarie et al. (1992) have reported the production of PTA in various countries and have studied its usages in manufacturing products and byproducts.

A typical, generic purified terephthalic acid (PTA) process comprises two separate steps, the production of crude terephthalic acid by catalytic oxidation of *para*-xylene and the purification of the crude acid by catalytic hydrogenation and crystallization. Crude terephthalic acid is obtained by oxidation of *para*-xylene in the presence of catalyst and acetic acid solvent (Kleerbezem et al., 1997). Due to side reactions or incomplete reaction some byproducts are formed, most of which are aromatic compounds which enter the wastewater. The synthesis of terephthalic acid and its major byproducts are shown in Fig. 1. Aromatic compounds in PTA wastewater mainly include p-toluic acid (p-Tol), benzoic acid (BA), 4-carboxybenzaldehyde (4-CBA), phthalic acid (PA) and terephthalic acid (TA) (Kleerebezem et al., 1999; Zhang et al., 2010). These five aromatic compounds make up to 75% of the COD of the wastewater. The pollution potential is generally estimated in terms of chemical oxygen demand (COD). Generally, for the preparation of 1 ton of PTA, approx., 4–10 kg COD m^{-3} are generated with 5–20 g COD L^{-1} and 3–4 m^3 of wastewater (Karthik et al., 2008; Macarie and Guyot, 1992). Terephthalic acid is non-toxic to aquatic organisms at concentrations lower than its water solubility (which is 15 mg L^{-1} at 10 °C) but microorganisms cannot survive in high concentration and the toxicity is introduced by the aromatic compounds present in PTA to wastewater

* *Corresponding author*. Tel.: +98 21 77240516; fax: +98 21 77491204.
E-mail address: anbia@iust.ac.ir (M. Anbia).
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