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Adsorption of phenolic compounds by activated carbon—a critical review

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Abstract

Adsorption of phenol and its derivatives on activated carbons is considered based on numerous papers related to this issue. Special attention is paid to the effects of carbon surface functionalities, pH of solution and heterogeneity effects that accompany adsorption of phenolic compounds. Moreover, in this paper the most important aspects are overviewed referring to irreversible adsorption of phenols and impact of different substituents of phenolic compounds on their uptake by activated carbons is considered. Finally, some remarks pertaining to applications of novel adsorbents for phenol adsorption are discussed and illustrated by means of a few examples.

Keywords: Adsorption of phenols; Activated carbon; Irreversible adsorption; Activated carbon fibers

1. Introduction

Phenolic derivatives belong to a group of common environmental contaminants. The presence of their even low concentrations can be an obstacle to the use (and/or) reuse of water. Phenols cause unpleasant taste and odour of drinking water and can exert negative effects on different biological processes. Most of these compounds are recognized as toxic carcinogens. Industrial sources of contaminants such as oil refineries, coal gasification sites, petrochemical units, etc., generate large quantities of phenols. Besides, phenolic derivatives are widely used as intermediates in the synthesis of plastics, colours, pesticides, insecticides, etc. Degradation of these substances means the appearance of phenol and its derivatives in the environment. Phenols have weak acidic properties. The basic information concerning phenolic compounds is included in Table 1 (Vidic et al., 1993).

Different methods designed to remove phenols have been proposed. Adsorption by activated carbons (ACs) is the best and most frequently used method. Other methods include, aerobic and anaerobic biodegradation, oxidation by ozone, and uptake by ion exchange resins, etc.

ACs possess perfect adsorption ability for relatively low-molecular-weight organic compounds such as phenols. They can be manufactured in such a way that a highly fractal material is obtained, which is similarly roughly structured with each magnification and with pores of any width. There are two most common physical forms, in which activated carbon (AC) is used, i.e.,

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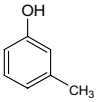
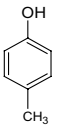
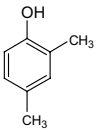
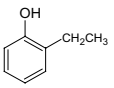
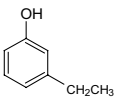
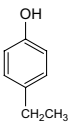
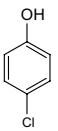
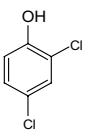
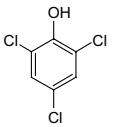
Table 1
Basic information concerning phenol and its derivatives (Vidic et al., 1993)

Phenolic compound	Boiling point (°C)	pK_a at 25 °C	Aqueous solubility at 25 °C ($g l^{-1}$)	Critical oxidation potential (COP) (Fieser, 1930) (V)
	182	9.89	93	1.089
	191	10.20	25	1.040
	202	10.01	26	1.080
	202	10.17	23	1.038
	211	10.58	Not available	0.895
	207	10.2	Sparingly soluble	Not available
	214	10.07	Slightly soluble	Not available
	218	10.0	Slightly soluble	Not available
	204	8.52	28	1.094
	214	8.97	26	Not available
	220	9.37	27	1.094
	210	7.90	4.5	Not available
	246	5.99	28.6	1.103