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Activated carbon from carrot dross combined with magnetite nanoparticles for the efficient removal of p-nitrophenol from aqueous solution

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HIGHLIGHTS

- Activated carbon from carrot dross (AC) prepared, magnetized and used for removal of PNP.
- Magnetization of AC (MAC) was made by mixing AC with Fe_3O_4 sol in two mass ratios.
- Surface area of AC and MAC with two mass ratios were 447, 435, and 340 $m^2\ g^{-1}$, respectively.
- Batch sorption for AC and MAC carried out at different pH, contact time, and concentration.
- Magnetic property of MAC facilitates the separation of solid phase much easier than AC.

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ABSTRACT

Activated carbon from carrot dross (AC) was prepared, magnetized and used for the removal of p-nitrophenol from aqueous solution. The magnetization of AC was carried out by mixing the AC with diluted Fe_3O_4 sol in two different mass ratios of Fe_3O_4/AC. The characterization of both magnetized and original AC were studied by X-ray diffraction, Fourier transform infrared spectroscopy, scanning electron microscopy, surface area measurement, elemental analyses, zero point charge measurement, and vibrating sample magnetometer. The surface area measurement of AC and magnetic activated carbons of carrot dross (MAC) with two mass ratios of Fe_3O_4/AC (1/8 and 1/5) were 447, 435, and 340 $m^2\ g^{-1}$, respectively. Batch sorption studies for the AC and MAC were carried out at different pH values, solid to liquid ratios, contact times, and initial concentrations of the pollutant in the presence and absence of ultrasonic irradiation. The sorption isotherms were obtained in the range of 50–500 mg L^{-1}. The results for the AC and MAC in the absence of ultrasound and for MAC in the presence of ultrasound fit well with Freundlich isotherm. In contrast, the results for AC in the presence of ultrasonic irradiation fit well with Langmuir model. In the case of AC, the values of intraparticle diffusion rate constant in the presence of ultrasound were greater than conventional method. In the case of MAC, the presence of magnetite nanoparticles on the surface of activated carbon led to a lower surface area but, the magnetic property of MAC facilitated the separation of solid phase from aqueous solution much easier than AC.

1. Introduction

There has been growing concern for public health and environmental safety over the last few decades. Chemical pollution of surface water exhibits a threat to the aquatic environment with hazardous effects [1,2]. P-nitrophenol (PNP) is an important chemical intermediate, serving as precursors of pharmaceuticals and pesticides [3]. The other sources for PNP are diesel fuel and gasoline exhaust which enter PNP into environment [3,4]. There are many methods to remove phenolic compounds from wastewater stream such as advance oxidation process (AOPs) [5–7] sonolysis [8–11] extraction [12], and adsorption [13–16]. Among these techniques, adsorption is widely used which is due to easy operation, simple design, and generation [17,18]. Adsorption processes with biological materials, mineral oxides, activated carbons, or polymer resins have attracted attention [19]. Production of low cost AC from natural material is an important case. A number of paper report chemical and thermal treatment of agricultural by-product as precursors for the preparation of carbon-based adsorbents [20–23]. Chemical treatment on agricultural waste affects on the surface properties of AC and introduces some functional groups on the surface [24]. The adsorption of PNP onto AC was found to mainly depend on porosity and surface chemistry of carbons. AC with micropore size in the range of 0.74–2.21 nm strongly influenced

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