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Removal of Organic Contaminant from Aqueous Solution Using Magnetic Biochar

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Abstract

In this study, raw biochar and magnetic biochar were prepared as adsorbent to remove 4-nitrotoluene from aqueous environment. Magnetic biochar (MB) was successfully synthesized by using raw biochar from palm kernel shell (PKS), ferrous chloride and ferric chloride for removal of 4-nitrotoluene. Ferrous chloride and ferric chloride used as magnetic medium and mix with biochar by chemical co-precipitation method. Characteristics of these adsorbent were analyzed with Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM) and BET surface area. Performances of both modified and raw biochar were compared to evaluate the effectiveness of adsorption capacity. It is found that magnetic biochar performed with better result compared to raw biochar in removal of 4-nitrotoluene from aqueous media. Langmuir and Freundlich isotherms were applied to describe the adsorption characteristics and the Langmuir isotherm describes the adsorption phenomena in this study much better than the Freundlich isotherm.

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Keywords: magnetic ; biochar ; palm kernel shell ; adsorption ; 4-nitrotoluene ; organic pollutant

1. Introduction

Nitroaromatic compounds are widely used in a lot of industrial processes, including the manufacturing of pesticides, explosives, dyes, herbicides, pharmaceutical and paper [1,2]. These compounds become water pollutant

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if the effluent is discharged into water bodies without proper treatment [2]. They are hazardous compound and give negative effect to human as well as environment [3]. Several studies have shown that these compounds are the major agents of mutagenity [4,5], carcinogenesis [6], ecotoxicity [7], immunotoxicity [8], reproductive toxicity [9,10] and urinary tract tumor [11]. There is more than 30 nitroaromatic compounds may be produced in manufacturing of trinitrotoluene (TNT) and dinitrotoluene (DNT) [12]. Among these compounds is a 4-nitrotoluene which generally used in the textile industry [13] and it is a common pollutant and suspected hormone distrupter [14].

Adsorption has been identified as common mechanism for organic and inorganic chemical pollutant removal. It can be described as surface phenomenon where adsorbate in a solution come into contact with a highly porous surface structure solid and the solute molecules from the solution are deposited and concentrated at the solid surface [15]. Adsorption process has advantage from other sorption method because of the simple design and can involve low investment in term of both initial cost and land required [16]. Furthermore, adsorbent can be classified into two categories which are natural adsorbent and synthetic adsorbent. Among of those adsorbent from natural and synthetic type, black carbon such as biochar, activated carbon, charcoal and soot have been observed as one of the promising sorbent due to the stronger sorption capacity than inorganic particle [17]. Activated carbon is one of the sorbent that has been widely used to remove water pollutant because of its high specific surface area, abundant surface functional group and well develop pore structure. However, activated carbon is not suitable to remove certain water pollutant because its surface is negative charged [18]. Furthermore, production of activated carbon itself is very costly since it requires high temperature during activation process [19]. Biochar is the carbon-rich residue from thermal decomposition of plant-derived biomass in the partial or total absence of oxygen [20]. Biochar exhibit a great potential to efficiently tackle water contaminant considering the wide availability of feedstock, low cost and favourable chemical and physical surface. Furthermore, the specific properties of biochar are fit for sorbent material such as large specific surface area, porous structure, enrich functional groups and mineral component [21].

In this study, magnetic biochar from palm kernel shell (PKS) is synthesized to remove 4-nitrotoluene from aqueous media. The objective of this present study to evaluate the effectiveness of the synthesized magnetic biochar and compared it with raw biochar to remove 4-nitrotoluene from aqueous media. Hence, magnetic biochar is optimized and characterized throughout this study.

2. Materials and methods

2.1. Material

Ferrous chloride, ferric chloride, sodium hydroxide, and 4-nitrotoluene were purchased from R&M Chemical Company. All the reagents and pellets were analytical grade or highest purity available, and were used without further purification. Palm kernel shell (PKS) biochar was obtained from Malaysia Palm Oil Board (MPOB). Distilled water was used throughout the experiments.

2.2. Preparation of magnetic biochar

The magnetic biochar was prepared by mixing PKS biochar with ferrous chloride and ferric chloride as the magnetic medium. They underwent method of chemical co-precipitation. Raw PKS biochar was labeled as B660 whereas magnetic biochar was labeled as MB660. 20g of raw biochar was added into a 200 ml solution containing ferrous chloride and ferric chloride (molar ratio 1:1). Under vigorous magnetic stirring, 5 molar NaOH solution were added into the solution slowly until the colour of the solution change from brownish green to black. The stirring continued for 30 minute. The solution later was rested in the room for 24 hours. Subsequently, the deposited was separated by using coffee filter and rinsed with distilled water several times until the pH become 7. The magnetic biochar sample was dried at 50^{o}C and it was ready to be used.

2.3. Characterization

All biochar samples (MB660 and B660) were characterized for their physical and chemical features. Field emission scanning electron microscopy (Hitachi FE-SEM, S4800) was used to observe the morphology of the