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Case Study

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BIOMASS WASTE-DERIVED ADSORBENTS FOR THE REMOVAL OF ORGANIC POLLUTANTS FROM WATER

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1. BACKGROUND

Many physical, chemical and biological approaches, such as coagulation/flocculation, advanced oxidation and membrane filtration have been used in the removal of pollutants from wastewater. Adsorption is an effective alternative for wastewater treatment and it has been widely employed to remove hazardous inorganic and organic pollutants present in the effluent. It is featured with some advantages such as simple design and toxic tolerance. A number of adsorbents including activated carbon, diatomite, clay, and adsorptive resin have been used for the treatment of wastewater. Biomass adsorbents derived from biomass wastes such as orange peel, rice husks, peanut husk, corn cobs and wheat straw are also applied in pollution control.

Flax biomass is often discarded in the land or incinerated outdoors, which not only result in a waste of bioresources, but also lead to environmental problems with inappropriate disposal. Flax biomass contain a certain amount of lignin and cellulose, showing the potential as adsorbent material. However, the adsorption of organic pollutants by flax biomass is not studied in previous works. Moreover, biomass wastes can be used to produce biochar. Biochar is carbon-rich material which can be obtained through pyrolyzing biomass at a given temperature. Biochar is featured by unique morphology and structure. It has the capacity to retain molecules of various sizes and chemical characteristics. Compared with other carbon-related adsorbents, biochar is considered as a cost-effective alternative for immobilizing organic contaminants such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls, pentachlorophenol, imidacloprid and atrazine. This study investigated the removal of organic pollutants from water using biomass-derived adsorbents. Both equilibrium and kinetic adsorption studies were conducted and the effects of aqueous chemistry on adsorption performance were also explored. The results of this study have important implications for the future application of biomass adsorbent in pollution control and prevention.

2. RESULTS

When flax biomass is placed in water, it usually possesses a net negative charge as a result of ionization of some of its surface functional groups. Cationic gemini surfactants may interact with limited and specific anionic sites at the surface. Due to the high charge density of gemini surfactant with short spacer, they can bind strongly with the anionic groups on the flax biomass surface. Moreover, the action of short-range noncoulombic attractive van der Waals forces and hydrophobic interactions can also contribute to the binding process. The hydrophobic tails in gemini molecules could present strong hydrophobic forces to some function groups on flax surface. The surface of modified flax biomass was characterized by synchrotron infrared and SEM analysis. The absorbed amount of some pollutants such as azo dyes varied with the change of adsorbent dosage, pH and ionic strength. The adsorption isotherm data well fit to the Langmuir model. The adsorption process followed the pseudo-second-order kinetics and the liquid film diffusion models. Thermodynamic studies indicated that the adsorption process was spontaneous.

The adsorption of Tetrabromobisphenol A (TBBPA) on pinecone-derived biochars was also investigated. The surface structures and functional groups of biochars produced at different temperatures were characterized through synchrotron-assisted FTIR analysis. The adsorption isotherms were well described by the Langmuir model. The adsorption capacity of TBBPA varied as pH and TBBPA initial concentration changed. The influences of some inorganic ions such as ammonium, phosphate and nitrate on the adsorption of TBBPA by biochars were revealed through fractional-factorial assisted analysis. The results indicated the main effects include negative effects of phosphate, positive effects of ammonium and insignificant effects of nitrate ions and there are interactions among these influencing factors. These results are useful for developing economically viable and environmental friendly approaches for the removal of organic pollutants from water.

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