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SURFACTANT-MODIFIED BIOMASS ADSORBENTS FOR ENHANCED REMOVAL OF POLLUTANTS FROM AQUEOUS SOLUTION

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ABSTRACT

From the view of economical efficiency and technology sustainability, considerable attention has been recently given to the use of low-cost biomass residues as adsorbents in pollution control. To achieve a desirable adsorptive efficiency, some efforts have also been made to modify biomass adsorbents through appropriate treatments. There is a particular interest in surfactant-assisted biomass surface modification. Although some findings from previous studies are encouraging, knowledge about the adsorption of pollutants onto surfactant-modified biomass is still limited. A number of issues about the characteristics of involved interface transport are poorly understood. The present study therefore aims to examine the adsorption of anionic azo dyes onto surfactant-modified biomass in the solution. Different surfactants are used for modification. The equilibrium and kinetic studies for the adsorption of anionic azo dyes on modified biomass are conducted and the effects of aqueous chemistry characteristics are also evaluated. The results present the potential of modified biomass as suitable adsorbent for the removal of anionic azo dyes from wastewater. It can help understand the migration patterns of organic pollutants at biomass-water interface.

Keywords: Adsorption; Biomass; Anionic azo dyes; Gemini surfactant modification

1. BACKGROUND

Dyes are important pollutants with considerable adverse environmental and health impacts (Bulut et al., 2007). More than 100,000 dyes originating from leather, paper, printing, cosmetics, textile industries exist in the water environment around the world (Nigam et al., 2000). Azo dyes are a major class of synthetic organic compounds, which can account for more than half of the annually produced amount of dyes (Stolz, 2001). Once discharged in to the water, these colored chemical compounds can not only be aesthetically undesirable but also inhibit sunlight penetration into the stream, leading to the reduction of the photosynthetic reaction (Bulut et al., 2007). Furthermore, the aromatic amines generated from the enzymatic breakdown and cleave of azo dye linkage may cause disorders of living systems, including carcinogenicity (Brown and De Vito, 1993). Therefore, there is an increasing need for developing effective strategies to remove azo dyes from wastewater.

Various techniques such as chemical sedimentation (Eric J. Weber and Adams, 1995), photocatalytic degradation (Stylidi et al., 2003), membrane filtration (Liu et al., 2007), advanced oxidation (Galindo et al., 2000), and electrochemical decolourisation (Fernandes et al., 2004) have been applied for the removal of azo dyes from effluents. Adsorption is an alternative technology, which is considered to be with the advantages of simple operation and good removal efficiency (Arami et al., 2006). From the view of economical efficiency and technology sustainability, considerable attention was recently given to the use of low-cost agricultural residues and by-products as adsorbents in pollution control.

The present study therefore aims to examine the adsorption of anionic azo dyes onto surfactant-modified biomass in the solution. A new gemini surfactant will be used due to its advantages compared with the traditional surfactants. This is the first study to our knowledge to explore the interaction between anionic azo dyes and gemini surfactant-modified biomass at the solid-liquid interface. The equilibrium and kinetic studies for the adsorption of anionic azo dyes will be conducted and the effects of aqueous chemistry characteristics are also evaluated.

2. METHODS

Acid red 18 (AR-18), acid orange 7 (AO-7), acid black 1 (AB-1), and cationic gemini surfactant (N1-dodecyl-N1, N1, N2, N2-tetramethyl-N2- octylethane-1,2-diaminium bromide, 12-2-12) were used. The batch adsorption method was adopted. Synchrotron based FTIR measurements were carried out at the beamline 01B1-01(MidIR) at the Canadian Light Source (Saskatoon, Canada). Surface morphology, BET surface areas, and particle size distribution were measured.

3. RESULTS

The present study investigated the performance of modified biomass for removing anionic azo dyes from solution. Gemini surfactant-assisted modification can significantly improve the adsorption capacity of wheat brans. The modification changed the surface configuration and the charged character of wheat bran. Langmuir isotherm could better fit equilibrium data for the adsorption of anionic azo dyes on modified biomass. Kinetic analysis results showed this process could be well described by pseudo-second-order and two-step intra-particle diffusion models. Chemisorption could be dominated in the adsorption process. The adsorption of AR-18 and AB-1 was endothermic in nature, while it was exothermic for AO-7. The optimum pH level for the adsorption of anionic azo dyes on modified biomass was at 3. The absorbed amount of anionic azo dyes onto modified biomass decreased when NaCl concentration ranged from 0 to 0.4 mol/L.

4. CONCLUSION

The results presented the potential of modified biomass as a suitable adsorbent for the removal of dyes from wastewater. The results can help understand the migration patterns of organic pollutants in biomass -water interface. Further study is also needed to help obtain more theoretical foundation for the interactions of wastewater pollutants and biomass characteristics. Different biomass types and modification approaches will be also investigated for scale-up application.

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