

Applicability and Reusability of Fly Ash and Base Treated Fly Ash for Adsorption of Catechol from Aqueous Solution: Equilibrium, Kinetics, Thermodynamics and Modeling

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Abstract : Catechol is a natural polyphenolic compound that widely exists in higher plants such as teas, vegetables, fruits, tobaccos, and some traditional Chinese medicines. The fly ash-based zeolites are capable of absorbing a wide range of pollutants. But the process of zeolite synthesis is time-consuming and requires technical setups by the industries. The marketed costs of zeolites are quite high restricting its use by small-scale industries for the removal of phenolic compounds. The present research proposes a simple method of alkaline treatment of FA to produce an effective adsorbent for catechol removal from wastewater. The experimental parameter such as pH, temperature, initial concentration and adsorbent dose on the removal of catechol were studied in batch reactor. For this purpose the adsorbent materials were mixed with aqueous solutions containing catechol ranging in 50 – 200 mg/L initial concentrations and then shaken continuously in a thermostatic Orbital Incubator Shaker at 30 ± 0.1 °C for 24 h. The samples were withdrawn from the shaker at predetermined time interval and separated by centrifugation (Centrifuge machine MBL-20) at 2000 rpm for 4 min. to yield a clear supernatant for analysis of the equilibrium concentrations of the solutes. The concentrations were measured with Double Beam UV/Visible spectrophotometer (model Spectscan UV 2600/02) at the wavelength of 275 nm for catechol. In the present study, the use of low-cost adsorbent (BTFA) derived from coal fly ash (FA), has been investigated as a substitute of expensive methods for the sequestration of catechol. The FA and BTFA adsorbents were well characterized by XRF, FE-SEM with EDX, FTIR, and surface area and porosity measurement which proves the chemical constituents, functional groups and morphology of the adsorbents. The catechol adsorption capacities of synthesized BTFA and native material were determined. The adsorption was slightly increased with an increase in pH value. The monolayer adsorption capacities of FA and BTFA for catechol were 100 mg g^{-1} and 333.33 mg g^{-1} respectively, and maximum adsorption occurs within 60 minutes for both adsorbents used in this test. The equilibrium data are fitted by Freundlich isotherm found on the basis of error analysis (RMSE, SSE, and χ^2). Adsorption was found to be spontaneous and exothermic on the basis of thermodynamic parameters (ΔG° , ΔS° , and ΔH°). Pseudo-second-order kinetic model better fitted the data for both FA and BTFA. BTFA showed large adsorptive characteristics, high separation selectivity, and excellent recyclability than FA. These findings indicate that BTFA could be employed as an effective and inexpensive adsorbent for the removal of catechol from wastewater.

Keywords : catechol, fly ash, isotherms, kinetics, thermodynamic parameters

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