ETHYLENEDIAMINE TETRAACETIC ACID (EDTA) MODIFIED RICE HUSK AS AN ADSORBENT FOR DYES AND HEAVY METAL IONS REMOVAL

Abstract:

The potential of various chemically modified rice husk to remove Methylene Blue (MB) and Reactive Orange 16 (RO16) from aqueous solution was investigated. It was found that ethylenediamine tetraacetic acid modified rice husk (ERH) has the highest adsorption capacity for both MB and RO16. ERH was produced by treating natural rice husk (NRH) with 0.5 g of ethylenediamine tetraacetic acid (EDTA) in 300 mL of 1 mol/dm$^3$ NaOH. Fourier Transform Infrared Spectroscopy (FTIR) was used to analyse the surface functional groups of ERH. Surface morphology analysis by atomic force microscopy (AFM) and scanning electron microscopy (SEM) showed that the surface topography of ERH was higher and smoother than NRH.

The effect of pH, contact time, influence of initial dye concentration, amount of adsorbent used, agitation rate and effect of particle size on the adsorption of MB and RO16 in single and binary systems were investigated under batch experiments. Equilibrium data were fitted into three isotherms models, namely Langmuir, Freundlich and Brunauer-Emmet-Teller (BET) model equations. It was found that the equilibrium fitted well in Freundlich isotherm with higher regression coefficient value, $R^2$. The maximum adsorption capacities of MB and RO16 in binary system were 49.505 mg/g and 17.241 mg/g, respectively. Adsorption kinetic was studied by fitting the experimental data with
pseudo-first and pseudo-second order kinetic models. Results showed that pseudo-second order kinetic model provided a better description of MB and RO16 adsorption in single and binary dye solutions as compared to pseudo-first order kinetic model.

The adsorption behavior of MB and RO16 onto column packed with ERH was investigated under continuous flow mode with three different parameters; the effect of influent concentration, the effect of bed depth and the effect of flow rate. Results obtained showed that the breakthrough time is longer for MB at both lower influent concentration and flow rate. An unusual rapid breakthrough was observed for RO16 in single and binary dye solutions. This implied that the adsorption of RO16 is a slow process and an effective adsorption only takes place after a sufficient lapse of time. Bed depth service time (BDST) model, Adams-Bohart model and Clark model were employed in this study to describe the adsorption behavior of dyes under continuous flow conditions. The breakthrough curves predicted by Clark model agreed well with the experimental breakthrough curves at various flow rates.

The optimum adsorption conditions for the uptake of MB and RO16 in both single and binary dye systems by ERH were studied using Plackett-Burman design coupled with response surface methodology (RSM). From Plackett-Burman design, the significant variables in affecting the uptake of single MB were determined to be pH and adsorbent dosage. As for single RO16, binary
RO16 and binary MB, pH and contact time were found to be significant in affecting the percentage uptake. The combined effects of interaction between the significant variables were determined using ANOVA analysis.

In heavy metal analysis, the potential of ERH in removing heavy metal ions was investigated. The adsorption of both Cu(II) and Cd(II) ions were found to be pH dependent. Greater uptake was observed at higher pH. Experimental data showed a better fitting in Langmuir isotherm as compared to Freundlich isotherm. The maximum adsorption capacities of 7.936 mg/g and 12.987 mg/g were obtained for Cu(II) and Cd(II) ions, respectively. With the presence of chelators, the uptake of both metal ions by ERH decreased

ERH therefore appeared to be a potential and efficient adsorbent for the removal of dyes such as MB and RO16 in textile wastewater as well as heavy metal ions in electroplating wastewater.