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Bench scale fixed-bed column adsorption studies and adsorption modelling: removal of methylene blue from aqueous solutions using glutaraldehyde cross - linked chitosan beads

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As dye-containing waste effluent is a big threat not only to the environment, but also to human life and the economical removal of dyes from wastewater has become an environmental challenge in nowadays. Therefore, this work focuses on the exploration of potential of using physically and chemically modified chitosan, glutaraldehyde cross-linked chitosan beads (GCLCBs) to remove a model dye, methylene blue (MB) from aqueous solutions using bench-scale fixed bed columns. GCLCBs (4.00±0.02 mm in diameter) were prepared by using glutaraldehyde as the cross-linking agent and it was characterized by Scanning Electron Microscopy (SEM) and Fourier-Transform Infrared Spectroscopy (FTIR). FTIR analyses confirmed the cross-linking of chitosan beads with glutaraldehyde. The effects of initial MB concentration (10, 12, 15 mg/L) and inlet flow rate (5, 10, 15 mL/min) at neutral pH and at room temperature (30 ± 2 $^{\circ}$C) on the performance of column packed with GCLCBs were analysed using breakthrough curves. The breakthrough time (T_b), time required for full bed exhaustion (T_t), bed capacity (BC) and length of unused bed (LUB) were determined at each column operating conditions. The highest % MB removal of 72.80% was obtained at initial MB concentration of 10 mg/L and inlet flow rate of 5 mL/min at 6 cm bed height of the adsorbent. The breakthrough time, T_b increased with decreasing inlet flow rate and initial MB concentration. Two kinetic models namely the Thomas model and Yoon – Nelson model were used to predict the column performance and column parameters important in designing large-scale columns in water purification systems. The results revealed that the Thomas rate constant decreased with increasing initial adsorbate concentration and inlet flow rate. The time required to achieve 50% of adsorbate breakthrough (τ) seems to agree quite well with the experimental data (τ experimental) according to the results obtained from Yoon – Nelson model. Both the Thomas and Yoon – Nelson models fitted the experimental data with high regression coefficient values ($R^2 \sim 1$) indicating the validity of both kinetic models for the studied column system. Based on the results it can be concluded that that the GCLCBs could be used as low-cost and environmentally friendly agent for the treatment of dye containing wastewater.

Keywords: Adsorption, Breakthrough curves, Fixed–bed column, Thomas model, Yoon –Nelson model.