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Removal of Heavy Metal Ions from Aqueous Solution by Polymer Enhanced Ultrafiltration Using Unmodified Starch as Biopolymer

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Abstract : The effects of pH, polymer concentration, and metal ions feed concentration for four selected heavy metals Zn (II), Pb (II), Cr (III) and Cr (VI) were tested by using Polymer Enhanced Ultrafiltration (PEUF). An alternative biopolymer namely unmodified starch is proposed as a binding reagent in consequences, as compared to commonly used water-soluble polymers namely polyethylene glycol (PEG) and polyethyleneimine (PEI) in the removal of selected four heavy metal ions. The speciation species profiles of four selected complexes ions namely Zn (II), Pb (II), Cr (III) and Cr (VI) and the present of hydroxides ions (OH-) in variously charged ions were investigated by available software at certain pH range. In corresponds to identify the potential of complexation behavior between metal ion-polymers, potentiometric titration studies were obtained at first before carried out experimental works. Experimental works were done using ultrafiltration systems obtained by laboratory ultrafiltration bench scale equipped with 10 kDa polysulfone hollow fiber membrane. Throughout the laboratory works, the rejection coefficient and permeate flux were found to be significantly affected by the main operating parameter, namely the effects of pH, polymer composition and metal ions concentrations. The interaction of complexation between two binding polymers namely unmodified starch and PEG were occurred due to physical attraction of metal ions to the polymer on the molecular surface with high possibility of chemical occurrence. However, these selected metal ions are mainly complexes by polymer functional groups whenever there is interaction with PEI polymer. For study of single metal ions solutions, Zn (II) ions' rejections approaching over 90% were obtained at pH 7 for each tested polymer. This behavior was similar to Pb (II), Cr (III) and Cr (VI); where the rejections were obtained at lower acidic pH and increased at neutral pH of 7. Different behavior was found by Cr (VI) ions where a high rejection was only achieved at acidic pH region with PEI. Polymer concentration and metal ions concentration are found to have a significant effect on rejections. For mixed metal ion solutions, the behavior of metal ion rejections was similar to single metal ion solutions for investigation on the effects of pH. Rejection values were high at pH 7 for Zn (II) pH 7 for Zn (II) and Cr (III) ions, corresponding to higher rejections with unmodified starch. Pb (II) ions obtained high rejections when tested with PEG whenever carried out in mixed metal ion solutions. High Cr (VI) ions' rejection was found with PEI in single and mixed metal ions solutions at neutral pH range. The influence of starch’s granule structure towards the rejections of these four selected metal ions is found to be attracted in a non-ionic manner. No significant effects on permeate flux were obtained when tested at different pH ranges, polymer concentrations and metal ions feed either by single or mixtures metal ions solutions. Canizares Model was employed as the theoretical model to predict permeate flux and metal ions retention on the study of heavy metal ions removal.

Keywords : polyethyleneimine, polyethylene glycol, polymer-enhanced ultrafiltration, unmodified starch
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