Uptake of Co(II) ions from aqueous solutions by low-cost biopolymers and their hybrid

Schidza Cime, Mohamadia Nassar, Abel E. Navarro PhD
Science Department, Borough of Manhattan Community College, CUNY, New York, NY

INTRODUCTION

Cobalt ion is a commonly underestimated pollutant that is responsible for several health problems. Biosorption is an alternative technique for the potential elimination of heavy metals from aqueous solution by the passive interaction of non-living biomass and the target pollutant. Alginate hydrogel beads (AB), spent peppermint leaf (PM) and a hybrid adsorbent of these two materials (ABPM) were studied as potential biosorbents of Cobalt (II) ions from aqueous solutions. Discontinuous batch experiments were conducted at room temperature to evaluate the effect of solution acidity and mass of adsorbent on the adsorption of Co(II) ions.

MATERIALS AND METHODS

Preparation of Cobalt(II) Solution

Solutions of 1000 ppm (mg/L) of cobalt nitrate hexahydrate were freshly made with deionized water for every adsorption experiment.

Preparation of adsorbents

- Spent peppermint tea leaves were obtained by vigorous boiling of peppermint tea bags. The tea bags were oven-dried overnight and were cut open. The content was ground and sieved to particle sizes within the range of 106 -150 µm.

- Alginate hydrogel beads were prepared by dissolving 4.5 g of sodium alginate in 200 mL of distilled water under magnetic stirring and gentle heating. Later, the alginate solution was put into a calcium chloride solution drop-wise.

- Hybrid ABPM biosorbent was prepared by encapsulating PM samples into the alginate beads. The procedure followed the same as the preparation of AB, except that for this solution, 4.5 g of sodium alginate was dissolved in 200 mL of distilled water

RESULTS

Effect of Initial Solution pH

Carboxylate groups are more populated when the pH values of the solution are higher than 3. Figure 1 shows the effect of the solution's pH on the adsorption of Co(II) on AB, PM and ABPM adsorbents. It was concluded that the optimum solution pH for removal of cobalt (II) ions is 5 to 7 for all adsorbents.

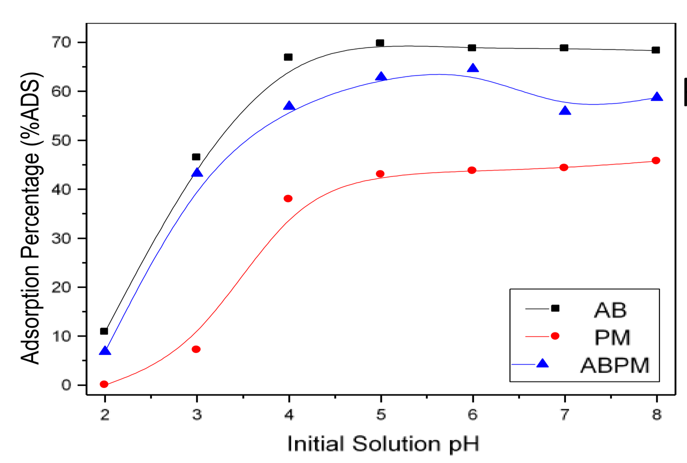

Figure 1: Initial solution pH effect on the adsorption of Co(II) ions

Effect of Mass Adsorbent

The %ADS increased with the adsorbent masses due to the higher number of adsorption sites. Figure 2 shows that higher adsorption capacities were obtained with 200, 200 and 120 mg of AB, PM and ABPM, respectively.

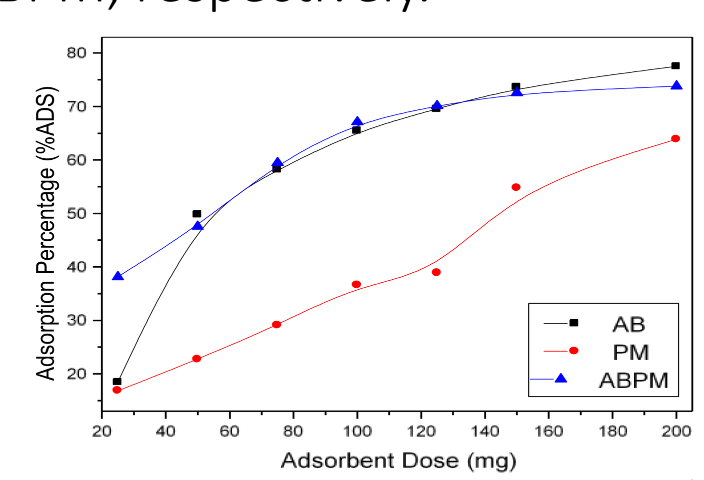

Figure 2: Mass of adsorbent effect on the adsorption of Co(II) ions

Effect of Salinity

It is expected that cations will display a strong effect on the adsorption due to the competition with Co(II) for the same adsorption centers. Figure 3 depicts the effect of salts such as NaCl, NaNO3, and Ca(NO3)2 on the adsorption of Co(II) ions. It indicates that salts have a negative effect on the adsorption of Co(II) for all the adsorbents.

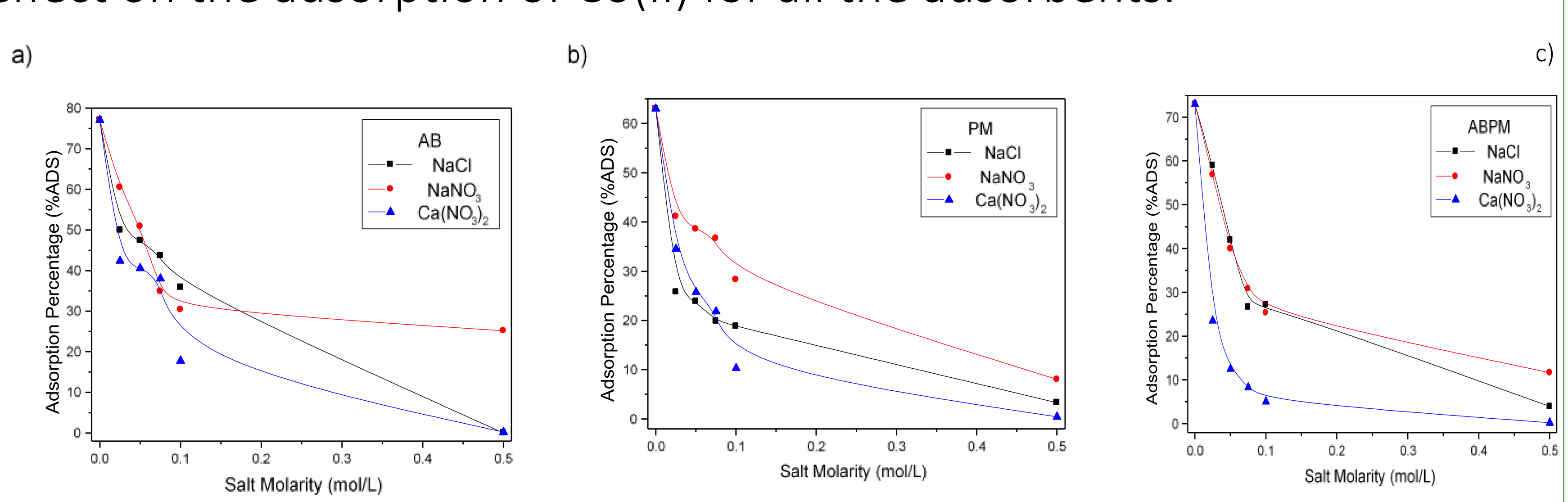

Figure 3: Salinity effect on the adsorption of Co(II) ions on: (a) AB, (b) PM, and (c) ABPM

Effect of Other Pollutants

Most of the wastewater do not only contain one pollutant, but mixtures of them. Co(II) ions were mixed with Pb(II) ions and an artificial dye (BY57). Figure 4 indicates a moderate decrease in the adsorption for PM and a small effect for AB and ABPM.

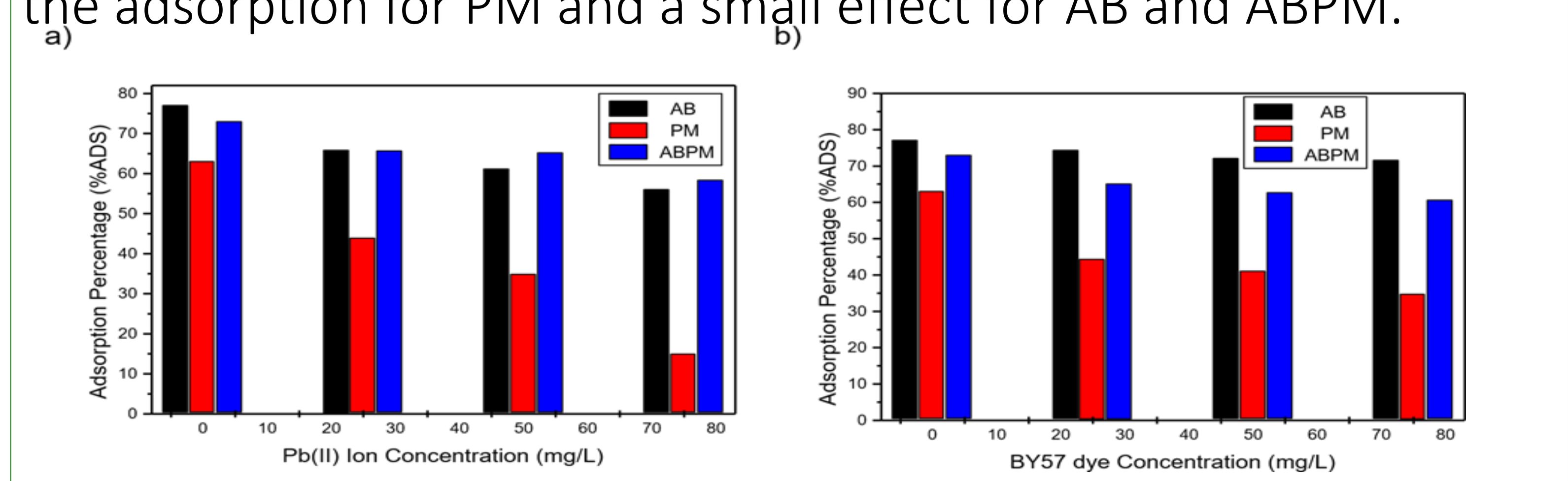

Figure : Effect on the adsorption of Co(II) ions by the presence of: (a) Lead(II) ions and (b) Basic Yellow 57 dye.

Characterization of the Adsorbents

The textural and morphological properties of the 3 adsorbents were investigated by scanning electron microscopy (SEM) at different zooms. Figure 6 displays the micrographs of AB, PM and ABPM.

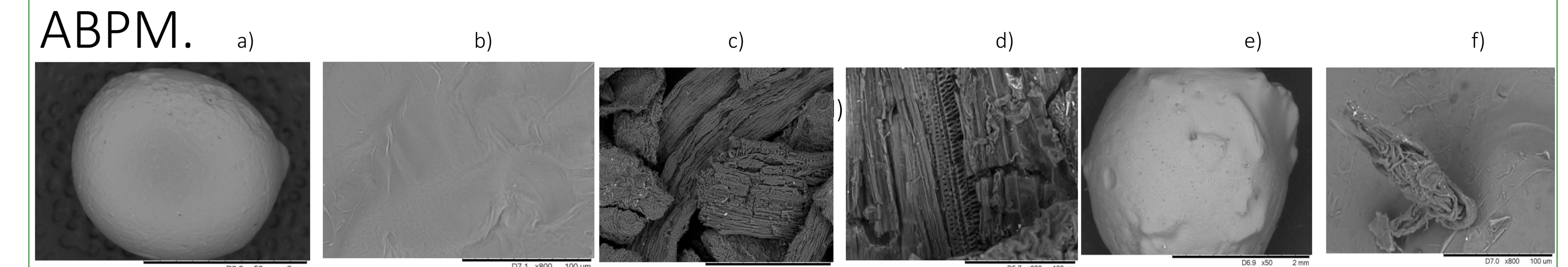

Figure 6: Scanning Electron Micrographs of the adsorbents are different zooms: (a,b) AB, (c,d) PM, and (e,f) ABPM

CONCLUSIONS

The adsorption results indicate that divalent cobalt maximizes its adsorption at pH values higher than 5, using adsorbent masses of 200, 200 and 120 mg for AB, PM and ABPM respectively. The Adsorption Percentage followed the trend: AB>ABPM>PM with values of 77%, 71% and 64%. Salinity had a strong negative effect, with a higher effect with Ca+2 and Cl-1 ions. Pb(II) ions and a cationic dye (Basic yellow 57) have a mild effect on the adsorption of Co+2 ions.

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