

CHAPTER V

CONCLUSION

The effective immobilization of humic acids on aminopropyl silica (Si-HA) was successfully achieved. Si-HA was used for the metal ion extraction from water sample. The studied metal ions were Au(III), Ag(I), Cd(II), Cr(III), Ni(II), Pb(II) and Zn(II). The effects of parameters influencing the extraction efficiency such as the pH of solution, the contact time, and the sorption capacity were investigated by batch method. The column system was also investigated to obtain the optimum conditions for the extraction and elution of the metal ions. The effects of the extraction and elution flow rate, the amount of sorbent and the interfering ions were evaluated.

The pH and the contact time affected the extraction efficiency and the optimum values for each metal ion was summarized in Table 5.1. The adsorption isotherm of all the metal ions onto Si-HA obeyed the Langmuir adsorption model. The maximum sorption capacities order was $\text{Cr(III)} > \text{Pb(II)} \approx \text{Au(III)} > \text{Zn(II)} \approx \text{Cd(II)} > \text{Ag(I)} > \text{Ni(II)}$. The order of associate affinity followed $\text{Au(III)} \gg \text{Cd(II)} > \text{Zn(II)} > \text{Ni(II)} > \text{Pb(II)} \approx \text{Cr(III)} > \text{Ag(I)}$.

In column method, the flow rate did not affect the efficiency of extraction and elution. 10%(v/v) nitric acid was chosen as eluent for Ag(I), Cr(III), Cd(II), Ni(II), Pb(II) and Zn(II). The 80-100 % recovery were in the acceptable range but Au(III) ions could not be eluted by using 10%(v/v) of hydrochloric acid. Sodium, potassium, calcium, chloride, nitrate and sulfate ions with concentrations $10\text{-}1000 \text{ mg L}^{-1}$ were studied as interfering ions. The results are summarized in Table 5.1.

This thesis attempted to develop a method for extraction heavy metal ions in aqueous solution to improve the quality of wastewater. A method is not complicate, easy to operate and give a good result although using at high flow rate that is suitable to apply for wastewater treatment. The optimum condition can conclude below;

Table 5.1 Condition for extraction of heavy metal ions by using humic acid immobilized on aminopropyl silica

	Ag(I)	Au(III)	Cd(II)	Cr(III)	Ni(II)	Pb(II)	Zn(II)
Batch system							
pH	4-6	3-5	4-7	4-6	4-7	4-7	4-7
extraction time (min)	30	30	30	30	30	30	30
maximum sorption capacity (mmol g ⁻¹)	0.019	0.065	0.022	0.091	0.018	0.065	0.022
Column system							
Flow rate (mL min ⁻¹)							
Extraction	0.5-5.0	0.5-2.5	0.5-5.0	0.5-5.0	0.5-5.0	0.5-5.0	0.5-5.0
Elution	3.5	-	3.5	3.5	3.5	3.5	3.5
Interfering ion/salts	Cl ⁻	NaCl	-	-	-	-	-
		NaNO ₃					
		Na ₂ SO ₄					
		KNO ₃					
		Ca(NO ₃) ₂					
		Mg(NO ₃) ₂					

Suggestions for future work

This present method was able to apply in the extraction of heavy metal in a real wastewater sample, but not in a huge volume of the sample. The efficiency of the extraction in a large volume of water and a pilot scale should be studied further.