Studies on the sorption of Pb(II) on the synthetic gel, potassium fluorophlogopite

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Sorption of Pb(II) has been studied on the synthesized gel similar to potassium fluorophlogopite \( \text{K}_3\text{Mg}_3(\text{Si}_3\text{AlO}_10)\text{F}_2 \), at pH 2, 4 and 7. The effect of parameters like equilibrium time (0.5 – 24.0 h), weight of the exchanger (30 – 150 mg) and temperature (25° – 45°C) have also been investigated. The uptake of metal ion Pb(II) has been expressed in terms of distribution coefficient values.

Contamination of the environment by heavy metal ions has led to major health hazards to human beings and animals. In industrial waste waters, concentration of lead can approach 200-250 ppm. This value is very high in relation to the water quality standards of 0.05-0.1 mg/l (WHO)\(^4\) and hence it is necessary that Pb(II) concentration in waste waters be reduced to an acceptable value. The common methods of removal of metal ions include chemical precipitation, solvent extraction, electrodialysis, electrolytic extraction, reverse osmosis, biosorption etc.\(^2\). The development of synthetic inorganic materials with higher selectivity of ions has received much attention during the last two decades\(^3-6\). A study of the several materials reported shows that the mica group of minerals has not been studied much. It was, therefore, thought of interest to study the sorption of Pb(II) on one of the mica group of minerals, potassium fluorophlogopite \( \text{K}_3\text{Mg}_3(\text{Si}_3\text{AlO}_10)\text{F}_2 \).

Experimental

The mica mineral, potassium fluorophlogopite \( \text{K}_3\text{Mg}_3(\text{Si}_3\text{AlO}_10)\text{F}_2 \), was synthesized by the hydrothermal method in a Teflon-lined stainless steel pressure vessel at a temperature 200°C for 72 h by literature method\(^8-10\). The chemical composition of the synthesized gel was checked for K, Mg, Al and Si by EDS and XRD powder method.

The XRD pattern of the gel was recorded on a computer interfaced PW3011(mini prop.) diffractometer system, while the EDS pattern of the gel was recorded (EDAXZAF quantification) at “SICART” Vallabh Vidya Nagar, Gujarat.

A weight amount of this gel was equilibrated with required concentrations of Pb(II) ions at pH 2.0, 4.0, and 7.0. The exchanger was also equilibrated with Pb(II) solution in a thermostated water bath at 25°, 35° and 45°C.

The selectivity of Pb(II) ions by this gel is expressed in terms of distribution coefficient, i.e., \( K_D \) values.

Results and discussion

The EDS analysis and X-ray diffraction suggest that the gel is similar to the fluorine mica, potassium fluorophlogopite \( \text{K}_3\text{Mg}_3(\text{Si}_3\text{AlO}_10)\text{F}_2 \). X-ray powder diffraction pattern of the sample shows maxima at 36.68 counts/s, d-spacing : 1.53347Å, relative intensity (%) : 100.00, angle: (2θ=60.30612), background (count/s) : 86.66 and significance : 1.03.

The KFP gel shows separation of the two hexagonal by a distance of 1.53347Å. Thus the structural investigation show that the hydrothermal phase resembles disordered potassium fluorophlogopite phase which may gradually be ordered to 1M type. The ordering of phase begins at 425°C below which the mineral exists in a gel like phase. Smith and Yoder\(^1\) have described the sheet structure of fluorine mica as made up of a hexagonal network with the hexagonal vacant sites available for the exchange of ions.

\( K_D \) versus time plot shows that \( K_D \) values for Pb(II) increases with time up to 7 h, after which it remains constant, therefore time required for equilibration for further studies was taken as 8 h. It was observed that while changing the exchanger to aqueous phase ratio, the \( K_D \) values increased with decrease in the ratio due to the availability of more number of sites for exchange. Studies with different amounts of the gel (30-150 mg) showed that 100 mg of the exchanger (1:500) was sufficient for optimum exchange.

Under optimum conditions sorption studies were carried at varying temperature (25°-45°C) and pH (2, 4 and 7). Data show that highest value of \( K_D \) was obtained at pH 4. It was also observed that with increasing temperature, \( K_D \) values increased.

The present studies shows that the synthetic ion exchanger, potassium fluorophlogopite, has a great
potential for Pb(II) of sorption at pH 4. The exchanger also has affinity for Pb(II) at higher temperatures.

References
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