

Separation of Trace-Metal Ions from Seawater by Adsorptive Colloid Flotation

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Summary An adsorptive colloid flotation process based on a collector-surfactant-air system makes possible the rapid separation of various cationic and anionic metallic species from seawater.

THE novel adsorptive colloid flotation technique reported previously for the separation of trace-metal anions in seawater has been extended to cations.

Previous work^{1,2} on the role and behaviour of iron(III) hydroxide and thorium(IV) hydroxide as collectors of trace

pH in the flotation cell, the positively charged surfaces of the molybdenum-enriched iron(III) hydroxide particles are attracted to the surfactant ions. These are concentrated and oriented in the air-water interphase in such a manner that the hydrophobic portion points to the air phase and the charged portion remains in the aqueous phase. A stable froth floats to the surface of the seawater from which it is easily removed and analysed by appropriate methods. The technique was also applied successfully to the separation of uranium, believed to be present as the stable uranyl carbonate complex ion, $[\text{UO}_2(\text{CO}_3)_3]^{4-}$.

Summary of results of the separation of trace ions by colloid flotation

Metal	Ionic species	Surfactant	pH	Ionic conc. in seawater ($\mu\text{g l}^{-1}$)	Recovery (%)	Method of determination
Molybdenum	MoO_4^{2-}	Sodium dodecyl sulphate	4.0 ± 0.1	11.4	95.3	Spectrophotometric (as Mo-CNS complex)
Uranium	$[\text{UO}_2(\text{CO}_3)_3]^{4-}$	Sodium dodecyl sulphate	5.7 ± 0.1	3.2	82.0*	Spectrophotometric (as Rhodamine-B complex)
Zinc	Zn^{2+}	Dodecylamine	7.6 ± 0.1	3.2	94.0	Atomic absorption
Copper	Cu^{2+}	Dodecylamine	7.6 ± 0.1	0.8	95.0	Spectrophotometric (as dibenzyl-dithiocarbamate complex)

* A recovery of 96% can be obtained by double flotation.

metals from seawater demonstrated that at optimal conditions virtually all the molybdenum in a sample of seawater was adsorbed on to the collector and could be removed as a co-precipitate by filtration. The separation was based upon the adsorption of the anionic molybdate on the active surface sites of the hydroxides which are positively charged in acidic solution. Therefore, combination of a collector with an adsorptive colloid flotation process should provide more effective separation of traces of anionic species. Although ion flotation and related techniques are relatively well known they have not yet been applied to seawater.^{3,4} We have reported the separation of molybdate from seawater by a collector-surfactant-air system comprised of positively charged iron(III) hydroxide, an anionic surfactant (dodecyl sodium sulphate), and air.⁵ The attraction between the colloidal collector and molybdate is presumably electrostatic and chemical. Upon addition of the anionic surfactant and bubbling of air through the seawater at low

We extended colloid flotation to the separation of trace cationic species from seawater by use of a negatively charged collector, a cationic surfactant, and air. We have separated Zn^{2+} and Cu^{2+} with iron hydroxide (which is negatively charged at pH 7.6), dodecylamine, and air. The main advantages of this technique are simplicity of equipment, effective recovery and reproducibility, and rapidity. The separation is achieved in 2–3 min. The results obtained are summarized in the Table. We believe that the technique can be applied to a wide variety of trace cations and anions in seawater by judicious selection of collector, surfactant, and pH. Although studies have been confined to laboratory scale, there is potential perhaps for the separation from seawater of various trace metals of economic importance such as uranium.⁶

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