

The Adsorption Behavior of Copper Ion on Manganese Nodules

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Abstract

The copper adsorption capacities of the manganese nodule powder were 13mg Cu/g at solution pH 1.5, 40mg Cu/g at pH 4.5, and 45mg Cu/g at pH 5.5, respectively. The adsorption of copper ions was found to be an endothermic process and increased with temperature between 20 and 80°C from 39.9mg Cu/g to 48.7mg Cu/g. The adsorption of copper on the nodule powder increased with the decreasing particle size and was not influenced by the addition of sodium ions and different kinds of anions. The amount of copper adsorbed on the nodule powder decreased with the increasing heat treatment temperature of the nodule powder. (Without heat treatment : 40mg Cu/g, with heat treatment at 500°C : 22.8mg Cu/g).

Key Words : Manganese nodules, Adsorption, Copper ion, Removal of heavy metal

Introduction

Manganese nodules are comprised mainly of oxides of manganese and iron containing minor metals such as copper, nickel and cobalt (Fuerstenau and Han, 1983). It is mainly because of these valuable metal elements that nodules have attracted attention in recent years as a potential mineral resource. The major phases in these nodules have been identified as todorokite and goethite (Fuerstenau, Herring and Hoover, 1973). Other metals are not present as separate minerals, but are associated with manganese and iron containing minerals.

The most remarkable physical characteristics of manganese nodules are their high porosity and specific surface area. Nodules are filled with extremely fine pores of the order of 100 Å diameter which results in porosities of near 60% by volume and surface areas of about 200 m²/g (Han, 1976, Agarwal, 1976). It has been also reported that manganese is present in nodules as δ-MnO₂ which has excellent adsorption capacity for heavy metal ions (Murray, 1967). These properties of manganese nodules has led to consideration of their use as an adsorbent, but only a few works on this field have been reported till now (Nishiyama, 1984).

The principal purpose of the present study is to examine the practical applicability of removal of heavy metal ions from the waste water using the nodules as an adsorbent. The adsorption behaviour of copper ions on nodules has been studied as a function of copper concentration, adsorption time, temperature, solution pH, particle size, and so on.

Experimental

Manganese nodule samples collected from the Pacific Ocean (Clarion-Clipperton Fracture Zone) by the Korea Institute of Geology, Mining & Materials were crushed and ground to different size fractions. The size of the nodule powder used in the tests was chosen to be minus 100 mesh except in tests for the particle size effect. Chemical analysis of the nodule powder is shown in Table 1.

Table 1. Chemical analysis of the manganese nodule samples.

Composition	Al ₂ O ₃	CaO	K ₂ O	MgO	Na ₂ O	Fe	Mn	Co	Ni	Cu
%	5.50	2.12	1.37	3.08	3.05	6.06	23.73	0.19	0.92	0.71

Experiments were conducted by mixing 1g of nodule powder and 100 ml of copper sulfate solution in flasks and solution pH was controlled by adding sulfuric acid or sodium hydroxide. The flasks were placed in shaker baths and agitated at an appropriate temperature for an appropriate time. The slurries were filtered after the adsorption tests were completed, and solution pH and copper concentrations of the filtrates were measured to determine the exact experimental conditions. Copper in the filtrates were analysed by a Perkin Elmer Atomic Absorption Spectrophotometer and then the amounts of copper adsorbed on the nodules were calculated.