Leaching of Rare Earth Metals from Deepsea Nodule by Dilute Sulfuric Acid Solution

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ABSTRACT

Leaching of total rare earth metals from the sea nodule was carried out using H_2SO_4 solution. Existence of phase of rare earth metals in the sea nodule was confirmed while leaching with different reagents. Concentration of H_2SO_4 and temperature are found to be critical factors on leaching of REMs. Although there is a high yield of REMs an average of 83.03%, the co-extraction of the other base metals like Fe, Co, Ni, Cu is very high too (average 32.59%) using 3 M H_2SO_4 at temp. 30 °C. In particular, an effective and selective extraction (57.6%) of total REMs was observed at H_2SO_4 concentration of 0.2 M and temp. 45 °C, in which the co-extractions of other base metals are less.

KEY WORDS: Deep sea nodule; rare earth metals; leaching; H_2SO_4 solution.

INTRODUCTION

Rare earth metals (REMs), include the series of 15 metals (specifically lanthanides) and yttrium. Due to growing requirement in technological applications (alloys in aircraft, cell phones, computer components, electric motors, specialty glass and lenses), REMs have become important in modern commercial and industrial processing (Gupta and KrishnaMurthy, 2005; Resende and Morais, 2010). These rare earth metals are so called hi-tech elements owing to their spectroscopic and magnetic properties (Martins, 2005; Koschinsky, 2011). The source, Deep sea nodule claims to have the total rare earth metals (REMs) ~ 500-1000 ppm, apart of bearing other valuable metals; nickel (1.25-1.5%), copper (1-1.4%), cobalt (0.2-0.25%) and Mo (~0.05%) (Fuerstuenau and Han, 1977; Monhemius, 1986). Nevertheless, it is considered as one of the best potential resource for the futuristic scope, although the occurrence of total rare earth metals very low over other RE sources e.g., Monazite (Gupta and KrishnaMurthy, 2005) and Bastnasite (Kul, 2008). From the literatures (Koschinsky, 2011; Fuerstuenau and Han, 1977), these rare metals are located on the lattice of manganese and iron phase (major contents of sea nodule). Therefore, one of the possibilities for the recovery of the rare earth metals can be either by reductive dissolution of the primary phase of sea nodule or by direct leaching with mineral acids.

A number of processing approaches have been made with the objective to increase the efficiency of recovery of the valuable metals (particularly base metals) from sea nodules (Das, 1986; Anand, 1988; Kanungo and Jena, 1988; Acharya, 1999; Zhang, 2001; Nam, 2003; Senanayake, 2011). However, none of the above approaches have mentioned about the extraction of rare earth metals yet. The processing technology of Deep sea nodule developed by KIGAM (Korea Institute of Geoscience and Mineral Resources) consists of smelting and acid leaching of matte followed by SX-EW of Cu, Co and Ni. It was observed that while smelting of the sea nodule, all the rare earth metals contents are transferred to the slag phase. It is quite difficult to recover rare earth metals economically from this slag. The research groups of KIGAM have developed a new technology for the recovery of rare earth metals from Deep sea nodule by leaching and solvent extraction process.

Based on several years research, hydrometallurgical processes (leaching, precipitation and solvent extraction) for the recovery of REMs have been developed. Though, varieties of lixiviants have been used such as sulfuric acid (Lokshin, 2002; Lyan, 2009; Resende, 2010) and hydrochloric acid (Pingwei, 1998), for the leaching of REMs in the hydrometallurgical route, still sulfuric acid has been found as a suitable lixiviant as compared to HCl due to high extraction efficiency and eco-friendly.

Therefore, our objective is to explore a simple process to recover rare earth metals effectively with a low recovery of other metals before smelting of the sea nodule. The present work concerned with the selective leaching of total rare metals and 3 more rare metals like Y, Th and U, from deep sea nodule using dilute sulfuric acid solution. The effects of time, temperature, stirring speed, H_2SO_4 concentration and pulp density on the extraction of these metals have been discussed.

MATERIAL AND METHODS

The sea nodule samples were procured followed by grinding with ball milling spillage to obtain a suitable size fraction. The particle size used for leaching study was -200 mesh. Following to the standard digestion procedure, the deep sea nodule was analyzed by ICP-MS (JOBIN-YVON JY 38) and the chemical composition of sea nodule used in present study is as given in Table 1. All the leaching tests were executed using a three necked 500 ml glass reactor. Heating and stirring were provided by temperature controlled mantle heater and externally placed variable speed stirrer motor, respectively. The lixiviant were heated at a desired stirring rate prior to the beginning of each of the experimental. After attainment of desired leaching temperature a