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Benchmarking D2EHPA-TOPO Solvent Extraction Process for the Recovery of Uranium from Philippines Phosphoric Acid

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INTRODUCTION

Phosphates are the raw material for the production of phosphatic fertilizers. However, these minerals also contain naturally occurring radionuclides such as uranium, thorium and rare earth elements (REE), which ends up as heavy metal contaminants in fertilizers [1-3]. Philippines, being an agricultural country, has 9% of its the GDP and 27% of employment coming from agriculture [4]. To sustain the agricultural demands, fertilizers are necessary to keep the land fertile and productive. Recovery of uranium during phosphate processing plays an important role in mitigating the risk of environmental contamination by production of cleaner fertilizers, paving way to maximizing a mineral resource and opportunity to utilizing recovered strategic elements that are otherwise lost.

Several methods are employed to recover uranium from phosphates (UxP), particularly from phosphoric acid. Among the most adapted method is the use of the synergistic mixture of D2EHPA-TOPO due to its selectivity and stability in different phosphoric acid systems [1-2]. The Philippines imports phosphate rocks from different countries, thus, the D2EHPA-TOPO process was benched marked as part of validating the process technologies that may be applied into the Philippine scenario. The study will also acquire technical data of the factors affecting the recovery rate and economics of the process. Recovery of uranium and other critical element from phosphate processing streams is a pioneering work in the country. This work aims to build core competency in the radioactive material/mineral recovery leading to the sustainable production of uranium in the country.

METHOD

Samples of phosphate rocks (Morocco rock, Togo rock, Egypt rock and Zin (Israel) rock), phosphoric acid (27%, 33%, 43% P2O5 content), phosphogypsum and fertilizer products (Urea, MOP (muriate of potash), NP (16-20-0 and 18-46-0) and NPK (14-14-14 and 16-16-8) fertilizer) were collected from the partner company, Philippine Phosphate Fertilizer Corporation (PHILPHOS) and were analyzed using AAS and Fluorimetry. Samples were also sent to Florida Industrial and Phosphate Research Institute for ICP-MS analysis of thorium and REE content. Solvent extraction of uranium from phosphoric acid was performed by contacting the phosphoric acid with a mixture of 0.5 M D2EHPA and 0.125 M TOPO dissolved in kerosene. The D2EHPA-TOPO Process involves two cycles of uranium extraction and stripping process wherein uranium is extracted and back-extracted in a multi-stage equilibrium manner concentrating the uranium before precipitation as yellowcake. The process parameters that affect the extraction and stripping efficiencies such as phosphoric acid concentration, optical density (acid clarity), oxidation-reduction potential (ORP), temperature and phase ratio were varied. Uranium concentration throughout the process was monitored to obtain the extraction and stripping isotherm.

RESULTS AND DISCUSSION

Detailed characterization of phosphate processing stream samples revealed that the source phosphate rocks contained uranium ranging from 66-145ppm with an average of 105 ppm U, 1-20 ppm Thorium and 108-1085 ppm total REE [3]. Uranium in the phosphoric acid varied from 66-109 ppm while the phosphogypsum contained around 2 ppm uranium indicating that majority of the uranium from phosphate rock distributes into the phosphoric acid phase. Thorium and REE, however, were found to redistribute into the phosphogypsum (1.25 ppm Th, 86-173 ppm REE). Analysis of nitrogen and potash fertilizer products has a combined U, Th and REE content of <1 ppm. Interestingly, it was notable that with increasing phosphate content in NP and NPK fertilizers, there was also an increasing trend in uranium concentration reaching up to 228 ppm [3], which is ˜20 times the global uranium content in soils (0.3 - 11 ppm) [4].

Results of D2EHPA-TOPO process can be summarized into two parts: the uranium extraction and the stripping process. In both processes, extraction and stripping efficiencies were found to be inversely proportional to optical density. In the extraction process, increasing the phosphoric acid and temperature of the reaction would lower the extraction efficiency. Effect of temperature on the extraction of uranium indicates that the reaction is exothermic in nature. Increasing ORP also increases the extraction efficiency. On the other hand, uranium stripping efficiency increases with increasing phosphoric acid content and temperature of reaction. Uranium stripping was determined to be endothermic in nature. Lowering the ORP of the solution increases stripping efficiency. The extraction isotherm obtained from the equilibrium data of the uranium distribution in the organic and aqueous phase indicated that a recovery rate of 93% can be achieved in 3-ideal stages operating at a 4:1 aqueous to organic phase volume ratio. The experiment gave vital information on optimum acid concentration, temperature and other conditions needed to achieve an overall high recovery rate. The output of this research could serve as baseline data towards further development of UxP technology as well as a way to push for a positive policy decision in this regard by the National authority.

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Country or International Organization

The Philippines

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