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A Sustainable Approach for Alternative Raw Material Resources:Re-Use of Phosphogypsum

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Abstract

The valorization of phosphogypsum (PG) is an efficient way to minimize its negative environmental impacts. In this study, the production of calcium carbonate and sodium sulfate from phosphogypsum was investigated. The phosphogypsum is considered byproduct from reaction process of sulphuric acid with phosphate rocks. Calcium carbonate can be used in the cement, paper industries and the environmental purposes, while sodium sulfate can be used in the glass and detergent industries. The reaction for chemical decomposition of phosphogypsum was made at room temperature in aqueous solution and studied at various concentrations (0.1,0.5 and 1.0 M), Our results demonstrate the high efficiency of thenardite (Na2SO4) %72-80 and calcite (CaCO3) precipitation by phosphogypsum dissolution using a sodium carbonate. The fate of trace elements present in the phosphogypsum waste was also investigated, and trace impurities were found to be completely transferred to the final calcite. The aim of this work focus on making a process flow diagram which is used in dealing with waste of phosphogypsum and production a useful product.

Keywords: Calcium carbonate, Phosphogypsum, Sodium sulfate, Sustainability, Valorization

1. INTRODUCTION

Phosphogypsum (PG) is a waste created from the phosphoric acid production, which widely produces from the chemical treatment of phosphate rock $Ca_5(PO_4)_3F$ with sulphuric acid as displayed by Eq. (1). It is generated in huge amounts worldwide and is mostly $CaSO_4.2H_2O$, also includes impurities of environmental concern as naturally occurring radionuclides, heavy metals, residual acids and fluoride. The impurities composition in phosphogypsum differs depending on source of the phosphate rock utilized in phosphoric acid production [1].

$$Ca_5F(PO_4)_3 + 5H_2SO_4 + 10H_2O\ 3H_3PO_4 + 5CaSO_4.2H_2O + HF \quad (1)$$

To produce 1 ton of orthophosphoric acid about 3–4.5 tons of phosphogypsum (PG) is obtained. The annual PG production reaches 280 Mt worldwide and only about 15 % of PG is used as secondary raw material, but rest is disposed in open type stacks [2]. Every year, more than 200 million tons of phosphogypsum discharge all over the world, which causes a number of environmental problems [3].

The objective of this study is to provide the utilization of PG, which is evaluated as a waste material, in the form of a raw material for other industrial areas, so PG is going to be no longer a waste but a re-assessed

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material. The importance of this study is the valorization of PG in terms of re-using the PG stacks and bringing them back into the economy for a more sustainable future.

2. MATERYAL AND METODS

2.1. Phosphogypsum and Samples Preparation

Phosphogypsum waste was used in this study is a byproduct obtained from the production of wet process phosphoric acid from rock phosphate at the Toros Tarım A.Ş on Mersin, Turkey. The phosphogypsum was dried firstly at 105°C for 48 hours. The dried samples was milled to <850 mesh size. The pulverized sample was then subjected to the analysis, the treatment and the preparation of sodium sulfate using the suitable technique.

2.2. Sodium Sulphate Production

The sodium carbonate Na_2CO_3 used in this research was from reagent grade chemicals, with the purity of 99 % (Merck 1.06393.1000, CAS-No:497-19-8). Reactional mixtures were prepared from the dried phosphogypsum dissolution in the sodium carbonate solution at room temperature, as indicates the following reaction [4], [5] :

$$CaSO_4.2H_2O + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4 + 2H_2O \quad (2)$$

The mixtures were put under stirring during different times. A white precipitate was formed ($CaCO_3$), it was separated from the solution by simple filtration and dried in the oven at 105 °C. The filtrates which contain Na_2SO_4 are introduced firstly the hot plate than after at 70 °C to oven to recrystallize the salts.

3. RESULTS AND DISCUSSION

Production of the calcium carbonate ($CaCO_3$) and sodium sulphate (Na_2SO_4) from phosphogypsum (PG) is successfully accomplished. Heavy metal contents of both PG waste and the produced products is shown in Table 1. The main impurities (as heavy metals) of the PG are Cd, Cr, Pb and Zn. All the compounds produced in this work were analyzed through the Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) technique, infrared spectra were performed on a Fourier Transform Infrared Spectroscopy (FT-IR) using KBr pellets and X-ray Diffractometers (XRD). Most of the metals were transferred to the calcium carbonate after phosphogypsum treatment.

Table 1. Mobility of heavy metals in conversion of PG the calcium carbonate ($CaCO_3$) and sodium sulphate (Na_2SO_4)

Concentration, ppm	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Mo**	**Ni**	**Pb**	**V**	**Zn**	**P_2O_5, %**
PG	2.05	1.77	18.33	11.84	19.86	0.87	8.73	10.61	3.24	58.61	2.27
Na_2SO_4 (Merck)	0.03	0	0.2	0.05	0.51	0	0.27	0	0	1.93	0
Na_2SO_4 (0.1 M)	0.15	0	0	0.3	0.31	0	0	0	0	0.44	0
Na_2SO_4 (0.5 M)	0.03	0	0.05	0.12	0.04	0.54	0.21	0	0	0	0
$CaCO_3$ (0.1 M)	37.8	0	89.21	0	137.5	0	0	0	0	593.02	5.94
$CaCO_3$ (0.5 M)	40.06	13.86	38.47	0	104.21	0	0	0	0	720.86	6.1

4. CONCLUSION

In this work, total conversion of phosphogypsum industrial waste into the calcium carbonate ($CaCO_3$) and sodium sulphate (Na_2SO_4) was confirmed. The reaction for chemical decomposition of phosphogypsum was made at room temperature in aqueous solution and studied at stoichiometric ratio and various concentrations of reactants (0.1, 0.5 and 1.0 M). Results demonstrate the high efficiency of thenardite (Na_2SO_4) %72-80 and calcite ($CaCO_3$) precipitation by the reaction of phosphogypsum with sodium carbonate. It can be concluded

that the Na_2SO_4 and the $CaCO_3$ production of industrial quality by this method can be feasible by using a few pre-treatments.

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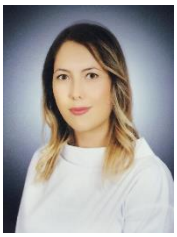
BIOGRAPHY



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