Studies on the Extraction of Lanthanides and Preparation of Pure Calcium Carbonate from Egyptian Phosphogypsum Produced during Phosphoric Acid Production Process

By

Osama El-Sayed Mohamed Roushdy

M. Sc. Chemistry 2014

For the Degree of Doctor of Philosophy (Ph. D.) in Chemistry

A Thesis Presented

To Chemistry Dept., Faculty of science

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2018

ACKNOWLEDGEMENT

I am in greatest thankful to ***allah*** The Most Merciful, The Most Gracious, by the grace of whom the progress and success of the present work.

It is my pleasure to express my deepest thanks to ***Prof. Dr. Saad Abdel-Wahab,*** *Prof. of Physical Chemistry, Chemistry Department, Faculty of Science, Ain- Shams University,* for his direct supervising of the work, valuable discussions, encouragement, kind help given throughout this work, and careful revision of the manuscript.

It is my pleasure to express my deep thanks, appreciation and gratitude to ***Prof. Dr. Hady S. Gado,*** *Professor of Geochemistry, Nuclear Materials Authority, Cairo,* for his support, direct supervision, encouragement, valuable discussions throughout the work. I am greatly indebted for granting me for early stage research training and for his generous help for supervision.

My deep thanks to ***Dr. Mohamed H. Taha,*** *Assistant Professor of Physical Chemistry, Nuclear Materials Authority, Cairo,* for his direct supervision of the work, encouragement, carful revision of the manuscript and kind help given throughout this work.

My thanks and best wishes extend to all members of the Phosphoric Acid Purification Pilot Plant (**PAPPP**), for

their support and huge facilities offered in different ways during the progress of this work.

My thanks and best wishes extend to ***Dr. K. Ahmed***, *Department of Radiological Protection, Nuclear Materials Authority, Cairo,* for his huge help given throughout this work.

Last but not Least, my thanks are due to ***my parents, my wife, my sister, my children*** *and all my* ***friends*** *for their love, support and encouragement which gave me the strength to overcome many obstacles. I cannot thank them enough.*

Osama El-Sayed Mohamed Roushdy

ABSTRACT

The utilization of phosphogypsum (PG) as a raw material for the production of valuable products is interesting. In this contribution, Rare earth elements (REEs) leaching from dihydrate phosphogypsum using sulfuric acid was investigated using One-factor-at-a-time (OFAT) methodology and Design of Experiment (DoE) methodology. Based on the OFAT methodology, the influence of various factors affecting the leaching process such as; reaction time, sulfuric acid concentration, liquid to solid ratio, leaching temperature, and stirring speed have been examined terms of high REEs leaching efficiency and low impurities.

In regards to DoE methodology, the multivariate 2^3 full factorial design is used to study the effect of sulfuric acid concentration, liquid/ solid ratio, leaching time on the REEs leaching process. The normal first order model (fitted model) between significant factors and the response was developed by the Design Expert 11.0 software. The obtained results clarify that REEs leaching efficiency was 72.3% under the following optimal conditions; 4 % sulfuric acid concentration, liquid/ solid ratio, ml/ g, 5/1, and reaction time of 3 hrs.

Dihydrate phosphogypsum, treated with sulfuric acid, has been converted into calcium carbonate and sodium sulfate using sodium carbonate. Phosphogypsum conversion process has been investigated using One-factor-at-a-time (OFAT) procedure and Design of Experiment (DoE) procedure. Regards to the OFAT procedure, the effect of different factors such as; stirring time, sodium carbonate concentration, liquid to solid ratio, reaction

temperature, and stirring speed on the conversion process using sodium carbonate have been investigated.

The full factorial design has been performed to optimize the conversion of phosphogypsum to carbonate using sodium carbonate. Four factors were taken into consideration in the experimental planning: time, solid/ liquid ratio, sodium carbonate concentration, and temperature. The analysis of variance (ANOVA) has been used to determine the main effects and interactions between the studied factors. The optimum conditions have been determined as, sodium carbonate concentration of 30 %, reaction time of 10 min and solid/ liquid ratio, g/ ml of 1:2. Under these optimum conditions, the phosphogypsum conversion to carbonate efficiency performance is 95.2 %. The characterization of the produced calcium carbonate has been achieved using XRF, XRD and FT-IR.

The environmental radiation impact as well as radiation hazard indices factors (exposure rate and absorbed dose rate, effective dose rate, the radium equivalent activity (Ra_{eq}), external hazard, internal hazard and (level index) I-gamma) have been measured and calculated in phosphogypsum working sample, phosphogypsum leached with sulfuric acid, produced calcium carbonate, and sodium sulfate. The obtained results clear that, the produced calcium carbonate, and sodium sulfate have normal level of natural background where these values are within the world permissible limits. This means that the produced sodium carbonate and sodium sulfate are acceptable for use in industrial applications.

Keywords: phosphogypsum, Rare earths, calcium carbonate, full factorial design, optimization

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