# Recycling of phosphogypsum: Recovery of rare earth elements and production of high-added value products

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Keywords: Green leaching; rare earths; phosphogypsum valorization; waste recycling; low-carbon cement.
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## 1. Abstract

Phosphogypsum (PG) is a by-product generated from fertilizer industry with an annual production of more than 280 million tons worldwide. This industrial waste is usually associated with impurities including radioactive elements and heavy metals, which restricts its applications. In view of its economic potential, numerous management strategies were designed to meet the environmental regulations and the green chemistry standards **[1,2]**. In this context, the recovery of valuable elements such as rare earth elements (REEs) could be considered a potential valorization pathway of PG **[3]**. In this work, green leaching of REEs from PG was explored using methanesulfonic acid (MSA) as a green organo-sulfonic acid in comparison with other acids such as p-toluenesulfonic acid (PTSA) and hydrochloric acid (HCl). MSA achieved the highest leaching efficiency of 78% with low solubility of PG under the operating conditions of 3 M, solid to liquid ratio (S/L) of 1/8, 120 min and 25 °C. The optimized leaching process was also modeled using shrinking core theory to assess the kinetics behavior of the system and to enable the determination of the predominant mechanisms **[4]**. The cleaned PG after leaching meets greatly the quality requirement of cement production. The content of the undesirable impurities in building materials were highly reduced such as fluorine, $P_2O_5$, heavy metals and radionuclides. It was demonstrated that the integration of up to 5-10% of purified PG in cement, with other biosourced reinforcing materials, provides high mechanical properties in terms of compressive and flexural strengths. The combination of PG with biosourced reinforcing materials could enable a partial replacement of clinker in cement which could contribute to reducing the $CO_2$ emission **[3]**.

## 2. Summary of the experimental procedure

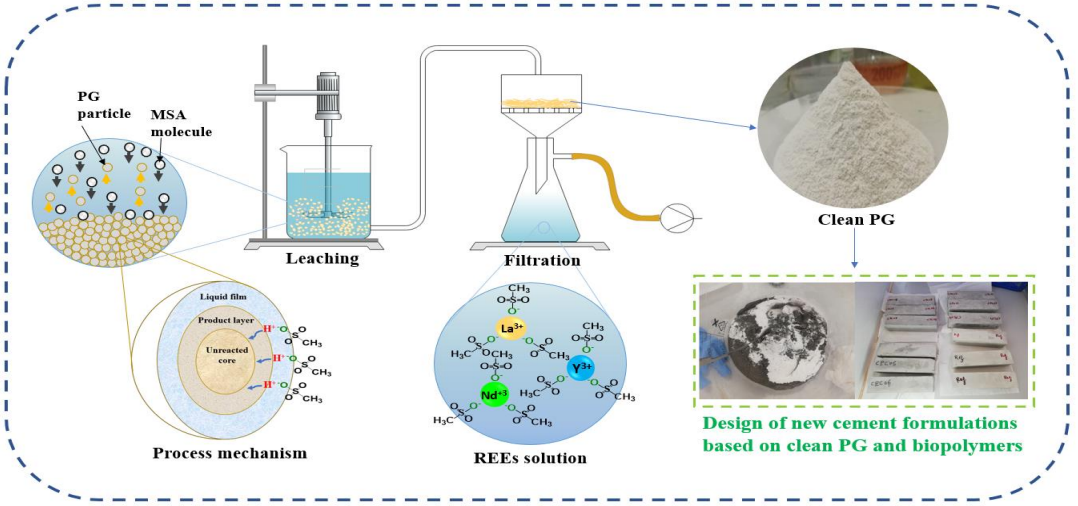



Figure 1. Illustration of the experimental procedure.

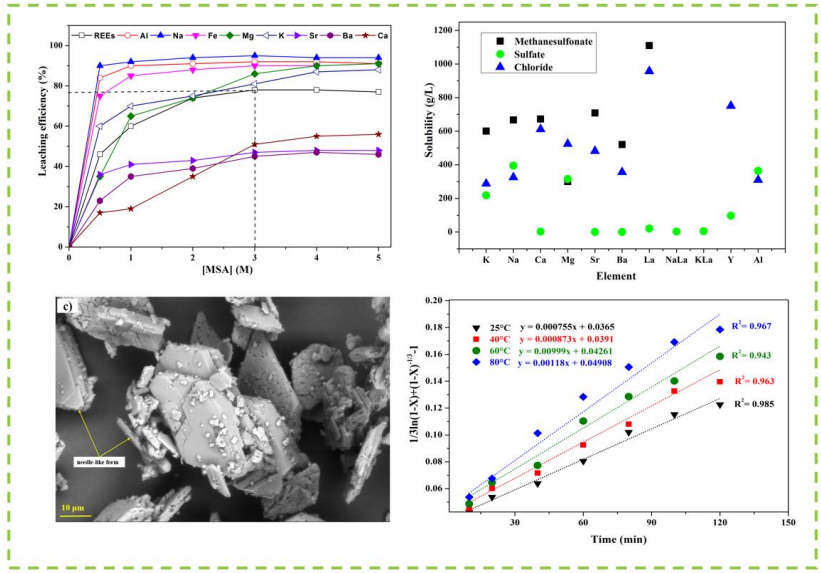
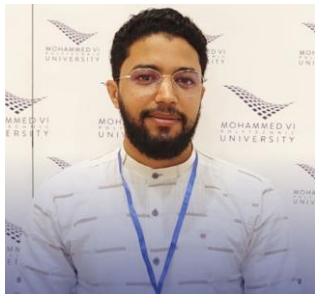



Figure 2. Summary of relevant results.

## 3. Author Biography



Mr. Jamal AIT BRAHIM is currently a 3rd year PhD. student at Institute of Sciences, Technology & Innovation (IST&I) of Mohammed VI Polytechnic University (UM6P) in Ben Guerir, Morocco. Mr. AIT BRAHIM hold a master degree in valorization and characterization of rare earth materials in 2018 at the Faculty of Sciences of Mohammed V university in Rabat. The doctoral research of Mr. AIT BRAHIM is mainly focused on the valorization and recycling of phosphate wastes and byproducts such as phosphogypsum and acid sludges. The valorization strategies include the recovery of valuable elements including rare earth elements (REEs) and the manufacture of high-added value products such as cement materials and fertilizers. His research interests include minerals processing, chemical engineering, green chemistry and waste management. Mr. AIT BRAHIM published relevant papers in Q1 journals (*see references*).

## 4. References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