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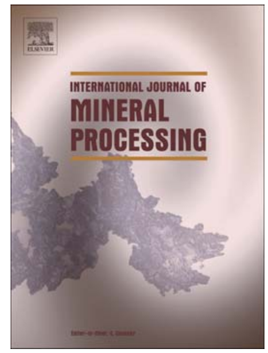

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Azadeh Hemmati, Jalal Shayegan, Jie Bu, Tze Yuen Yeo, Paul Sharratt

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Process Optimization for Mineral Carbonation in Aqueous Phase

Azadeh Hemmati[a,b], Jalal Shayegan[b], Jie Bu[a,1], Tze Yuen Yeo[a], Paul Sharratt[a]

[a]*A*Star, Institute of Chemical and Engineering Sciences, 1 Pesek Road, Jurong Island, 627833, Singapore*

[b]*Sharif University of Technology, Azadi Street, Tehran, Iran*

Abstract

Carbon dioxide sequestration by a pH-swing carbonation process was considered in this work. A multi-step aqueous process is described for the fractional precipitation of magnesium carbonate and other minerals in an aqueous system at room temperature and atmospheric pressure. With the aim to achieve higher purity and deliver more valuable mineral products, the process was split into four steps. The first step consists of Mg leaching from the magnesium silicate in a stirred vessel using 1 M HCl at 80 °C, followed by a three step precipitation in reactors in sequence to remove $Fe(OH)_3$, then $Fe(OH)_2$ and other divalent ions, and finally $MgCO_3$ nucleation and growth. Hydrated magnesium carbonate [$MgCO_3 \cdot 3H_2O$, nesquehonite] crystals were confirmed using X-ray diffraction (XRD) as final products. The optimal pH of precipitation reactors based on the maximum solid purity and production were determined by carrying out detailed mass balance. The maximum productivity and highest purity for nesquehonite was found to be dependent on pH values for the two last steps. The results also demonstrated that the process is optimized at pH 9 and 10 for the second and third step of precipitation respectively. The highest carbonation efficiency expressed as the conversion of Mg ions to magnesium carbonate, reached 82.5wt %. The maximum magnesium content in the final product was 99.21 wt % of MgO when the second precipitation reactor pH was equal to 9. This experimental study demonstrates that carbon dioxide sequestration requires at least 3.74 times the weight of ore to provide the Mg for mineral production. This confirms the possibility to use this process route for CO_2 mitigation.

Keywords: mineralization, carbon capture and utilization, nesquehonite, pH optimization, multi-step, CO_2

Research highlights

▸ Multi-step pH-swing process to produce high value products ▸ The optimum pH for maximum productivity and purity of final product was investigated. ▸ Magnesium silicate ore was used as alkaline source for carbon sequestration. ▸ The maximum purity in P_{III} was 99.21 wt % of MgO when the pH_{II} was equal to 9.

[1] Corresponding author, *E-mail: bu_jie@ices.a-star.edu.sg*