

## Synthesis of brucite from reject brine and its direct carbonation for possible use as construction material

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Reactive magnesium oxide (MgO) cement (RMC) has been shown to exhibit a significant mechanical property development under concentrated CO<sub>2</sub> curing, attributed to the hydration of MgO to form brucite and its further reaction with CO<sub>2</sub> to form interlocking carbonates of higher unit volume [1]. RMC is conventionally produced for calcination of magnesite (MgCO<sub>3</sub>) at a temperature between 700-1000 °C. Despite limited sequestration of CO<sub>2</sub> as a result of carbonation, the environmental benefit of RMC as a construction material is in doubt. The decomposition of MgCO<sub>3</sub> alone is more CO<sub>2</sub> intensive than that of CaCO<sub>3</sub> [2], the main raw material used in the production of ordinary Portland Cement. Together with fuels required for combustion in the calcination process, the total CO<sub>2</sub> emission is estimated to be 1.7 tonnes per tonne of RMC [3].

RMC could also be produced from reject brine through precipitation to form brucite and its calcination [4]. This route would eliminate CO<sub>2</sub> released from the chemical decomposition of MgCO<sub>3</sub> as in the dry route. It has also been shown that supercritical CO<sub>2</sub> (scCO<sub>2</sub>) significantly enhanced carbonation and strength development of RCM-based composites [5]. It is hypothesized that scCO<sub>2</sub> could be used to directly carbonate brucite. In this study, the synthesis of brucite from reject brine and its direct carbonation were investigated as a more sustainable route in the production and utilization of brucite. Cost-effective CaO or Ca(OH)<sub>2</sub> was used as the precipitation agent at 4 concentration levels (2, 3, 4 and 5 times the saturation limit) to investigate the product yield. The precipitates were filtered and washed with deionized water to removed impurities. The powders were dried in oven at 100 °C for 12 hours and were allowed to cool in air. Water was then added at a ratio of 0.50 to produce a paste, which was used to prepare 13 mm pellets under an applied pressure of 5 MPa. The pellets were exposed to two carbonation conditions: (i) 20% CO<sub>2</sub>, 80% relative humidity (RH) and 30 °C, and (ii) scCO<sub>2</sub> condition at 8.25 MPa and 35 °C. XRD, TGA, SEM, and nanoindentation were implemented on the samples before and after carbonation.

It was revealed that the yield increased with the content of Ca(OH)<sub>2</sub> and the precipitates were composed of Mg(OH)<sub>2</sub>, Ca(OH)<sub>2</sub>, CaCO<sub>3</sub>, and other minor impurities. Both CO<sub>2</sub> regimes induced carbonation in all the samples with the indentation modulus increased by a factor of 1.1 under 20% CO<sub>2</sub> and 1.6 under scCO<sub>2</sub> at the average

indentation depth of 500 nm in samples prepared using 3 times saturation of Ca(OH)<sub>2</sub>. Samples synthesized with higher Ca(OH)<sub>2</sub> content exhibited higher mechanical properties, attributable to observed morphological improvement and matrix densification. TGA results confirmed the formation of carbonates in all samples under CO<sub>2</sub> and were used to calculate the carbon sequestration factors. SEM-EDX confirms the incorporation of carbon in the microstructure and the increased presence of rod-like carbonation products of samples under scCO<sub>2</sub> (Fig. 1). The findings prove the possibility of direct carbonation and the associated binding action, in addition to the strength development of brucite synthesized from reject brine. Such an innovative solution will eliminate the energy required for calcination and CO<sub>2</sub> released from the chemical decomposition of MgCO<sub>3</sub> in the production of RMC, paving the way for truly carbon-negative construction material.

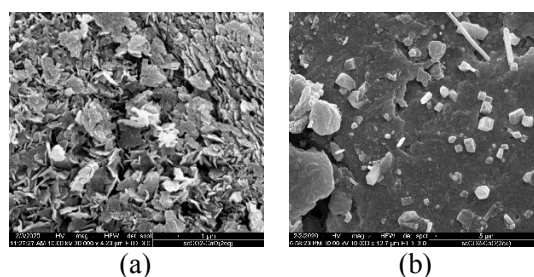


Figure 1: Microstructure of brucite pellet (a) before and (b) after scCO<sub>2</sub> exposure

### References

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