cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
22 a 26 de novembro de 2026
Costão do Santinho
Florianópolis-SC

Atmospheric CO_2 Capture and Carbonate Formation Using Mining Waste-based Geopolymers

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Introduction

Direct air capture (DAC) is a promising strategy for atmospheric CO_2 removal. Geopolymers are inorganic materials produced through the alkaline activation of aluminosilicate precursors, with the potential to incorporate mining waste. Geopolymer-based DAC systems can promote the interaction between atmospheric CO_2 and alkaline solutions, leading to carbonate formation and combining CO_2 capture with waste valorization.

Objectives

The aim of this study is to develop a geopolymer-based system incorporating mining waste for atmospheric CO_2 capture and carbonate production.

Methodology

Geopolymers were prepared using metakaolin, sodium silicate, and NaOH, incorporating 50 wt.% iron waste or sand (reference).The specimens were partially immersed in a 0.05 mol/L NaOH solution, with their upper surfaces exposed to atmospheric air. The porous geopolymer structure enabled the upward transport of the alkaline solution by capillary action, promoting its interaction with atmospheric CO_2 and subsequent carbonate precipitation on the exposed surfaces. The precipitated solids were periodically collected and weighed over 20 days, followed by XRD and FTIR characterization.

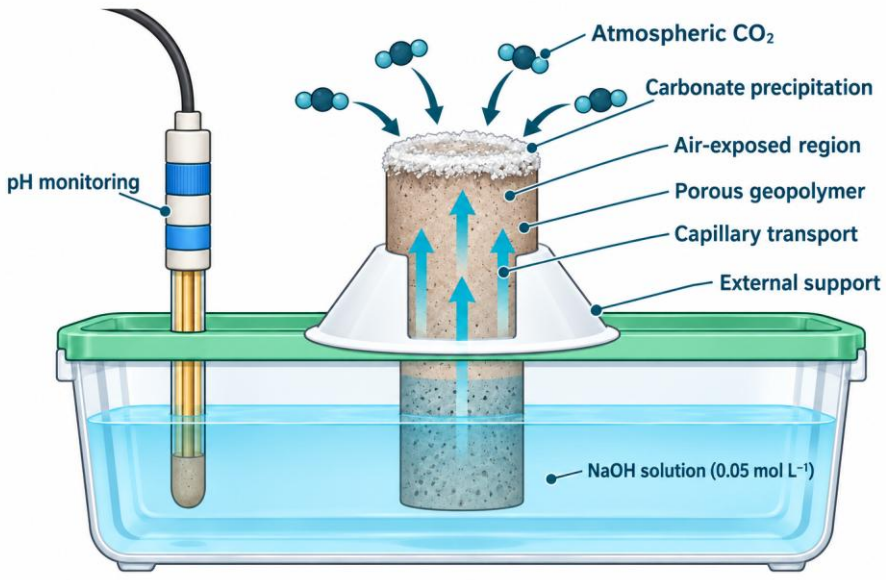


Figure 1. Schematic representation of the proposed direct air capture system.

Results and Discussion

Carbonate precipitates were observed on the exposed surfaces of both geopolymer formulations, demonstrating the potential of the proposed system for atmospheric CO_2 capture.

XRD and FTIR analyses indicated the formation of carbonate compounds. XRD patterns revealed the presence of thermonatrite ($Na_2CO_3 \cdot H_2O$) and sodium carbonate heptahydrate ($Na_2CO_3 \cdot 7H_2O$) in both formulations, confirming the formation of crystalline sodium carbonates.

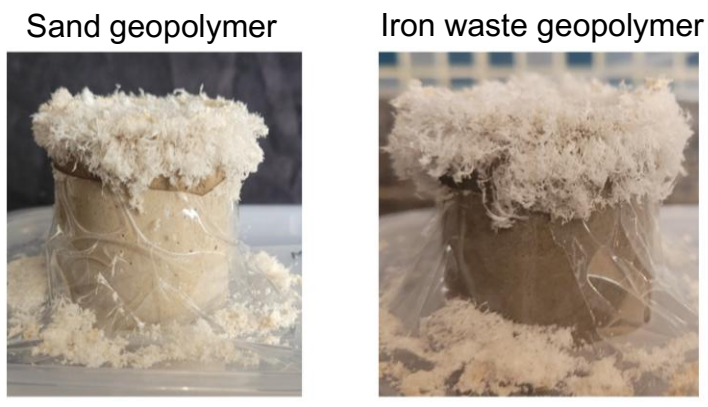


Figure 2. Photographs of geopolymer specimens showing carbonate formation on their surfaces.

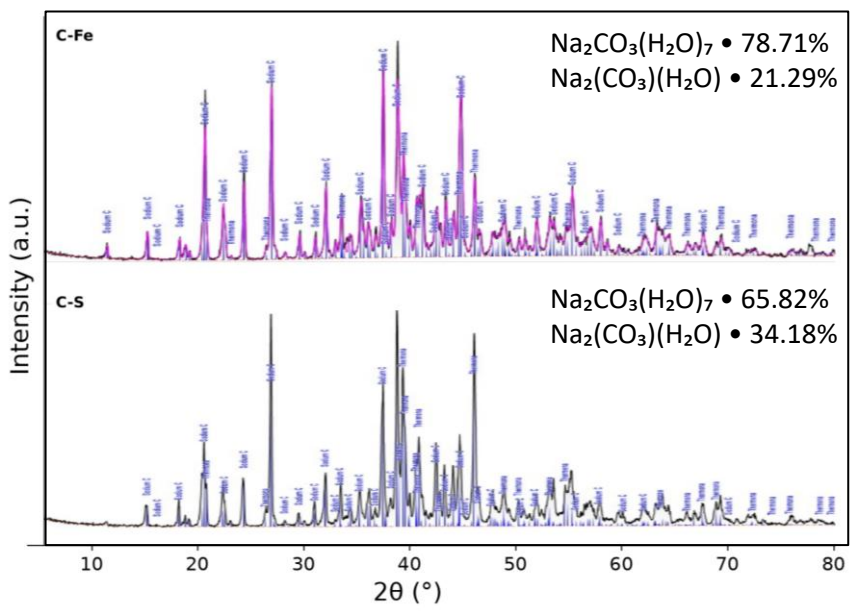


Figure 3. XRD patterns of carbonates recovered from iron waste-based (C-Fe) and sand-based (C-S) geopolymers.

Conclusions

The geopolymer-based DAC system demonstrated potential for atmospheric CO_2 capture through carbonate formation. XRD and FTIR analyses confirmed the presence of sodium carbonate compounds, highlighting the feasibility of using mining waste-based geopolymers for CO_2 capture and waste valorization.

References and Acknowledgments

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