

ABSTRACT:

Foamed Geopolymer-Zeolite Composite for CO₂ Capture

J.A. Dalandas¹, A.R.M. Dibratun¹, C.S. Alfaro², R.L. Menchavez³, R.D. Guerrero^{1,2},
A.O. Mosqueda^{1,2}, R.R.M. Abarca^{1,2}

¹Department of Chemical Engineering and Technology, Mindanao State University
Iligan Institute of Technology, Iligan City 9200, Philippines

²Center for Energy Research and Technology, Mindanao State University
Iligan Institute of Technology, Iligan City 9200, Philippines

³Department of Materials and Resources Engineering and Technology,
Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

This study examines the rheological behavior and carbon capture capabilities of a geopolymer-zeolite composite made from rice hull ash and metakaolin, focusing on creating self-supporting foamed structures. A systematic analysis was conducted to evaluate the effects of Si/Al molar ratios, H₂O₂ concentration, and mixing duration on the viscosity evolution of geopolymer gels, foam stability, and the final characteristics of the material. Rheological profiling revealed a critical viscosity range that facilitates effective gas entrapment during the foaming process. The experimental results showed that increasing the Si/Al ratio delayed the gelation transition, while higher concentrations of H₂O₂ led to an increase in pore volume and foam height, though this came with some trade-offs in structural stability. X-ray diffraction confirmed the formation of faujasite-type zeolite phases, while scanning electron microscopy revealed a transition from angular particles to a more rounded morphology with increasing silica content. BET-BJH analysis indicated hierarchical pore architectures combining micropores and mesopores, which enhance mass transport properties. Using Thermogravimetric equipment for CO₂ adsorption of zeolite with Si/Al = 1.0 has 14.31% of CO₂ uptake, while zeolite with Si/Al = 1.5 has 14.32% CO₂ uptake. These findings highlight the potential of hierarchical biochar-zeolite composites as promising, sustainable adsorbents for post-combustion CO₂ capture and gas separation technologies, offering a viable pathway toward scalable carbon mitigation solutions.