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ABSTRACT:

Foamed Geopolymer-Zeolite Composite for CO_2 Capture

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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, H_2O_2 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 H_2O_2 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 CO_2 adsorption of zeolite with SiAl = 1.0 has 14.31% of CO_2 uptake, while zeolite with SiAl = 1.5 has 14.32% CO_2 uptake. These findings highlight the potential of hierarchical biochar–zeolite composites as promising, sustainable adsorbents for post-combustion CO_2 capture and gas separation technologies, offering a viable pathway toward scalable carbon mitigation solutions.