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Functional porous physisorbent materials from phosphorite waste: Advanced characterizations and applications

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Porous materials have sparked tremendous interest as solid sorbents for various applications due to chemical variability and tunability in building blocks, degrees of order, surface areas, pore sizes and shapes, and surface functionalities to optimize their performances. Among the industrially relevant porous physisorbents, zeolites, mesoporous silicas, and metal-organic frameworks (MOFs) have shown promising potential to circumvent the energy and environment-related drawbacks associated with the commonly employed chemical adsorbents. However, their large-scale deployment or widespread adoption is hampered primarily by economic factors related to prohibitively expensive precursors and a lack of green synthesis protocols with industrially feasible steps. Greening the synthetic route for porous materials has piqued researchers'interest as a critical step toward practical industrial applications. In this work, we employed strategic synthesis method to transform the main components of phosphorite waste into different classes of functional porous materials in subsequent steps. The alumina and silica components were isolated to fabricate zeolites and mesoporous silicas while the residual metals were directed to grow MOFs in the subsequent step. The successful assembly of the porous materials was confirmed using various characterization techniques, including XRD, SEM-EDX, TEM, FTIR, TGA-DSC-MS, N2 adsorption at 77 K, CO2 adsorption at different temperatures, and H2O sorption analyses. The resulting zeolites showed enhanced CO2 capture property. The obtained mesoporous silicas demonstrated to have practical applications for heavy metal capture from wastewater. One of the prepared MOFs with the optimal pore aperture size (~3.4 Å) also showed a potential for alcohol dehydration with a steep and fast moisture adsorption profile and negligible alcohol uptake. Besides recycling waste byproducts, the approach allows the economical production of high-value-added materials that are otherwise expensive to prepare from commercial-grade pure chemicals.

Primary authors: Mr YIMER, Ali Mohammed (Mohammed VI Polytechnic University); ASSEN, Ayalew Hussen (Mohammed VI Polytechnic University); Dr BELMABKHOUT, Youssef (Mohammed VI Polytechnic University)

Presenter: Dr BELMABKHOUT, Youssef (Mohammed VI Polytechnic University)

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