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Unlocking the Potential of Phosphatic Wastes: Sustainable Valorisation Pathways for Synthesizing Functional Metal-Organic Frameworks and Zeolites

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Abstract : This study delves into sustainable approaches for valorising phosphatic wastes, specifically phosphate residue tailings and phosphogypsum, which are byproducts of phosphate industries and pose significant environmental challenges due to their accumulation. We propose a unified strategic synthesis method aimed at converting these wastes into value-added porous material materials. Our approach involves isolating the primary components of phosphatic wastes, such as CaO, SiO2, Al2O3, P2O5, and trace metals, to fabricate functional porous materials falling into two distinct classes. Firstly, alumina and silica components are extracted or isolated to produce low-silica zeolites (including CAN, GIS, SOD, FAU, and LTA), characterized by a Si/Al ratio of less than 5. Secondly, residual calcium is utilized to synthesize calcium-based metal–organic frameworks (Ca-MOFs) employing various organic linkers like Ca-BDC, Ca-BTC, and Ca-TCPB (SBMOF-2), thereby providing flexibility in material design. Characterization techniques including XRD, SEM-EDX, FTIR, and TGA-MS affirm successful material assembly, while sorption analyses using N2, CO2, and H2O demonstrate the porosity of the materials. Particularly noteworthy is the water/alcohol separation potential exhibited by the Ca-BTC MOF, owing to its optimal pore aperture size (~3.4 Å). This innovative synthetic transformation approach represents a novel valorisation route for converting phosphatic wastes into extended porous structures, promising significant environmental and economic benefits.

Keywords : porous materials, low-silica zeolites, calcium-based metal–organic frameworks, sustainable synthesis, valorization
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