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Title: Zeolite constructor kit: Design for catalytic applications

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<AT>Zeolite constructor kit: design for catalytic applications

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<ABS-Head><ABS-HEAD>Graphical abstract
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<ABS-HEAD>Highlights► Approaches aiming in generation of mesopores in zeolites were discussed. ► Fundamental features of bottom-up and top-down strategies were analyzed. ► <ST>Methods</ST> for encapsulation of metal nanoparticles in zeolite pores were considered.

<ABS-HEAD>Abstract

<ABS-P>Pure microporosity of conventional zeolites is a disadvantage for the processes required enhanced accessibility that can be overcome by the design of mesoporous or hierarchical zeolites. Approaches for development of additional porosity in zeolite materials including diverse bottom-up and top-down strategies are considered and compared in this paper. Zeolites are presented as construction kits to produce more open and hence active materials for catalytic applications. This review focuses on the understanding of advantages and limitations of each synthesis approach. The advances in design of hierarchical materials as catalysts are exemplified by comparison with bulk analogues. The possibilities for encapsulation of nanoparticles in microporous or hierarchical zeolitic frameworks are also assessed.

<KWD>Keywords: hierarchical zeolites; heterogeneous catalysis; zeolite nanoparticles; soft templating; hard templating; demetallation; ADOR; metal encapsulation

<H1>1. General aspects

Diversity of zeolites and their key benefits. Zeolites are crystalline microporous elementosilicates (usually, aluminosilicates) with frameworks constructed from tetrahedra having cation such as Si or Al at the center and oxygen atoms at the corners. Due to the high porosity and well-defined pores zeolites attract continuous interest as efficient heterogeneous catalysts. Zeolites are widely used in refinery, petrochemistry and other large scale processes for (hydro)cracking, (hydro)treating, reforming, isomerization, alkylation, selective catalytic reduction etc. [1, 2]. In addition to purely acidic sites of different strength, multifunctional catalytic centers (basic, redox) can be introduced to zeolites usually by isomorphous substitution, ionic exchange or loading of metal nanoparticles [3]. The diversity in number and nature of active sites, and microporous dimensionality allowing to control [4] the product selectivity are the main advantages of zeolite for catalytic applications. However, the pure microporosity of the zeolites can be considered also as a significant drawback, because micropores are too small for transformation of relatively bulk reactants or formation of bulk products. It is especially crucial since the increased importance of bio feedstock containing massive biopolymers for large-scale industry [5]. To overcome this key limitation of conventional zeolites, scientific community spent enormous efforts to develop novel concepts including synthesis of nanosized zeolite, design of mesoporous zeolites, etc. which will be considered in this paper. In general, the development of hierarchical porous system in particular zeolite aimed in i) reduction of mass