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Editorial

New Horizons in Zeolites and Zeolite-Like Materials

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Zeolites have been known for about 250 years, though their active life in science and industry started in the late 1960s. The traditional definition of zeolites as crystalline aluminosilicates experienced a few attacks from aluminophosphates (i.e., no silica in the compositions, such as AlPOs, SAPOs, MeAPOs, etc.) and metallosilicates (i.e., no aluminum in the compositions, such as Fe-silicate, B-silicate, Ti-silicate, and others) in the 1980s, then from mesoporous oxide materials (mesocrystalline silicate families MCM-41, SBA-15, mesoporous TiO_2, ZrO_2, and the like), and now from the organic–inorganic hybrid materials (metal–organic frameworks (MOFs), covalent organic frameworks (COFs), and porous coordination polymers (PCPs)), though the latter may contain no traces of silicon or aluminum. All these new materials should be classified as zeolite-like materials [1,2]. They are not true silica-alumina compositions and cannot be included in the family of zeolites. On the other hand, they do exhibit a clear molecular sieve effect and extended micro/meso porosity. In some respects, these new materials are better or richer in properties and structures than the classical zeolites and provide more opportunities for variation in structure and composition. The new zeolite-like materials are not "boiling stones" anymore. Moreover, some of them are hydrophobic materials with preference for adsorption of non-polar molecules rather than water. However, the zeolitic nature or character of these newcomers in the zeolite world can be easily recognized from the shape-selectivity effects, huge specific surface areas reaching 5000 m^2/g and pore volumes approaching 2 cm^3/g, and a typical zeolite architecture.

The new wave of materials looks like a dangerous avalanche that can absorb the classical zeolites, but this will not happen, because the Si-Al zeolites have already inscribed their names (faujasites, mordenites, ZSM-5 zeolites, just to mention a few) in the history of modern industry: oil refining, petrochemical synthesis, air separation, detergents, and other applications. Zeolites continue to be catalysts of choice in the conversion of light and heavy oil hydrocarbons, and the last decade offered a number of challenges for the use of zeolite-like materials. The conversion of biomass is another intriguing area where zeolites and zeolite-like materials are expected to show promising results. There is still a substantial amount of room in the fields of fine chemicals synthesis, renewables conversion, and other areas of potential applications where zeolites do not provide an ideal solution. Yet the time has not come to judge whether the new zeolite-like materials are better or not than their classical counterparts.

This Special Issue collected interdisciplinary state-of-the-art research articles and communications related to various aspects of the synthesis, characterization, and application of zeolites and zeolite-like materials. Two rapidly developing vectors are currently emerging in this area: novel applications for the "old" systems (conventional zeolite) and fascinating hybrid zeolite-like materials, including diverse mesoporous and hierarchical materials (oxide-, carbon-, and polymer-based) and coordination polymers, such as MOFs, COFs), and zeolitic imidazolate frameworks (ZIFs). Zeolite-like materials play a paramount role in contemporary research and practice. Advanced architectures provide a driving force for progress in diverse research areas, including the development of new nano-engineered catalysts and adsorbents, smart and stimuli-responsive materials, sensors, as well as materials for energy applications (harvesting, storage). The incentive of this Special Issue was to show the progress in the key aspects of the broad "zeolite arena".

The papers included in this Special Issue cover diverse areas of the synthesis and application of zeolite-like materials and composites, for instance, aluminosilicate gels from geopolymers and nanocrystalline zeolites that have comparable strength properties, making them a potential replacement for ordinary cements [3]. Crystalline sodium Y (NaY) zeolite has been synthesized using an alternative natural source of aluminate and silicate, extracted from natural kaolin [4]. Also, a sustainable route for synthesizing all-silica SOD (i.e., sodalite type) zeolite under solvent-free conditions has been found [5]. The method of solvent-free synthesis includes mixing, grinding, and heating raw solids.

The application of new zeolite-like structures in gas adsorption and separation is one of the most exciting areas of research in recent years. The hydrogen adsorption characteristics and mechanism of transition metal-doped zeolite template carbon as a novel porous material are studied by theoretical calculations employing the first-principle all-electron atomic orbital method based on density functional theory [6]. A quite comprehensive review on the application of metal–organic frameworks for natural gas storage is an important contribution to this Special Issue [7].

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