Nanoporous Materials for Gas Storage, Catalysis and Battery Applications

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Porous materials play a key role in the development of novel catalysts, but also mobile and stationary energy storage applications, which are important system technologies to promote the use of renewable energies and environmentally friendly electric vehicles.
Metal-Organic Frameworks (MOFs) are a relatively young class of porous solids with record porosity. Materials synthesized in Dresden (named DUT-n) such as DUT-32, -49, or -76 profit from modular construction and reach specific surface areas up to 6400 m^2/g. They are promising materials for natural gas storage but also reveal fundamentally interesting novel phenomena. For system integration, separation, and air purification, materials shaping and integration into textiles is an important requirement. The modular construction of MOFs enables the integration of catalytically active metal nodes (Rh_2-clusters), metal nanoparticles, or chiral groups suitable to induce enantioselective catalytic conversions or chiral separations. In order to improve the chemical stability of modular porous solids we have also developed Element-Organic Frameworks (EOFs) with catalytic activity or highly hydrophobic properties and high stability. The most intriguing phenomena were recently discovered in MOFs showing distinct structural transitions causing counterintuitive adsorption phenomena such as “negative gas adsorption” (NGA). Xenon NMR and *in situ*-analytical techniques are crucial tools to unravel the underlying adsorption mechanisms in hierarchical porous materials.
Hierarchical porous carbons are certainly more robust and their high electrical conductivity renders them as highly useful components in the area of supercapacitors and batteries. Especially lithium sulfur batteries require materials with a high specific pore volume for sulfur loading. Lithium sulfur batteries are considered as highly promising next generation batteries because of the high theoretical capacity. An increase of energy density up to 350-400 Wh/kg is within reach. However, an interdisciplinary approach is needed to resolve remaining challenges of cycling stability due to the subtle interplay of anode, cathode, electrolyte and separator technologies. At Fraunhofer IWS currently 4.000 mAh prototype pouch cells with an energy density > 300 Wh/kg are developed.

References:

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