Hierarchical Graphene-Based Aerogel Catalysts and Sorbents

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Directed self-assembly of graphene derivatives into structured aerogels and foams is explored as route to create unique, porous catalyst systems with highly-tailored materials characteristics, including hierarchical porosity, mechanical durability, and electro-thermal responsiveness. Here, template-based assembly approaches are explored to produce sponge-like nanocarbon aerogels with a wide range of well-controlled hierarchical microstructures. Different gas-phase and wet-chemical methodologies are developed to enable uniform and structure-preserving aerogel functionalisation with catalyst nanoparticles (anionic clays, mixed metal oxides, precious metals).[1,2] Advanced X-ray micro-CT and FIB-SEM-EDX techniques are employed to characterise the aerogels' three-dimensional microstructure and surface chemistry. Embedding nanoparticles within the aerogels is shown to provide remarkable improvements in functional performance (activity, selectivity, kinetics, recyclability) across a range of chemical applications, including high-pressure CO2 capture,[1] fine-chemical catalysis,[2] and fuel desulfurisation.[3] Beyond this boost in functional nanoparticle performance, graphene-derived aerogels also provide valuable additional functionality. For example, the electrical conductivity of the 3D-interconnected graphene network can be utilised for energy-efficient flash Joule-heating.[4] Ultrafast and ultrahot resistive aerogel heating (>2000°C) is exploited for highly controlled nano-catalyst synthesis and rapid thermal catalyst recycling. Nanoparticle-decorated aerogels are also explored as flow-through catalysts within chemical flow processes, an area of increasing interest due to substantial benefits in process control and sustainability. Specifically, the performance of aerogel catalysts in chemical flow reactions and potential for controlling the chemical reaction profile through graphene aerogel microstructure are explored.

References

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Figures

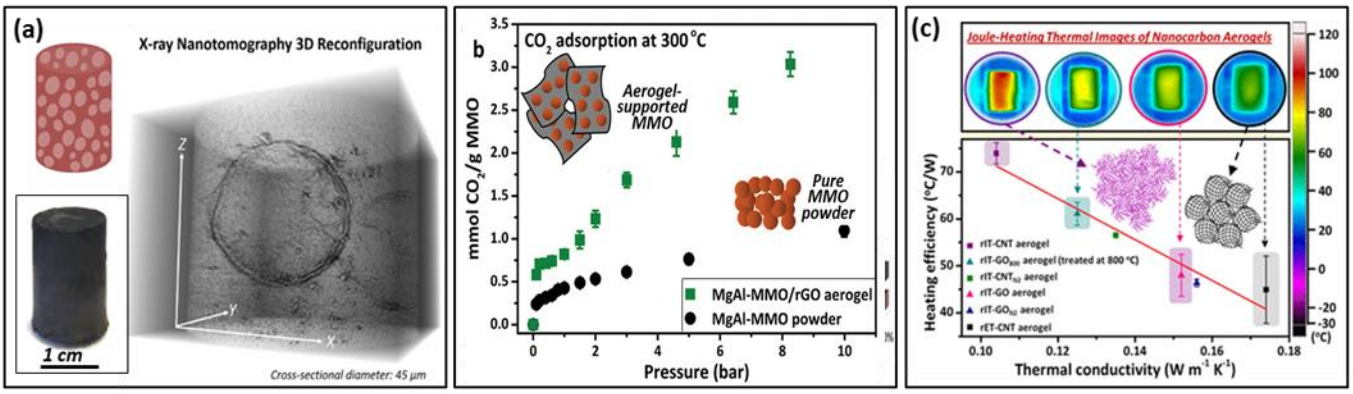

Figure 1: (a) X-ray nanotomography of an emulsion-templated nanocarbon aerogel catalyst; (b) High-pressure CO_2 capture performance of rGO aerogels functionalised with mixed-metal-oxide (MMO) nanoparticles; (c) Thermo-electric structure-property relationship study of different nanocarbon aerogels.