Hierarchical Nanocarbon Aerogel Catalysts

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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 CO_2 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 interconnected 3D nanocarbon network can be utilised for energy-efficient and very fast direct electrical 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 fine-chemical flow reactions and potential for controlling the chemical reaction profile through aerogel microstructure are explored.

References

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Figures

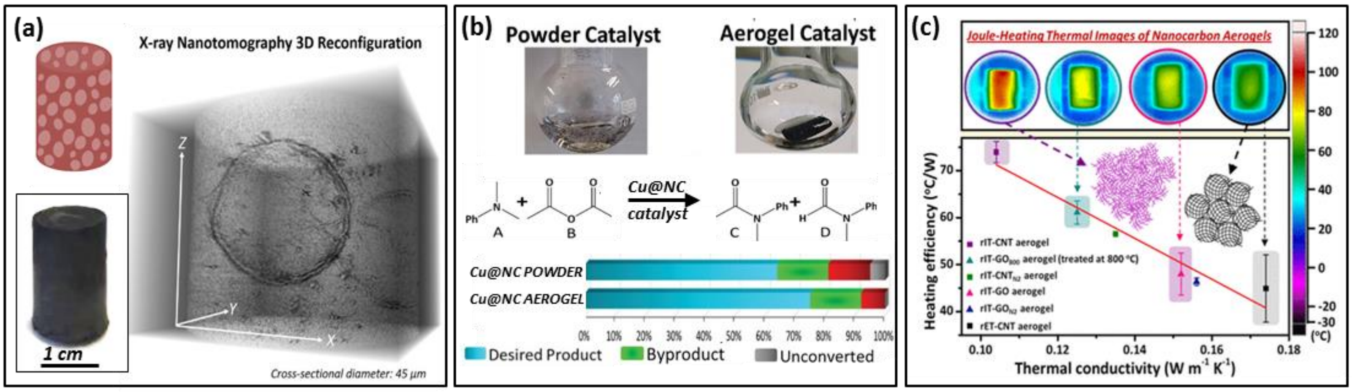

Figure 1: (a) X-ray nanotomography of an emulsion-templated nanocarbon aerogel catalyst; (b) Catalytic performance of metal-decorated nanocarbons in powder and aerogel form; (c) Thermo-electric structure-property relationship study of different nanocarbon aerogels.