Hierarchically porous carbons with simultaneously high surface area and colossal pore volume via ice templating

Herein, we present a strategy for a hierarchical porous carbon (HPC) materials platform with adjustable textural properties and the ability to imbue porosity on all three different porosity regimes: micro- (<2 nm), meso- (2-50 nm) and macroporosity (>50 nm). We will show how optimization and modification of this strategy has resulted in HPCs with very large measured specific surface areas (>2500 m^2/g via BET) combined with colossally high micro/mesopore volumes (~10 cm^3/g)—the combination of which are rarely seen in porous carbon materials. We will show how we achieved these often disparate textural characteristics by utilizing ice templating not only as a macroporous pore former, but to also synergistically allow for the modification of the mesopore formation. We will reveal how ice templating allows for the mesopore formers (a colloidal silica template) to be well dispersed, even when the silica to carbon precursor is relatively high (2:1 and 3:1 ratios of silica to precursor) resulting in modification of mesopore size as well as increasing the surface area and particularly the pore volume to previously unreported values (>10 cm^3/g). Furthermore, we will demonstrate how the modifiable nature of this HPC materials system extends to the atomic scale by presenting the ability to vary from an atomically disordered, or hard carbon HPC; to a more ordered or graphitic HPC material.