Porous crystals from aggregate containing charged sphere suspensions

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Abstract:

Porous crystals are valued in many applications for their unusual elastic and transport behaviour. Despite occasional observations, porous colloidal crystals thus far evaded reproducible fabrication. We here study possibilities for their formation from multicomponent colloidal melts. Simple mixtures show a rich microstructure, but no pore formation. Systems containing small aggregates show an enhanced nucleation behaviour. However, charged colloidal spheres in low-salt suspensions containing moderately sized aggregates comprising some 5-10 particles reveal the formation and stabilization of a porous crystalline microstructure. Using optical microscopy, we observe the transformation of an initially crystalline colloidal solid with homogeneously incorporated aggregates to individual, compositionally refined crystallites of perforated morphology coexisting with an aggregate-enriched fluid phase filling the holes and separating individual crystallites. We show that this route to porous materials is neither restricted to nominally single component systems nor to a particular microstructure to start from. However, it necessitates an early rapid solidification stage during which the aggregates become trapped in the bulk of the host-crystals. A preliminary kinetic characterization shows their growth to follow power law behaviour. The thermodynamic stability of the reconstructed crystalline scaffold against melting under increased salinity was found comparable to that of pure phase crystallites grown very slowly from a melt. Future implications of this novel route to porous colloidal crystals are discussed.