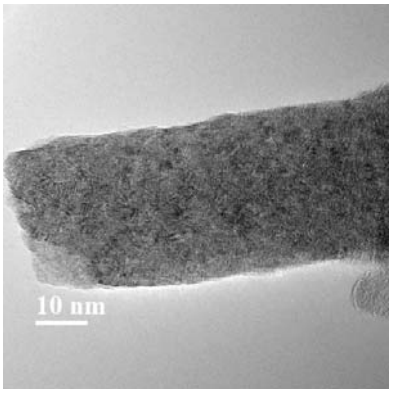
Nano Grows Cold

Nanostructures grown in ice molds with environmentally friendly method

EMSL researchers and their collaborators have tested a new way to build nanostructures that is "green" and elegantly simple. Taking a cue from nature, collaborators from the University of Central Florida, Pacific Northwest National Laboratory, and Defence Academy of the United Kingdom grew cerium oxide nanostructures inside the tiny voids that form in aqueous solutions upon freezing. By controlling solution freezing rate, nanoparticle concentration, and storage temperature, the team's ice mold method may be used to produce nanostructures with tailored shapes and sizes that have a myriad of applications – from biology to electronics.



TEM image of a cerium oxide nanorod formed in an ice channel.

The team's green chemical method was made possible by two natural phenomena: solute rejection and self-assembly. Upon freezing, aqueous solutions force out, or reject, impurities because they cannot be accommodated in the rigid lattice structure of ice. Depending on the freezing conditions, ice does not form a perfect lattice throughout. Rather, it has tiny pockets and channels. It is into these voids that impurities, in this case cerium oxide nanoparticles, become trapped together and can self-assemble.

Upon freezing cerium oxide nanoparticles in solution at different temperatures and rates and storing the frozen solution for days to weeks, the research team used transmission electron microscopy and other tools to characterize the resulting nanostructures. They observed that cerium oxide nanoparticles trapped in channels in the ice formed nanorods, and those trapped in larger voids formed octahedral superstructures. The team's experimental observations were consistent with molecular dynamics simulations of nanoparticle behavior under geometrically constrained conditions.

Scientific impact: Defining the conditions under which nanoparticles can be made to self-assemble into desired geometries opens new doors for nanomaterials research. In addition, studies such as these support EMSL's goals to design and synthesize increasingly complex materials.

Societal impact: Many existing processes to manufacture nanomaterials use high molecular weight surfactants and solvents such as toluene, often generating chemical waste. The research team demonstrated a new method to produce nanostructures that minimizes harm to the environment in a cost effective manner. Nanomaterials produced with the research teams' new water-based method are less expensive and could drive technological advancements in a variety of nano-fields.

For more information, contact EMSL Communications Manager Mary Ann Showalter (509-371-6017).

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