Filled Carbon Nanotubes: Superior Latent Heat Storage Enhancers

Nanomaterials provide a unique opportunity to significantly improve the mechanical, electrical, thermal and chemical properties of bulk materials. These exceptional properties have the potential to be integrated into innovative products and processes that may lead to substantial energy savings and carbon emission reduction. This collaborative program between Argonne

National Laboratory (ANL) and the University of Illinois at Chicago (UIC) will focus on challenges in the areas of high-rate heat transfer and thermal energy storage. The technical objective of this nanomanufacturing concept definition study is to demonstrate the feasibility of filled carbon nanotubes (CNT) as latent heat storage enhancers, with potential applications as next generation thermal management fluids in diverse applications in industries ranging from high-demand microelectronic cooling, manufacturing, power generation, transportation, to solar energy storage. The concept, developed at UIC, envisages the ability of filling carbon nanotubes with liquid-gas transition phase change materials without large pressure built-up in the host media. This offers a significant advantage. The project team will also explore the filling of CNTs with polymers or metals, each with solid/liquid phase transition in a temperature range that is characteristic of a specific process application. The issue of capping the CNTs to seal in the filled content (such as water) would be addressed.

One of the most effective approaches for the production of large area of highly ordered, isolated, long CNTs with monodispersed tube diameter and length is based on template-confined growth of CNTs. The diameter, length, and packing density of CNTs can be fully controlled when the nanotube arrays are fabricated in porous anodic aluminum oxide (AAO) templates. The nanotube uniformity in the planned thermal experiments is critical for proper data interpretation. ANL has developed a simple but effective method by dropping polymer solution on the AAO template followed by calcination in a tube furnace. The project team will explore the feasibility of making much larger templates for producing much larger CNT samples. Alternatively, making multiple templates is expected to be quite feasible.

The changes in effective thermal conductivity k, specific heats Cp, and viscosity of this new class of materials offers an opportunity for significant impact on potential heat transfer enhancement and pumping power reduction and therefore energy savings and carbon emission reduction. These issues would be examined by analytical theory and simulation within a percolation framework. The competing factors would be analyzed. The exceptionally high k for individual CNT would be exploited. The theoretical analysis would work closely with the synthesis and measurement tasks to seek the common ground between what can be synthesized, its percolation characteristic and expected k and Cp performance and regime of industrial interest in terms of reduction of pumping power, heat transfer enhancement and therefore energy savings and carbon emission reduction.

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