Novel Aerogel-Based Insulation May Transform Building Efficiency

The last ten years have been the ten warmest on record globally. Any plan to address climate change must directly reduce heating and cooling consumption, which typically accounts for half of a commercial or residential building's energy usage. Recent data from the 48 largest electric utilities in the U.S. show that energy efficiency, with an average cost of just $24 per saved megawatt-hour, is 2–8 times more economical than conventional power generation.

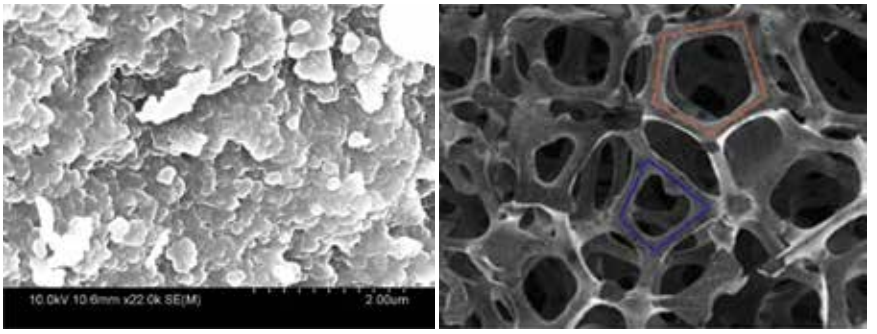
The easiest and most direct way to reduce heating and cooling needs is thermal insulation; however, existing products are either difficult to handle and install (*e.g.,* fiberglass, mineral wool), or highly flammable (*e.g.,* foamed plastics). Liatris Inc., a Maryland-based small business funded by the U.S. National Science Foundation (NSF), is rapidly commercializing a new generation of nanopore insulation made with organic-inorganic composite materials that combine the high performance of foam with the non-flammability of fiberglass and mineral wool. In less than five years, the company has demonstrated two products: a fully non-combustible insulation board made with foamed cement and clay being sold to leading wall panel suppliers; and a next-generation "super-insulation" product made using silica aerogels dried in a matrix with reinforced fibers (*e.g.,* fiberglass, polyethylene terephthalate/polyester).

The aerogel-fiber composite delivers two times the R-value per inch (*i.e.,* the capacity of an insulating material to resist heat flow, measured per unit area) of foam insulation but can be manufactured using existing capital equipment and processes for high-volume production. Traditionally, the cost challenge in creating nanopores comes from engineering the materials at nanoscale (to <100 nm, below the mean free path of air, for limiting molecular collision and lowering air conductivity) while preserving drastically increased pore populations to maintain the high porosity (>95%) needed for cost-competitive insulation products. Liatris's ambient pressure drying of aerogels prevents the collapse and shrinkage of pores by integrating pressurized drying with *in situ* foaming of a binder to optimize the cost of nanopore generation. The company can also incorporate low-cost, eco-friendly binder materials such as cellulose fibers and exfoliated clays to facilitate additional *in situ* nanopore creation.

The non-flammability of all of Liatris's primarily inorganic composites, including the aerogel fiber super-insulation, is a key market differentiator due to major shifts in building codes restricting the use of foam insulation in high-rise and mid-rise construction. The fire and temperature tolerance also gives the Liatris technology broad applicability in industrial, marine, and other markets that have similar specs. Future development is aimed at making more flexible and shapeable products, which would simplify use on industrial pipes and process systems that consume several times the energy of buildings.

"Liatris's high-performance, easy-to-install insulation products, which are both cost-effective and resilient, address one of the most significant needs in building materials," says Chris Anderson, CEO of Vantem, a manufacturer of net-zero modular buildings backed by Breakthrough Energy Ventures, which is scaling up 20 factories across the U.S.

Liatris CTO and co-founder Arthur Yang was one of the first researchers to work on aerogel super insulation dating back to the early 1990s. However, despite major R-value enhancements and clear economic and societal benefits, aerogel insulation has not penetrated the mass market due to high costs. Demonstrating ambient drying as an alternative to supercritical processes expands the potential for mainstream applications such as buildings. Furthermore, Liatris's ambient-dried aerogels can be integrated with various other forms of insulation (*e.g.,* polystyrene and polyurethane foam) to increase R-value, making it a versatile, high-impact platform technology. With buildings accounting for 40% of U.S. energy use and industry another 30%, nanopore super insulation has the potential to be a unique game changer. CEP



▲ Liatris's development efforts are aimed at increasing the nanopore content of insulation to reduce heat transfer. Its insulation products display significantly smaller pores (left) than the pore structure of conventional foam insulation (right), delivering R-values of 9.5 to 10.3.

This technology was supported in part by the U.S. NSF through the Small Business Innovation Research (SBIR) program.

This article was prepared by the U.S. National Science Foundation in partnership with *CEP*.