IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Hydrogels-based Materials for Energy-Efficient Thermal Comfort Control of Buildings

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Abstract

The buildings sector accounts for over 40% of all U.S. primary energy consumption and associated greenhouse gas emissions. In 2018, ~7.59 quads of energy (equivalent to ~$20 billion) was lost through unnecessary large area environmental conditioning and poor thermal insulation of building components, making it imperative to reduce energy consumption in buildings through the development of next-generation, energy-efficient building technologies and practices. Superabsorbent polymers, or hydrogels, are materials that contain more than ~ 90 wt% water and are commonly used in contact lenses, wound dressing, tissue engineering, and drug delivery. Recently, hydrogels have been proposed for temperature and humidity control of buildings due to their superabsorbent and environmentally friendly capability. The goal of this study was to develop hydrogels-based materials for energy-efficient thermal comfort control of buildings. Multiple approaches at the forefront of hydrogels for next-generation building technologies have been studied including the development of artificial ‘skins’ for building cooling, thermo-responsive adsorbents for moisture control, and composite phase change materials (PCMs) for thermal energy storage (TES).

Highly stretchable and mechanically tough double network hydrogels (DN-Gels) were developed as durable and reusable “sweating skins” for building cooling. Our results suggest that bio-inspired sweat cooling using tough DN-Gel coatings represents a promising energy-efficient technology for cooling buildings with a reduction of ~290 kWh of annual electricity consumption for air conditioning and ~160 kg of CO_2 emission. Thermo-responsive hydrogel composite (TRHC) adsorbents with high adsorption capacity and low energy-cost regeneration are also developed for efficient humidity control of buildings. TRHC adsorbents have drastically different affinities to water upon phase transition thanks to their thermo-responsive matrix. The low energy-cost regeneration results from the thermo-responsive hydrogel matrix, which becomes hydrophobic and releases water during shrinkage above its lower critical solution temperature (~32°C). TRHC desiccant represents a promising energy-efficient humidity control technology by consuming only 1/6 energy compared to silica gels during the regeneration.

Biography

Dr. **Shuang Cui** currently is a postdoctoral researcher in the Buildings and Thermal Sciences Center at National Renewable Energy Laboratory (NREL). Her research focuses on both fundamental study of nanoscale heat transfer and energy conversion and advanced materials development, spanning intelligent soft materials/devices for moisture control and composite phase change materials for thermal energy storage in buildings. She has been a selected participant of the International School for Materials for Energy and Sustainability VIII at Caltech, 2019 U.S. C3E Women in Clean Energy Symposium at Texas A&M University, and The Rising Stars Women in Engineering Workshop at Seoul National University (Korea). She is also nominated by NREL for the highlight of the Department of Energy’s (DOE) “Women @ Energy: STEM Rising”. Dr. Cui collaborates with scientists and engineers from diverse fields including mechanical, electrical, chemical and civil engineers, material scientists, and chemists to pursue her research projects. Her research has been supported by multiple federal agencies (DOE BTO, ARPA-E, and NREL) and private sector partners (Wells-Fargo) leading to 13 peer-reviewed journal articles and 4 patents.

Dr. Cui received her Ph.D. in Mechanical Engineering at the University of California, San Diego. She received M.S. and B.S. degrees in Thermal Engineering at Wuhan University, China. Her previous research focuses on thermal metrology development for nanomaterials and intelligent soft materials/devices for thermal regulation, water harvesting, and desalination.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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