NAPLES, ITALY 30 JUNE - 4 JULY
ACEX2025 NAPLES
18th International Conference on Advanced Computational Engineering and Experimenting

ABSTRACT

Advancement in Aerogel Insulation: From Bulk Applications to Thin Coating

M.A.M. Yajid[1,2*], Z.A.A Halim[1], I. Nuhu[1,3], R. Amran[1], N. Awang[4], W.F.F.W. Ali[1,2]

[1] Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia.
[2] Materials Research and Consultancy Group (MRCG), Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor Bahru, Malaysia
[3] Centre for Renewable Energy Research, Umaru Musa Yar'adua University, Katsina, Nigeria
[4] Facilities and Maintenance Engineering Section, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, 81750 Johor Bahru, Johor, Malaysia

Silica aerogel-based thermal insulation composites have evolved from bulk applications to thin coatings, offering enhanced thermal performance, mechanical stability, and ease of application. Their mesoporous structure, high hydrophobicity, and low thermal conductivity enable superior insulation, surpassing conventional materials such as mineral wool. Polymer matrices [1], including epoxy, acrylic, and polyurethane, improve aerogel dispersion and mechanical reinforcement, allowing for high filler loading while preserving insulation efficiency. Recent developments focus on bio-derived silica aerogels [2], optimizing sustainability while maintaining superior properties. Traditional aerogel blankets, though effective, suffer from dust release, weight, and handling complexity, leading to a shift toward aerogel-based coatings [3]. These coatings, applied as paints, conform to complex geometries, facilitate in-situ application, and lower maintenance costs. Challenges remain in ensuring high filler retention, adhesion, and mechanical durability within paint formulations. In the oil and gas industry, aerogel coatings offer thermal insulation and corrosion-under-insulation (CUI) prevention, while in construction, they enhance energy efficiency and self-cleaning surfaces. Grafting techniques and optimized formulations are crucial for improving compatibility with various paint matrices. Overcoming these challenges will accelerate the adoption of aerogel-based coatings in industrial and domestic applications, advancing energy-efficient and sustainable insulation technologies.

[1] F. Akhter, S.A Soomro and V.J Inglezakis, Silica aerogels; a review of synthesis, applications and fabrication of hybrid composites. J Porous Mater 28, 1387–1400 (2021).
[2] N. Asim et al. Biomass and Industrial Wastes as Resource Materials for Aerogel Preparation: Opportunities, Challenges, and Research Directions. Ind. Eng. Chem. Res. 58, 17621–17645 (2019).

[3] A. Simpson et al. Thermal performance of thermal paint and surface coatings in buildings in heating dominated climates. Energy and Buildings 197, 196–213 (2019).