Title: Solvent-Engineered Polyurethane/Silica Aerogel Coatings for Durable and Thermally Insulating Cotton Fabrics

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Abastact: This study presents the development of thermoplastic polyurethane (TPU) and silica aerogel powder (SAP)-based composite coatings for enhancing the thermal insulation performance of cotton fabrics. A solvent pre-filling and replacement method using N, N-dimethylformamide (DMF) was employed to preserve the aerogel's porous structure during processing. By systematically varying TPU concentration (15%–25%), TPU/SAP ratio, and coating thickness (35–55 μm), the effects on thermal conductivity, mechanical durability, water repellency, and comfort were investigated. Results showed that DMF pre-filling effectively prevented TPU infiltration into aerogel pores, improving insulation efficiency. Optimal performance was achieved at 20% TPU, a 7:3 TPU/SAP ratio, and a 55 μm thickness, yielding a low thermal conductivity of 0.1043 $W\,m^{-1}\,K^{-1}$, a water contact angle of 112°, and an air permeability of 7.68 mm/s. After five washing cycles, the fabric retained good insulation properties with only a 3.3% increase in thermal conductivity and a 13.2% reduction in peel strength. These findings demonstrate the feasibility of TPU/SAP/DMF coatings for durable, breathable, and thermally insulating textile applications**.**

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