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Development of Mesoporous Gel Based Nonwoven Structure for Thermal Barrier Application

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Abstract : In recent years, with the rapid development in science and technology, people have increasing requirements on uses of clothing for new functions, which contributes to opportunities for further development and incorporation of new technologies along with novel materials. In this context, textiles are of fast decalescence or fast heat radiation media as per as comfort accountability of textile articles are concern. The microstructure and texture of textiles play a vital role in determining the heat-moisture comfort level of the human body because clothing serves as a barrier to the outside environment and a transporter of heat and moisture from the body to the surrounding environment to keep thermal balance between body heat produced and body heat loss. The main bottleneck which is associated with textile materials to be successful as thermal insulation materials can be enumerated as; firstly, high loft or bulkiness of material so as to provide predetermined amount of insulation by ensuring sufficient trapping of air. Secondly, the insulation depends on forced convection; such convective heat loss cannot be prevented by textile material. Third is that the textile alone cannot reach the level of thermal conductivity lower than 0.025 W/ m.k of air. Perhaps, nano-fibers can do so, but still, mass production and cost-effectiveness is a problem. Finally, such high loft materials for thermal insulation becomes heavier and uneasy to manage especially when required to carry over a body. The proposed works aim at developing lightweight effective thermal insulation textiles in combination with nanoporous silica-gel which provides the fundamental basis for the optimization of material properties to achieve good performance of the clothing system. This flexible nonwoven silica-gel composites fabric in intact monolith was successfully developed by reinforcing SiO2-gel in thermal bonded nonwoven fabric via sol-gel processing. Ambient Pressure Drying method is opted for silica gel preparation for cost-effective manufacturing. The formed structure of the nonwoven / SiO_2 -gel composites were analyzed, and the transfer properties were measured. The effects of structure and fibre on the thermal properties of the SiO_2-gel composites were evaluated. Samples are then tested against untreated samples of same GSM in order to study the effect of SiO_2-gel application on various properties of nonwoven fabric. The nonwoven fabric composites reinforced with aerogel showed intact monolith structure were also analyzed for their surface structure, functional group present, microscopic images. Developed product reveals a significant reduction in pores' size and air permeability than the conventional nonwoven fabric. Composite made from polyester fibre with lower GSM shows lowest thermal conductivity. Results obtained were statistically analyzed by using STATISTICA-6 software for their level of significance. Univariate tests of significance for various parameters are practiced which gives the P value for analyzing significance level along with that regression summary for dependent variable are also studied to obtain correlation coefficient.

Keywords : silica-gel, heat insulation, nonwoven fabric, thermal barrier clothing
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