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ORIGINAL

Dynamic heat and moisture transfer in bulky PAN nanofiber mats

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Abstract In this study a non-conventional electrospinning technique was designed for the production of high bulky polyacrylonitrile (PAN) nanofiber mats. Optimum nanofiber mats are achieved with 15 wt.% solution of PAN in dimethylformamide. Such mats result in a bulk porosity which is as high as 99.9 and a density as low as 0.84×10^{-3} g/cm^3. The effect of the porosity of nanofiber mats on the air permeability and coupled heat and moisture transfer of fibers was investigated. Based on the results, high bulky nanofiber mats possess high heat and moisture transfer. Experimental data reveal that upon a slight decrease in the bulk porosity, air permeability and heat transfer decrease noticeably, while moisture transfer variation is low.

1 Introduction

Recently, significant attention has been focused on electrospinning as a unique technique for the fabrication of nanofibers [1]. The technique provides an ultra thin mat of extremely fine fibers with very small pore size and high porosity, which makes them unique candidates for use in filtration, and possibly protective clothing applications. The thin nanoweb has limited mechanical properties that preclude the use of conventional web handling. Therefore nanofiber webs have been applied onto various substrates [2]. For example for filtration application, substrates are often chosen to resemble conventional filter materials. The potential of nanofiber mats for future protective clothing has been investigated by several researchers [3–7]. Gibson et al. have compared the performances of electrospun fiber mats with properties of textiles and membranes which are currently used in protective clothing systems, and showed that electrospun layers are extremely efficient for trapping airborne particles [4–7]. Also, they reported that the air flow resistance and aerosol filtration properties are affected by the coating weight. It was shown that extremely thin layers of nanofiber mats can eliminate particle penetration through the layer [4]. Ryu et al. [8] investigated transport properties of electrospun nylon6 mats and found that polymer solution concentration affects the fiber diameter, pore size, Brunauer-Emmett-Teller (BET) surface area and gas transport properties of mats.

Researchers found that the electrospun mats provide good aerosol particle protection, without a significant change in moisture vapor transport. It was shown that materials used in protective clothing must provide a combination of high barrier performance and thermal comfort [3, 4]. It has been recognized that the heat and moisture transport behavior of textile materials is one of the most important factors influencing the dynamic comfort and performance of clothing in normal use [9]. Significant theoretical and experimental investigation has been done in this field by various researchers [9–11].

Despite the many excellent studies which have been done on the properties of nanofiber mats, due to insufficient information on surface roughness and heat and moisture transfer of nanofiber mats, more studies in these fields are required.

In our previous work we investigated the effect of polyacrylonitrile (PAN) polymer concentration on the characteristics of the nanofiber mats. Results indicated the

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