Transport properties of Bulky PAN Nanofiber Mats

Sedigheh Borhani[1*], Seyed Abdolkarim Hosseini Ravandi[1], Seyed Gholamreza Etemad[2]

[1]Department of Textile Engineering, Isfahan University of Technology
Isfahan 84156-83111, Iran
[2]Department of Chemical Engineering, Isfahan University of Technology
Isfahan 84156-83111, Iran

Abstract

In this study a non-conventional electrospinning technique was designed for production of high bulky polyacrylonitrile (PAN) nanofiber mats. Optimum nanofiber mats are achieved with 15 wt% solution of PAN in DMF. Such mats result in a bulk porosity which is as high as 99.9 and density as low as 0.84×10^{-3} g/cm^2. Effect of nanofiber mats porosity on the air permeability and moisture transfer was investigated. Based on the results, high bulky nanofiber mats possess high moisture transfer. Experimental data reveals that with a slightly decrease in the bulk porosity, air permeability decreased noticeably, while moisture transfer changed slightly.

Keywords: Polyacrylonitril, moisture transfer, Bulk porosity, Air permeability.

1. Introduction

Fibrous materials used for filter media provide advantages of higher filtration efficiency and lower air resistance, which are closely associated with fiber fineness [1, 2]. Filtration efficiency is one of the most important concerns for filter performance [1- 5]. There are various methods to produce ultra fine fibers [1, 2]. Recently, much attention is being directed towards electrospinning as a unique technique for the fabrication of nanofibers [1- 9]. In electrospinning, a high voltage is applied to a capillary containing polymer solution. At a sufficient voltage to overcome surface tension forces, a charged fluid jet is ejected from the needle tip. The jet is stretched and elongated before it reaches the target, then dried and collected as randomly oriented structures in form of nonwoven mat. Electrospinning 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 [1- 5].

These nanowebs have good aerosol particle obstruction and comparatively low air resistance. Recently, the filtration properties of electrospun mats have been studied [3- 8]. To provide appropriate mechanical properties, nanofiber webs have been applied onto various substrates. Substrates are often chosen to resemble conventional filter materials [8].

Gibson et al [6, 7] have reported some properties of electrospun mats. They compared performances of electrospun fiber mats with properties of textiles and membranes currently used in protective clothing systems and showed that electrospun layers are extremely efficient for trapping airborne particles. Also, they reported that the air flow resistance and aerosol filtration properties are affected by the coating weight. It was shown that an extremely thin layer of electrospun nanofibers eliminated particle penetration through the layer [6-7]. Transport properties of electrospun nylon6 mats were investigated by Ryu et al [9]. They found that concentration of polymer solution affected the fiber diameter, pore size, Brunauer-Emmett-teller (BET) surface area and gas transport properties of mats. It was shown that the filtration efficiency of Nylon6 nanofilters is superior to the commercialized high efficiency particulate air (HEPA) filter for 0.3 micrometer test particles [4]. Li et al [10] found that the pore size and pore size distribution of electrospun polylacticacid (PLA) membranes are strongly associated with fiber mass, fiber diameter and fiber length.

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 [6, 11]. 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 [12]. Significant theoretical and experimental investigation has been done in this field by various researchers [12, 13]

* sborhani@cc.iut.ac.ir