Characterization of Polyamide Nanofiber Media for Aerosol Filtration Applications

J. Matulevicius, L. Kliucininkas, D. Martuzevicius

Department of Environmental Engineering, Kaunas University of Technology, Radvilenu pl. 19, LT-50254 Kaunas, Lithuania

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Presenting author email: jonas.matulevicius@gmail.com

Introduction

The aim of the study was to form polyamide (PA) nanofiber media with properties suitable for air filtration applications. In order to develop filter media with suitable characteristics authors have performed series of experiments with polyamide 6 and polyamide 6/6. Polyamide is strong, somewhat flexible material that can take small impacts and resist some pressure while being bent.

The electrospinning method was applied to form nano fiber media. The electrospinning parameters, such as voltage, tip to collector distance, and collection time were investigated.

The comparative characterization of PA fibers was focused on fiber size, solidity of the fibers and thickness of filter media. All these characteristics are important to achieve high filtration efficiency and reduce pressure drop.

Experimental

The homogeneous solutions were obtained by dissolving PA 6 and PA 6/6 pellets in several systems of solvents: formic acid, formic acid/acetic acid 3/2 (v/v), and formic acid/dichloromethane 3/1 (v/v). The solutions were sprayed by syringe pump (LSP01-1A, Longerpumps, PRC) with a syringe needle of internal diameter of 0.7 mm. Electrospun fibers were collected on a vertically positioned cylindrical collector coated with aluminium foil and rotating at a linear speed of 150 cm/min.

The morphology, diameter, and thickness of the PA fibers and media were investigated by using scanning electron microscope (Hitachi S-4800, Japan) and atomic force microscopy (Asylum Research MFP-3D,USA). The basis weight was defined using ultra-microbalances (UYA 3Y, Poland). The solidity of the fibers was calculated from the experimental data.

Results

The range of electrospinning parameters and characteristic values of the filter media are presented in Table 1. The relationships between the solution concentration and fiber diameter (Fig. 1) show that both PA 6 and PA 6/6 follow similar trends of increasing diameters with increasing concentrations of polymers. The minimal fiber diameter of 60 nm was observed for PA 6/6.

It was found that collection time and tip-to-collector distance are the major parameters of electrospinning that have effect on the characteristics of nanofiber media. Basis weight and thickness characterize solidity of the media and have direct influence on the filtration parameters. We noticed that due to the lower length of polymer chain PA 6 tended to form spider-net structure. Spider-net (ultrafine fibers) was formed between the regular fibers and increased surface to volume ratio of filter media. At the same time it contributed to a higher mechanical strength of the filter media.

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Table 1. The parameters of electrospinning and characteristic values of fiber media $\left(\frac{\min \div \max}{median}\right)$

El-spinning parameters	Concentration, % w/v	Voltage, kV	Distance, cm	Collection time, min
PA 6/6	$\left(\frac{8 \div 14}{11}\right)$	$\left(\frac{12 \div 20}{16}\right)$	$\left(\frac{6 \div 12}{9}\right)$	$\left(\frac{5 \div 20}{10.5}\right)$
PA 6	$\left(\frac{20 \div 28}{24}\right)$	$\left(\frac{12 \div 20}{16}\right)$	$\left(\frac{6 \div 12}{9}\right)$	$\left(\frac{5 \div 20}{10.5}\right)$
Filter media	**Diameter, nm**	**Basis weight, g/m^2**	**Solidity**	**Thickness, µm**
PA 6/6	$\left(\frac{60 \div 376}{218}\right)$	$\left(\frac{0.12 \div 1.16}{0.64}\right)$	$\left(\frac{0.01 \div 0.17}{0.09}\right)$	$\left(\frac{1.3 \div 8.4}{4.85}\right)$
PA 6	$\left(\frac{99 \div 234}{166.5}\right)$	$\left(\frac{0.11 \div 1.07}{0.59}\right)$	$\left(\frac{0.01 \div 0.164}{0.087}\right)$	$\left(\frac{1.2 \div 7.9}{4.55}\right)$

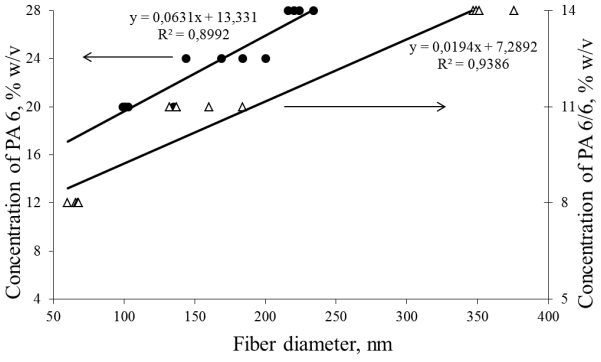

Figure 1. Relationships between the concentrations of PA 6 and PA 6/6 solutions and fiber diameters

The current study provides prerequisites for PA nanofiber media to be used in air filtration applications.