ASPECTS REGARDING ACCOMPLISHING MULTILAYERED FILTRATION MEDIA, USING ELECTROSPUN WEBS

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Filtration media are widely used in industry in various forms for the filtration and removal of particles from fluids. Filtration media represented by the non-woven fibrous materials with the fibers disposed close enough to each other so the inter-fiber spacing or effective pore size to be small enough but in a sufficiently thick layer, able to trap the particles in a desired size range. The present work presents an improved multilayered filtration media that includes a self - supporting highly permeable substrate layer, *textile type*, which provides support structure for the media and has a low relative efficiency and low relative flow restriction, a thin, non-self - supporting, efficiency layer of fine fibers - *electrospun polymer layer* and a smooth, non-self - supporting protective cover layer of fibers which is self-adhering to the efficiency layer and adds negligible efficiency and flow restriction to the overall media.

Keywords: agrotextiles, property, application.

INTRODUCTION

Filtration media are widely used in industry in various forms for the filtration and removal of particles from fluids. Increasing demands from industrial and environment protection reasons for higher degrees of filtration, led to the need for filtration media with smaller fibers and pores size for trapping a smaller class of particles from the fluids to be developed. According, filtration media represented by the non-woven fibrous materials (generally consists of a matrix or mass of fine diameter fibers) with the fibers disposed close enough to each other so the inter-fiber spacing or effective pore size to be small enough but in a sufficiently thick layer, able to trap the particles in a desired size range.

The filter media are then fabricated into the desired form for the particular application (panels, pleated cartridges, flat disks and canisters, etc.), as is generally known in the state of the art. A diversity of materials has been used, including fiberglass, metals, ceramics, and a wide range of polymer materials were used in making non-woven fine fiber filter media.

The present work presents an improved multilayered filtration media that includes a self supporting highly permeable substrate layer, *textile type*, which provides support structure for the media and has a low relative efficiency and low relative flow restriction, a thin, non-self supporting, efficiency layer of fine fibers - *electrospun polymer layer* and a smooth, non-self supporting protective cover layer of fibers which is self-adhering to the efficiency layer and adds negligible efficiency and flow restriction to the overall media.

The three-layer microfiltration media is characterized by high particle capture efficiency and minimal flow restriction.

The present work provides an improved multilayered filtration media that includes a selfsupporting mono or multilayer *textile structure*, a thin fibrous *polymer electrospun layer* and a protective cover layer of fibers.

EXPERIMENTS

Research objective of the work is to develop and validate at the laboratory scale, a demonstration model of textile type filters containing micro/nanofibrous layers produced by electrospinning, with the aim to separate the suspended particles from aqueous solutions.

The textile filter is a multilayer composite (figure 1), which includes:

- Superior hydrophilic electrospun web layer (1);
- Inner polymeric porous electrospun web layer, with micro/nano filtering features (2);
- Inferior woven fabric layer, with support and supplementary filtering features (3).

Figure 1. Multilayer flexible composite filter structure concept

Experiments suppose two stages, namely:

- filter component accomplishing,
- filter system accomplishing.

Raw Materials and Methods

Electrospun polymeric layers are engineered to have filtering behaviors, by using cellulose acetate polymeric solutions, together with some solvents, as follow:

- cellulose acetate (AC), from Aldrich;
- acetone (A), from Aldrich;
- *N,N*-dimethylformamide (D), from Alfa Aesar,
- chloroform (C), from Chimreactiv.

Woven fabrics are made of man-made-fibers, namely: PVC, PES, PA. These are conventional fibers in textile domain, but with a technical end-use indication.

For the weaving stages, there have been used 100% fibers in yarns, and in woven fabrics.

Electrospinning device is laboratory type, and the process of electrospinning was a conventional process. Weaving process was realized on a automatized Picanol weaving machine, rapier type.

All the processing stages are conventional, with no additional devices, settings.

RESULTS

Component Parts of Filtering System, Textile Type

There were realized three types of electrospinning solutions. In figure 2 there details with the three electrospinning solutions.

Variant binary solvent system DMF/ chloroform (code DC11) was selected to be the superior web electrospun layer with hydrophilic behavior.

But ternary system DMF/acetone/chloroform (code DAC121) was selected to be the inner layer, an electrospun web, with filtering behavior.

Figure 2. SEM images of cellulose acetate electrospun from several solutions: (a) binary system DMF/ acetone; (b) binary solvent system DMF/ chloroform (DC11); (c) ternary system DMF/acetone/chloroform (DAC121)

Table 1. Specific characteristic for woven fabrics, selected to be part of the two demonstrators

Characteristics of selected woven fabrics	V04	V05
Nature of yarn raw materials	PES	PA
Composition, %	100	100
Specific mass, g/m ²	297.5	82
Thickness, mm	0.504	0.160
Warp no/cm	14.00	42.0
Weft no/ cm	12.00	39.8
Air permeability, 100Pa, l/m ² /s	435.00	1281.65
Mass specific density, g/cm ³	1.38	1.13
Theoretically cover degree, %	0.6570	0.6790
Cover degree, flattening considering	0,7320	0,7408

Selected woven fabrics for electrospinning 2 layer depositions have fabric report no more than 4 and are balanced to yarn density, yarn length density, on warp and weft.

Demonstrative Model Accomplishing

For demonstrative models validation, were realized 2 (two) variants of models, differentiated by woven fabric support.

In figure 3 are presented the electrospinning devices (3 a) and detail of filtering system, textile type, realized with the woven fabric variants V04, V05.

Figure 3. Demonstrative model a) flash of the electrospinning process; b) DAC121/ DC 11 web fibers electrospun deposition on fabric support, variant V04 (demonstrative model MD1) and V05 (demonstrative model MD2).

In figure 4 there are details of the 2 (two) web electrospun layers, namely superior (a) and inner (b).

Figure 4. SEM image of demonstrative model DAC/DC: a) surface detail of superior covering web layer b) surface detail of inner filtering web layer

After the filtering system realization, in the two variants, MD1 and MD2, the stability, the uniformity between system layers were investigated using Carl Zeiss FESEM/FIB/EDS Auriga. Contact angle also was tested on MD1 and MD2. In image from figure 5 it is a detail in this respect.

Figure 5. Contact angle a) DAC121/DC11 web electrospun layers; b) V04 woven fabric filtering support; c) filtering system, MD1

Evaluation of the Filtered Particle Retained Capacity

For filtering capacity evaluation, in order to validate on laboratory scale, of demonstrative model, MD1 and MD2, were used colloidal solution of Ag (SCAg), of 50 ppm, respective NpZnO suspensions, of same concentration. MD1 (DAC121/DC11-V04) and MD 2 (DAC121/DC11-V05).

The samples of demonstrators are fixed between the 2 rings so that to be exposed to the referential solution to be filtered, in respect of micro and nano particles (figure 6).

In figure 6a it is a detail on validation, filtering installation type.

In 6b and 6c images there are details before and after filtration on the superior layer of the filtering systems for the demonstrator.

Figure 6. Evaluation of filtering capacity

Before and after filtering process the efficiency validation was done through spectrophotometric method, of light absorption in UV-Vis.

Absorption spectra (figure 7) were obtained on UV-Vis-NIR, V-570 type (Jasco, Japan), for the colloidal suspensions of Ag, in reference solution and in the solutions resulted after filtering process, for MD1 and MD2.

Figure 7. Absorbency spectra in UV-Vis for SCAG: a) reference, b) MD1

Also the filtered particle dimensions were evaluated, using DLS method. In figure 8 micro and nano particles of AG are visible on the surface of filtering system, MD1.

Figure 8. NpAg filtered on filter surface, for MD1 – particle dimensions 154,4 – 303 nm from reference solution SAG

CONCLUSION

Research objective of the work is to develop and validate at the laboratory scale, a demonstration model of textile type filters containing micro/nanofibrous layers produced by electrospinning, with the aim to separate the suspended particles from aqueous solutions.

The textile filter is a multilayer composite, which includes:

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Variant binary solvent system DMF/ chloroform (code DC11) was selected to be the superior web electrospun layer with hydrophilic behavior and ternary system DMF/acetone/chloroform (code DAC121) was selected to be the inner layer, an electrospun web, with filtering behavior.

Selected woven fabrics for electrospinning 2 layer depositions have fabric report no more than 4 and are balanced to yarn density, yarn length density, on warp and weft. Two woven fabrics, one PES type and one PA type were selected for realization of 2 demonstrators (MD1 and MD2).

After the filtering efficiency evaluation, MD1 demonstrator was validated as final solution at this stage of the research.

This is a partial solution, having in view that from now the working hypothesis could be enlarged, by developing the filtering process and media features, especially from static to dynamic status.

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