TESTS OF PI NANOFIBRES FILTRATION PROPERTIES [*]

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Introduction

The project is focused on the technology of fabrication of new generation of filtration materials, based on nanofibres with nanoparticle-formed catalysts. These materials shall be used for development and production of devices for filtration and catalytic reduction of toxic agents in waste and industrial gases. The first stage of the project comprises research of appropriate chemical composition of the nanofibres and filtration properties of filtration materials based on nanofibre structures. Filtration materials must be sufficiently resistant to chemically and thermally aggressive properties of waste gases. However, the filtration properties, represented by filtration efficiency and pressure drop, are very important for intended applications. This paper describes filtration tests of filtration media based on the PI nanofiber layer placed on the glass woven textile. Tested properties are initial pressure drop and initial filter efficiency.

PI nanofibers were prepared from the polymer solutions with different concentration and placed on glass woven substrate. Then all samples were transformed by heating process (imidization) and some of the samples were fixed on the textile substrate by applying mechanical pressure to improve the mechanical performance of the filter material. Filtration properties were tested for all samples after spinning and after imidization. Description of tested samples is shown in table 1.

Description of the test method

The used test method is specified for the high efficiency filters. The method is based on the NaCl aerosol particles with the mean size 0,6 m, which penetrate into the test sample. Properties tested by means of this method are initial pressure drop and initial filter efficiency. All tests were made according to the British Standard BS 4400. Parameters of test are shown in table 2.

Samples code	PI solvent concentration	Imidization	Pressing (better fixation on the textile substrate)
21,5NN	21,5	no	no
21,5YN	21,5	yes	no
21,5YY	21,5	yes	yes
22NN	22	no	no
22YN	22	yes	no
22YY	22	yes	yes
22,5NN	22,5	no	no
22,5YN	22,5	yes	no
22,5YY	22,5	yes	yes

Table 1: Description of tested samples.

Corresponding standards	BS 4400 (Method for sodium chloride particulate test for respirator filters)
	EN 143 (Respiratory protective devices – Particle filters – Requirements – testing – marking)
Filtration test area	100 cm^2
Filtration face velocity	5 m/min
Filtration flow	50 l/min
Particle concentration	up to 13 mg / m^3
Size of particles	up to 2 µm, mean value 0,65 µm

Table 2: Parameters of filtration test.

Tested properties are:

1. Filtration efficiency: $E = m_1/m_2 \,.\, 100$ (1), where m_1 is the amount of captured particles and m_2 is the amount of all particles upstream the filter.
2. Pressure drop: $p = p_1 - p_2$ (2), where p_1 is pressure upstream the filter and p_2 pressure downstream the filter.

Test results

In addition to the filtration properties, the thermal stability of the filtration nanofiber materials was evaluated experimentally. Samples were heated in the controlled temperature furnace over the defined period

[*] This result is realized under the state subsidy of the Czech Republic within the research and development project "Research and Development of Nanomaterials for Filtration – Reduction of Emmision Rates from Waste and Industrial Gases" FR-TI1/457- Programme “TIP” supported by Ministry of Industry and Trade of the Czech Republic.

of time and the changes of morphology of nanofiber layer were characterized by SEM pictures examination.

Sample code	Filter efficiency (%)	Filter pressure drop (Pa)	Assumption of nanofiber layer pressure drop (Pa)*
21,5NN	91,65	493	132
21,5YN	88,2	677	316
21,5N	**90,54**	**639**	**278**
22NN	95,9	531	170
22SN	96,02	705	344
22N	**97,18**	**635**	**274**
22,5NN	84,32	444	88,6
22,5SN	92,06	740	379
22,5N	**95,36**	**628**	**267**
Glass woven substrate only	13,5	361	

Table 3: Filtration properties of tested samples

** Assumption of pressure drop of only nanofiber layer was made by the deduction of glass substrate pressure drop from total pressure drop.*

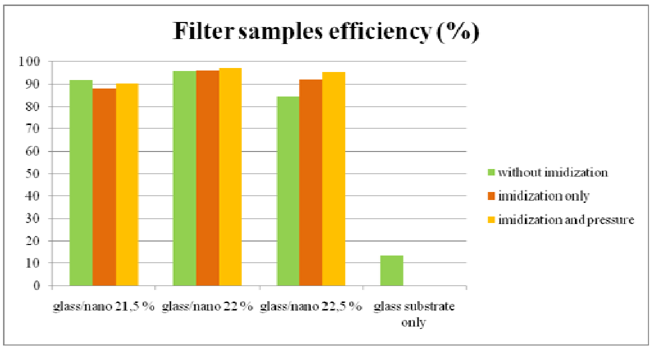

Fig. 1: Filter efficiency of tested samples

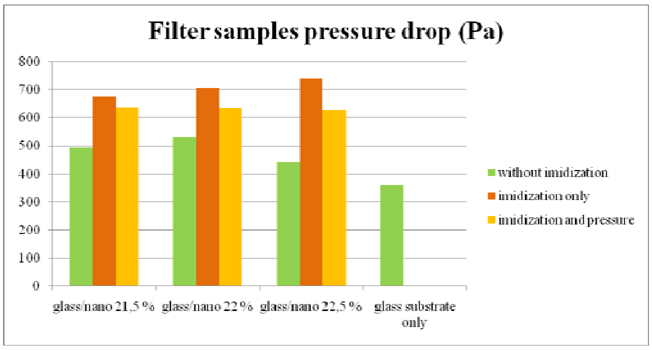

Fig. 2: Filter pressure drop of tested samples

Conclusion:

From the filtration test results it is possible to find following conclusions:

1. The best filtration properties of the material were reached by spinning the nanofibers from 22 % w/w concentration of PI solution- the filter efficiency is the highest and pressure drop is reasonably low.
2. After imidization process the filter efficiency is changing slightly but the pressure drop rapidly increases. Nevertheless the imidization process is essential for the heat stability of the final filter.
3. It is possible to use the pressure for fixing the nanofiber layer on the glass substrate. Surprisingly the final pressure drop is less than with imidization only. The reason is probably in the fact that the pressure was applied before the imidization process and the dimensional changes were not so significant.
4. Filtration materials show satisfactory thermal stability up to 265°C in the long-term thermal load.