NONWOVEN STRUCTURES DOPED WITH CARBON ADSORBENT AND MESOPOROUS SILICA MATERIAL TO DEODORIZATION

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EXTENDED ABSTRACT

KeyWords: sorption capacity, mesoporous silica material, activated carbon, melt-blown process

1. INTRODUCTION

The protective parameters of the respiratory protection equipment (RPE) currently in use are not evaluated for the specific conditions associated with volatile organic compounds (VOC), which significantly affect the time of protective action. Economic development and emerging new threats to society require the development of new and innovative materials for health human. As a result of industrial processes, waste management and sewage management, VOC are introduced into the atmosphere and their mixtures (odorants). People exposed to hazardous and unpleasant odors are exposed to a variety of ailments, e.g. respiratory irritation [1].
Currently used adsorbent materials for these hazards include activated carbon (AC). It's most commonly used in air-purifying RPE due to very good sorption properties [2]. An alternative to this type of material can be siliceous materials, which due to their physical and chemical properties, pore size, shape can adsorb a large amount of VOC from the air for a longer period of use [3-5].
The aim of this study is compare sorption and textural properties as well as conduct basic protective and filtration tests for melt-blown composites of fibrous composites with the addition of various modifiers and their blends. As part of the performed tests, the breakthrough time of the obtained nonwovens against the ammonia vapor (18.7 ppm) was evaluated.
On the basis of the obtained test results, it can be stated that the best protective properties of all variants are shown by the nonwoven fabric with the addition of AC C_2 and C_2/silica adsorbent (12 minutes). The least visible effect was observed for the variant with the C_1 AC (2 minutes). Against the background of the performed tests it was found that the ability to adsorb VOC to a large extent depends on the textural parameters and the chemical composition of the modifier.

2. EXPERIMENTAL PART

2.1 Materials

The production of melt-blown nonwovens was based on blowing the polymer melt into elementary fibers of various thickness and length in one production cycle. This was done by blowing out streams of molten polymer extruded through the fiber-forming head by means of a stream of hot air. The nonwoven structures produced were modified by introducing a modifier in the form of a carbon adsorbent, mesoporous silica material or a mixture of these materials into a stream of semi-liquid polymer fibers.
The melt-blown process for the production of nonwovens used polypropylene granules type Borealis HL 508J with a high melt index of 800 g/10min (supplier: NEXEO Solutions Poland Sp. z o.o.). As a modifier used carbon absorbent (C_1, C_2) and mesoporous silica material MCM-41. As part of the technological process, 5 types of nonwoven structures with electrostatic charge were produced with a surface mass of 134.0-212.0 g/m^2.

Table 1. Five types of polypropylene electret filter media were prepared using melt-blown technique with different types of modificator.

Type	Description	Mean surface mass, g/m^2	Mean nonwoven thickness, mm	BET surface area, m^2/g
PP/A	polypropylene nonwoven with carbon adsorbent C_1	172.7	3.6	750.56
PP/B	polypropylene nonwoven with carbon adsorbent C_2	211.9	3.6	603.89
PP/C	polypropylene nonwoven with mesoporous silica material MCM-41	134.0	4.1	310.70
PP/D	polypropylene nonwoven with carbon adsorbent C_1 and mesoporous silica material MCM-41	150.1	3.7	460.78
PP/E	polypropylene nonwoven with carbon adsorbent C_2 and mesoporous silica material MCM-41	170.1	4.1	477.45

2.2 Methodology

Individual nonwoven structures were evaluated in terms of their sorption properties in terms of the breakthrough time against ammonia vapors, with the lowest allowable concentration equal to 18.7 ppm, corresponded to their maximum allowable concentration (MAC) levels pursuant to the Polish Regulation of the Minister of Labor and Social Policy [6]. During the measurements, gas concentration should not exceed ±5 ppm of the initial value at a relative humidity of (70±5)% and a temperature of (21±1)°C.

3. RESULTS

The study of the breakthrough time for the produced nonwoven with mesoporous silica material and carbon activated and their blends, against ammonia are presented in Figure 1.

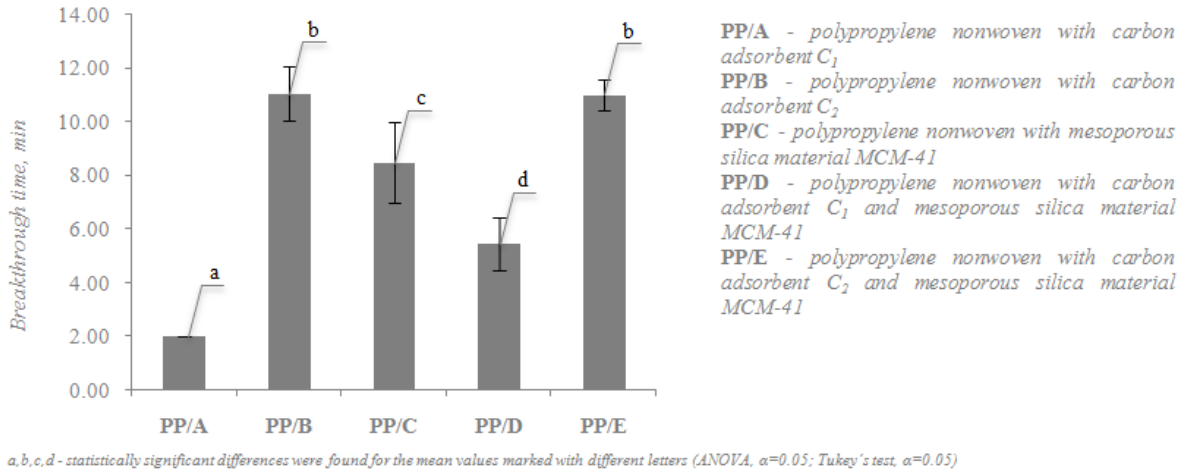

Figure 1. Breakthrough time of nonwoven structures doped with active carbon and mesoporous silica material against ammonia vapour (MAC 18.7 ppm).

On the basis of the obtained test results, it can be concluded that the best protective properties of all variants are shown by the nonwoven with the addition of carbon C_2 (PP/B) and carbon/silica adsorbent (PP/E) with a surface mass of 211.9 g/m^2, 170.1 g/m^2, and BET surface area: 603.89 m^2/g, 477.45 m^2/g, respectively. The time of protective action was about 12 minutes. Despite the lowest BET surface area (310.70 m^2/g) a satisfactory operation time (about 8 minutes) against ammonia vapors was also obtained for a nonwoven fabric with a surface mass of 134.0 g/m^2, in which the modifying agent was a mesoporous silicate material (PP/C). The least visible effect of the modifying agent on the time of protective action was observed for the variant with the C_1 carbon adsorbent (PP/A; BET surface area: 750.56 m^2/g), which was 2 minutes. Statistically significant differences were shown for nonwoven structures type PP/A, PP/C and PP/D. In the case of samples with an addition AC C_2 and blend of C_2 and MCM-41, there is no difference statistically significant. Against the background of the performed tests, it was found that the ability to adsorb volatile chemical compounds to a large extent depends on the textural parameters (surface area, BET surface area and volume of pores) and the chemical composition of the modifier.

4. CONCLUSION

Nonwoven structures doped with active carbon and mesoporous silica material can be used as a filtering material for filtering half masks protecting against odorogenic compounds. The obtained of the breakthrough time against ammonia indicate that the physicochemical and textural parameters of modifiers vahe a big influence on the time of functioning of nonwoven structures.

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