



Review Article

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Modified Polypropylene Nonwoven Textile for Filter Facial Masks

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Introduction

Coronavirus (COVID-19) the most frequently spreads from human-to-human through respiratory droplets. Due to the outbreak of the COVID-19 pandemic in 2020, the research of protective equipment, especially facial masks, increased significantly. The filtering materials of facial masks are typically nonwoven textile. These materials, initially using natural fibers, came into greater importance with the introduction of synthetic thermoplastics, particularly polypropylene (PP), which creates the basic material for nonwoven textile for facial masks production. PP is non-toxic, hydrophobic material, resistant to steam sterilization, with a good ability to be fiberized. Unfortunately, it is also relatively sensitive to microbial attacks, such as bacteria, viruses, and mould [1,2]. Therefore, a less microbially sensitive chlorinated polypropylene derivative (CPP) was electrospun and tested for production of nonwoven masking fibers. CPP is also non-toxic, tasteless, hydrophobic, yellowish thermoplastic polymer with the higher resistance to oxidation and steam sterilization.

Materials and Methods

CPP granulates (Mw ~100,000; Tg (DSC) 54 °C; up to 26 wt% chlorine content) were dissolved in tetrahydrofuran (THF), so that the mass concentrations CPP was 10 %. THF was purified by distillation (b.p. 66 °C). Oxidative agents H₂O₂ and HNO₃ were used in the commercial quality.

The electrospinning process was carried out using Elmarco Nanospider™ NSLAB 500 pilot plant unit, cylindrical electrode, rotation speed 10.2 rpm. The distance between electrodes was 120 mm. The collecting foil was moving with the speed of 0.1 m. min⁻¹ [3]. The homogeneity of nonwoven textile and fibre structure were observed by SEM, using SEM Tescan MIRA3. The imaging used secondary emission mode, depth regime of 15 kV, working distance

of 10 mm and a magnification of 20.000 times. The contrast-enhancing colouring was used for contrast visualization. The average fibre width (FW) was calculated from manually marked 10 fibres width [4-6]. The surface hydrophobicity was determined by measuring water contact angle (CA), using a Digidrop contact angle measuring device (Surface Energy Evaluation System), from DataPhysics [7,8]. 1 µl distilled water was placed on the sample surface, the water contact angle value was determined from the droplet image by tangent method, using software SCA 20. Sterilization treatment tests of CPP nonwoven textile was performed with 2x3 cm long fibre samples, placed on glass slides, and fixed by an elastic band for.

Experimental Results and Discussion

Commercial PP fibres used for facing masks measure approximately about 25 µm in diameter, whereas electrospun CPP nonwoven textile fibres reach only approximately 0.95 µm in diameter. Due to this fact, the CPP filter facing mask material could be used in thinner layer with denser fiberization, with higher protective effect. SEM images confirm homogenous fibre structure with randomly fibre orientation. Water contact angle analysis determinate hydrophobic behavior (Figure 1). Presents the SEM images of fibre samples and data for CA measurements. Nonwoven samples were treated first by water steam, which can be also used for PP fibre facile mask material sterilization. Then CPP samples were submerged into H₂O₂ (concentration 35%) and HNO₃ (concentration 65%) for 30 min. Both treated fiber structures were subsequently compared with commonly used steam sterilized fiber structure. No morphological changes were observed. The CA values of treated fibers do not vary a lot, so hydrophobicity behavior was not significantly changed.



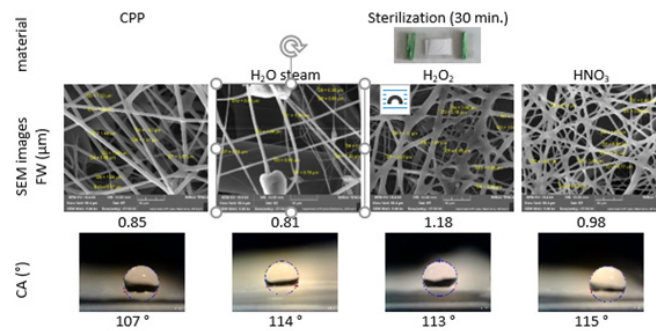


Figure 1: SEM nonwoven fiber structure, FW, CA.

Conclusion

Resistant CPP polymer was successfully fiberized using electrospinning technology. Fiberized CPP nonwoven textile seems to be an excellent filter material against viruses and other microorganisms. We concluded from this study that CPP fibres could greatly reduce viruses and bacterial penetration through the mask because of the textile morphology. In current medical masks, PP is compressed into several layers of membrane, the thinner CPP fibres could allow to use less layers due to their structure and higher fibre density. Moreover, the CPP capability to be repetitively sterilized by water steam as well as by an oxidizing agent make the material potentially interesting for commercial production. The experiments used in this study were simple but effective, presented the ability of CPP nonwoven textile formation using electrospinning technique, fibres exposing high homogeneity of fibre structure, hydrophobicity, and oxidative stability.

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