Abstract
Multilayer and Multiscale Structures for Personal Protective Equipment †

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The COVID-19 pandemic has revealed the numerous limitations of personal protective equipment (PPE) such as face masks and has shown an urgent need for the adaptation of standardization criteria to ensure systematic use. Face masks confer protection to the user, acting as a filtration barrier through mechanisms of sedimentation, inertial impact, interception, diffusion, and electrostatic interaction, among others. Different non-woven fabrics (spun-bound and melt-blown) are normally combined to reach the particle-retention levels needed, and their fabrication is in high demand. Consequently, there is a strong need to select and create new materials, such as layered multifunctional fabrics, following a rational design to ensure not only an efficient filtering capability but also comfortable and breathable fabrics. Electrospun nanofibre mats meet these requirements as a randomly oriented fibrous structure that can be deposited on top of any substrate for conjugated properties.

In this study, different fibrous structures were placed over an electrospinning flat collector and polyamide (PA) nanofibers were deposited on top of them. After optimization, a 20 wt% PA in formic (90%) and acetic (10%) acid solution was added to a syringe; was applied to a steel capillary needle (22 G) at a fixed voltage of 28 kV; and was solution-fed at a rate of 0.4 mL/h, needle-to-collector distance of 10 cm, and controlled temperature and relative humidity values. Samples with different deposition times and different numbers of electrospun layers were analysed by scanning electron microscopy, and conclusions about the nanofibre diameters and porosity were obtained. The substrates (controls) and the electrospun-layered substrates (samples) were analysed in terms of their mechanical, structural, and thermal properties, along with their particle retention efficiency and breathability.

By evaluating the performance of different multi-layered structures, one can conclude that the combination of nanofibrous with macrofibrous structures can be highly advantageous for the filtration efficiency. Moreover, a design tool can interestingly be used to discard some possibilities and to avoid strong experimental loads. Thus, these structures can turn into a very promising asset for the development of innovative facemasks.

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