Smart Nanofiber Filters for Personal Protection

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Abstract

The objective of this work is to prove the retention efficacy and the elution of polycarbonate nanofibers against an aqueous suspension of Bacillus thurigensis spores (simulator of Bacillus anthracis) as well as to verify if there exists interference of the nanofibers with the detection techniques employed.

The electrospinning technology has been used to develop the polycarbonate nanofiber filter. In order to do so, a suitable solution of polycarbonate with appropriate solvents and other additives has to be developed with the suitable viscosity so that when subjected to a high potential difference between the solution and the place of deposition (collector) is applied nanofibers are produced and deposited in the form of a non-woven material. The main difficulty of this work is related to finding the appropriate selection of process parameters, which are many and interrelated, and range from the polymer blend/solvent system ratios in the solution, required stabilisers, mixing time, applied voltage, flow rate, collector to needle tip distance, needle diameter and humidity. The best results were obtained with a solution composed of:

- ✓ 20% PC
- ✓ DMF/THF (50/50 wt)
- ✓ TBAC (1% wt with respect to PC)
- ✓ Flow rate: 0,5 ml/h
- ✓ V: 15 kV
- ✓ Needle tip to collector distance: 150 mm
- ✓ Needle diameter: 0.6 mm
- ✓ Relative humidity: 30%
- ✓ T-range: 23 ºC

Figure 1 shows a shows a circular PC sample without beads (47 mm in diameter) successfully extracted from the Al foil that was used as a collector and figure 2 shows a SEM micrograph of the PC nanomesh obtained were it can be seen that there is no presence of defects such a beads or excess solvent an the nanofibers show a quite uniform range of diameters that vary between 200-300 nm.

The number of microorganisms retained by the polycarbonate nanomesh was measured by comparing the ufc/ml of the stock solution with the ufc/ml of the filtered product using a kitasato flask to which a vacuum pump was attached. Figure 3 shows the experimental setup. Counting was carried out using flow cytometry. Figure 4 shows number of viable spores counted for a standard nylon filter and the polycarbonate nanofiber filter after several washes. Almost all spores are recovered with the first wash. This is shown more clearly in figure 5 where the total number of spores found in the stock solution, the nylon filter and the polycarbonate nanofiber filter after the first wash is presented.

The main conclusions from this work are:

- ✓ The polycarbonate nanofiber filter retains 99,6% of the Bacillus thuringiensis in the aqueous suspension.
- ✓ The spore recovery from polycarbonate nanofiber filter, washing with PBS+0,05% Tween-20 is complete.
- ✓ Polycarbonate nanofibers do not interfere with test techniques used in this study.

Figures

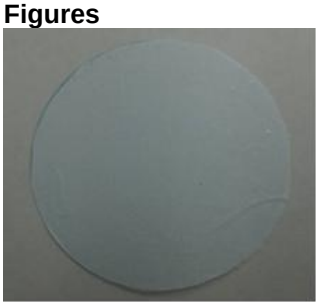

Figure 1. Photograph showing a circular PC sample without beads (47 mm in diameter) successfully extracted from the Al foil.

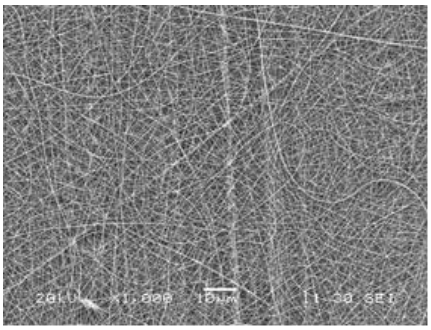

Figure 2. SEM micrograph of a PC nanomesh without beads.

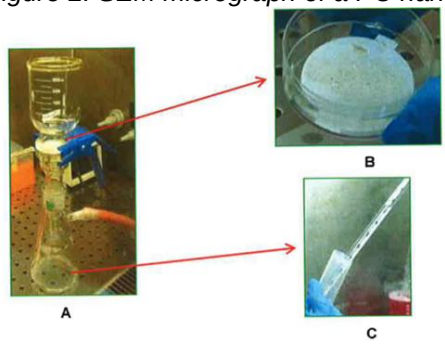

Figure 3.- Experimental setup (A), nanofiber mesh in a Petri plate (B) and filtered product in a sterile Falcon tube.

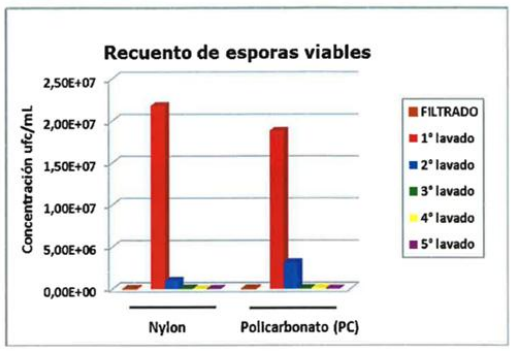

Figure 4. Number of viable Bacillus thuringiensis spores counted for a standard nylon filter and the polycarbonate nanofiber filter after several washes.

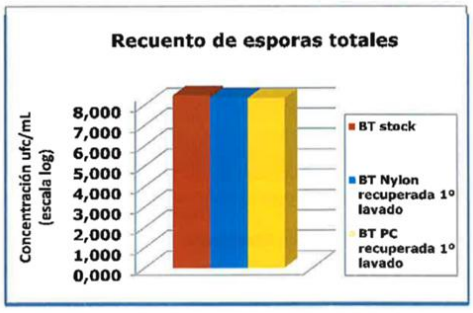

Figure 5. Total number of Bacillus thuringiensis spores found in the stock solution, the nylon filter and the polycarbonate nanofiber filter after the first wash is presented.