Design of Biologically Active Surfaces Based on Functionalized Polysulfones by Electrospinning

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OBJECTIVES

Development of a new generation of electrospun polymeric materials designed to accomplish multi-performance in a bioinspired integrated system

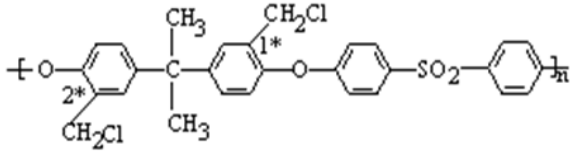
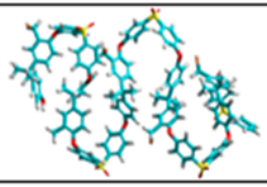
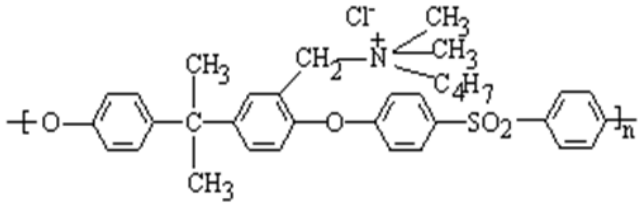
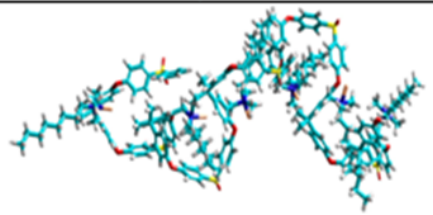
- The relationship between processable solutions properties and morphological aspects was assessed.

- The antibacterial activity of PSFQ fibers against Gram-negative and Gram-positive bacteria has indicated potential for biomedical use.

EXPERIMENTAL

MATERIALS

Chemical and conformational structures (with minimized energies, considering four repeating units) of synthetized polysulfones
chloromethylated polysulfone (CMPSF) and quaternized polysulfone (PSFQ))

Sample	Chemical structure	Conformational structure	Mn (g/mol)
CMPSF			29,000
PSFQ			28,000

METHODS

Solution preparation: PSFQ homogeneous solutions for electrospinning were prepared by dissolving in N,N-dimethylformamide (DMF) and 2-Methoxyethanol (2-MOEt) at room temperature. The polymer solutions concentration of 40 g/dL was chosen to obtain fibers with sizes in the sub-micrometer range.

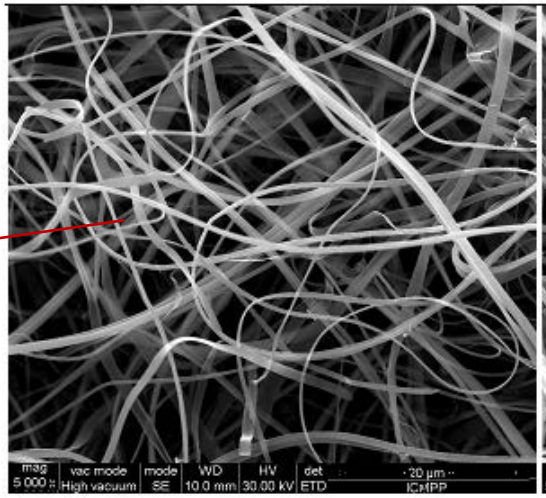
Electrospinning: Around 3 mL PSFQ solution of 40 g/dL concentration was electrospun under to applied voltage potential of 15-20 kV with a needle tip-collector distance of 15 cm and flow rate of the solution through the syringe of 0.75 mL/h. An aluminum rotary disc was used as collector for PSFQ fibers.

Morphology: Electrospun fibers was investigated using an environmental scanning electron microscope (ESEM), Quanta 200 operating at an accelerating voltage of 20 kV with secondary electrons in low vacuum mode.

In *vitro* antibacterial activity: Electrospun PSFQ was tested on two bacteria strains (*Staphylococcus aureus* ATCC 25923 and *Escherichia coli* ATCC 10536), by the diffusion method (Kirby-Bauer), and the diameter of the inhibition zone was evaluated.

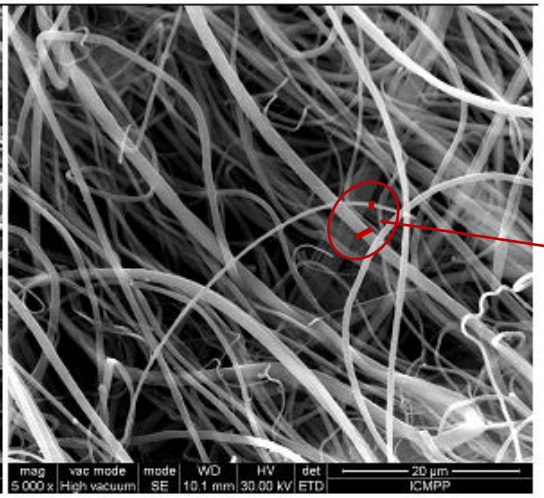
Morphological aspects

PSFQ in DMF



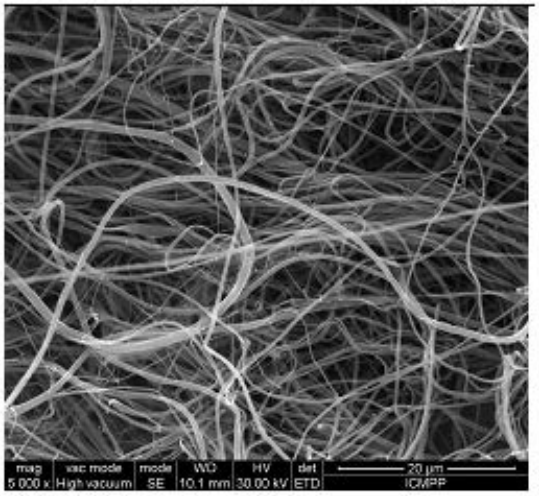
1.60 μm

PSFQ in 2-MOEt

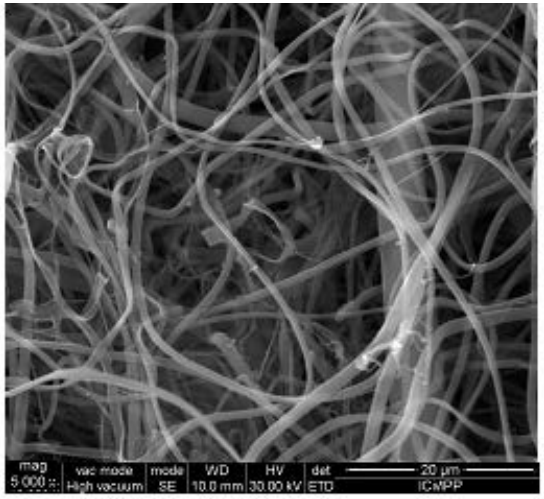


0.65 – 2.40 μm

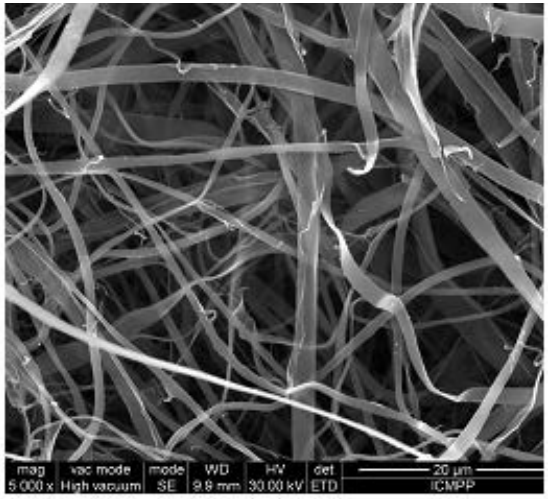
75/25



50/50



25/75

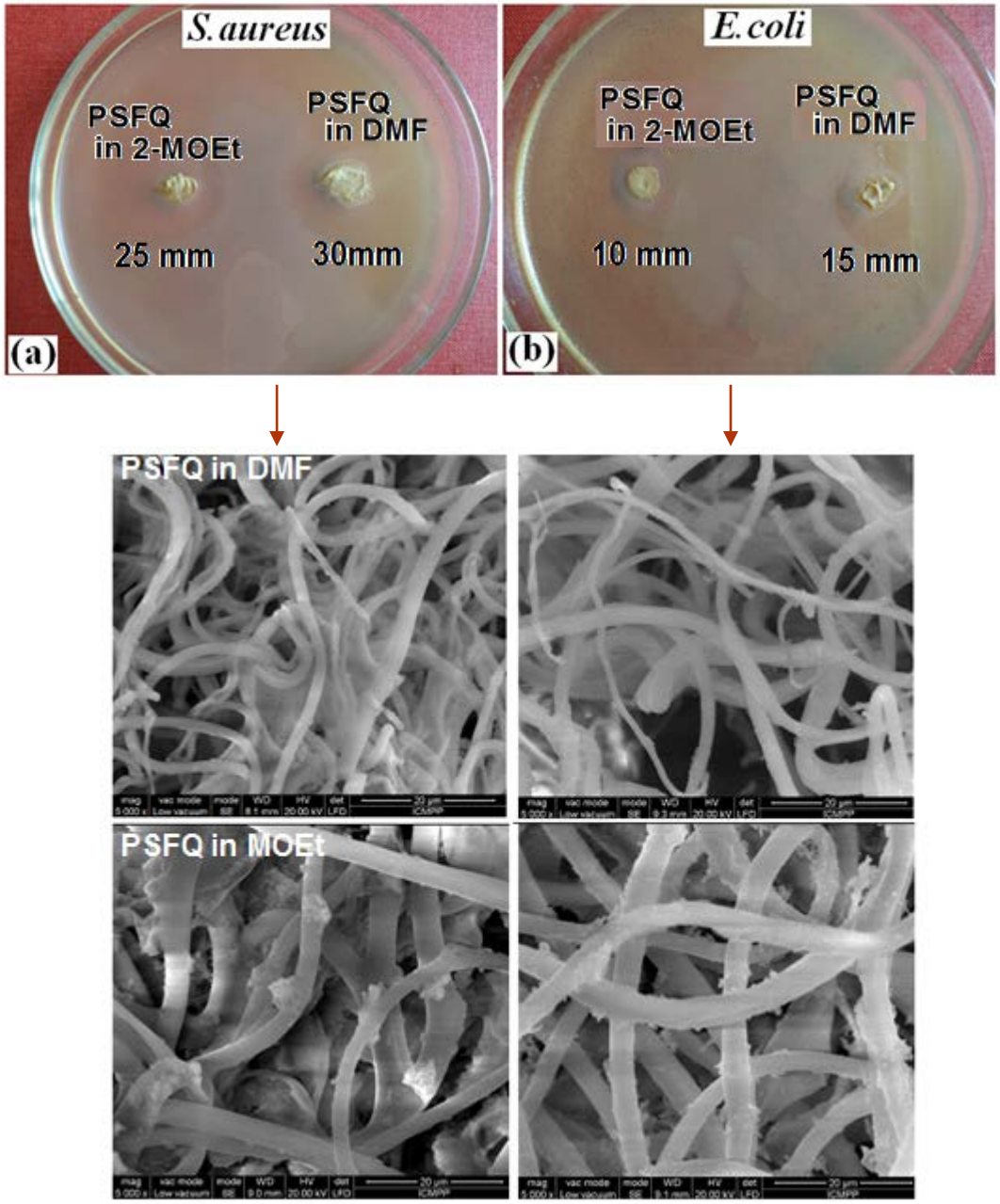


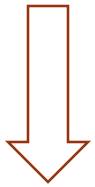
SEM images of PSFQ fibers obtained in: DMF and 2-MOEt at 40 g/dL polymer concentration for 50μm scan area and magnification of 2000x

Relationship between processable solution properties and morphological aspects shows that the morphology of formed fibers, with different forms and dimensions, can be attributed to the combined effects of the polymer solutions concentration, thermodynamic quality of the used solvents, implicitly the cumulative effects of specific interactions, as well as the process parameters.

- The fibers obtained from PSFQ solutions in 2-MOEt have a wide distribution of diameters, ranging from 0.65 μm to 2.40 μm
- For PSFQ solutions in DMF, the fibers with more regular shapes and larger diameters are obtained (average fibers diameters = 1.60 μm)
- Fibers morphology, by different forms and dimensions can be explained in terms of the different solution properties, (i.e., the boiling point of the solvents, the viscosity, and the surface tension) and intramolecular repulsive interactions between the ionized groups (i.e., ammonium groups)

Antibacterial activity of PSFQ fibers





- **PSFQ fibers obtained both in the 2-MOEt and in DMF show the antibacterial activity against both microorganisms, but *S. aureus* is much more sensitive to the investigated fibers than *E.coli*.**

- **PSFQ fibers obtained in DMF, with the smaller diameters (around 1.60 μm), inhibit the growth of microorganisms and the inhibition becoming stronger against *S. aureus*.**

- **Inhibition of the hydrophilic *E. coli* to the hydrophilic PSFQ fibers is lower than the inhibition of hydrophobic *S. aureus* cells.**

CONCLUSIONS

Processing of the functionalized polysulfones with quaternary ammonium groups (PSFQ) solutions by electrospinning allows the obtaining the new materials with high-performance characteristics - biologically active surfaces - designed to be integrated in a bioinspired system in medical therapy.