ELECTROSPINNING OF POLYLACTIDE AND POLYCAPROLACTONE MIXTURES FOR PREPARATION OF MATERIALS WITH TUNABLE DRUG RELEASE PROPERTIES

Luís del Valle,[1] Roger Camps,[1] Angélica Díaz,[1,2] Lourdes Franco,[1,2] Alfonso Rodríguez-Galán,[1,2] Jordi Puiggalí[1,2]

[1]Departament d'Enginyeria Química, Universitat Politècnica de Catalunya, Av. Diagonal 647, E-08028, Barcelona, SPAIN

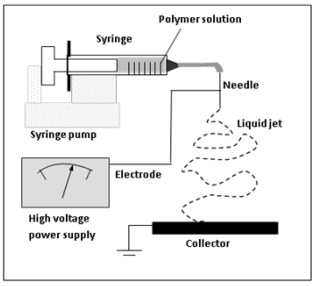
[2]Centre de Recerca en NanoEnginyeria (CRNE), Universitat Politècnica de Catalunya, Edifici C', c/ Pascual i Vila s/n, E-08028, Barcelona, SPAIN

https://psep.upc.edu

ABSTRACT

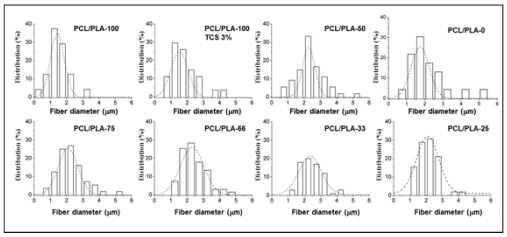
Electrospun microfibers with a variable ratio between polycaprolactone and polylactide homopolymers were prepared from chloroform/acetone solutions. Thermal properties of both as-processed and melt crystallized samples were studied. Time-resolved WAXD patterns were taken during heating runs in order to evaluate the initial crystallinity and changes occurred during cold crystallization. DSC and WAXD experiments clearly indicated that fiber orientation facilitated the crystallization of polylactide, especially when fibers had a high polycaprolactone content.

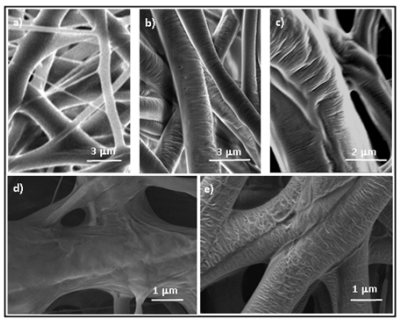
Triclosan could be effectively loaded by electrospinning and was well mixed in the polycaprolactone and polylactide phases. SAXS patterns allowed inferring that both polymers were also well mixed in the electrospun fibers and that triclosan hindered the lamellar stacking of polycaprolactone. The release of drug loaded samples into different mixtures of ethanol and Sörensen medium was evaluated and the different affinity between triclosan and the two studied homopolymers was demonstrated. In this way, it was possible to obtain a series of materials with tuned release behavior and tuned antibacterial effect. The biocompatibility of all triclosan loaded polymer mixtures was evaluated by studying cell adhesion and proliferation.



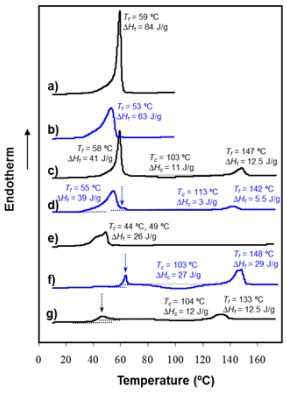
Electrospinning uses electrostatic forces (10-100 kV) to stretch a polymer dilute solution as it solidifies.

Sample	Voltage (V)	Flow (mL/h)	Distance[a] (cm)	Fiber Diameter (μm)	Error (μm)
PCL/PLA-100	25	10	12	1.45	0.032
PCL/PLA-100 TCS 3%	25	10	12	1.49	0.049
PCL/PLA-75	25	10	12	2.08	0.030
PCL/PLA-75 TCS 3%	25	10	12	2.12	0.037
PCL/PLA-66	25	5	12	2.31	0.076
PCL/PLA-66 TCS 3%	25	5	12	2.35	0.070
PCL/PLA-50	25	5	12	2.27	0.061
PCL/PLA-50 TCS 3%	25	5	12	2.14	0.052
PCL/PLA-33	25	5	12	2.36	0.110
PCL/PLA-33 TCS 3%	25	5	12	2.30	0.142
PCL/PLA-25	15	10	12	2.09	0.022
PCL/PLA-25 TCS 3%	15	10	12	2.11	0.027
PCL/PLA-0	15	10	12	1.83	0.050
PCL/PLA-0 TCS 3%	15	10	12	2.05	0.057

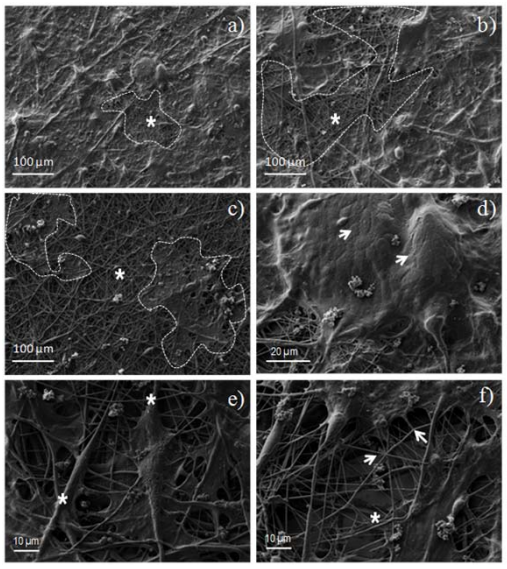




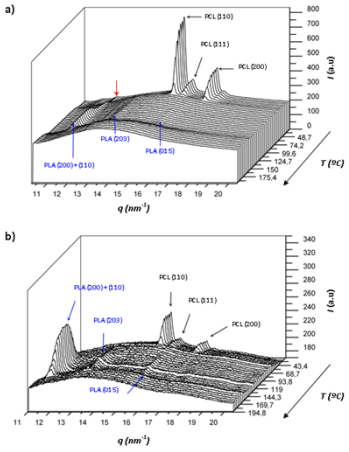
Scanning electron micrographs of electrospun samples revealed that unloaded samples with a high polycaprolactone content had a smooth surface, whereas small cracks were visible when the polylactide ratio increased, probably as a consequence of their higher stiffness. These cracks were predominant in the fiber bends. Triclosan loaded samples were characterized by a rough surface especially samples with a higher PLA content .



DSC heating traces of PCL/PLA-100 (a, b), PCL/PLA-50 (c-e) and triclosan unloaded (a, c, f) and 3 wt-% triclosan loaded (b, d, e, g) PCL/PLA-0 (f, g) samples. The second heating run of a triclosan loaded PCL/PLA-50 sample is shown in (e). Dotted arrows point out PLA enthalpic relaxation peaks.

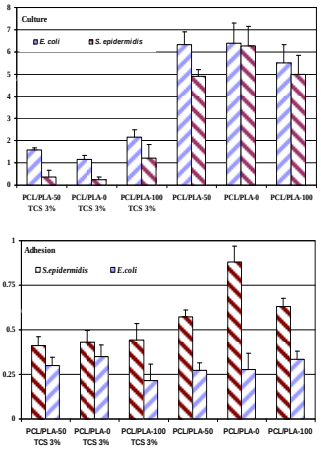


The three-dimensional porous structure of the microfiber mats supported cell adhesion and growth and how it was used by the cells to rapidly colonize the material. It is worth pointing out that cells can be clearly seen inside the material.

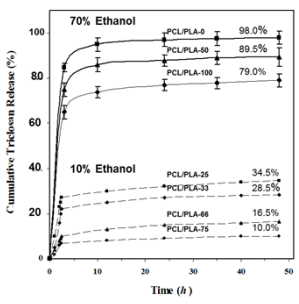


The disappearance of the Bragg reflections of the polycaprolactone crystalline phase and the subsequent cold crystallization process that rendered new Bragg reflections associated with the polylactide phase.

The triclosan release reaches a saturation level that clearly increases with the ethanol percentage in the medium. the release behavior of the electrospun mixtures can be well differentiated as preparations with a higher polycaprolactone ratio have the lowest saturation level.



Antibacterial effect of triclosan released from microfiber mats in E.coli and S.epidermidis.



CONCLUSION

Electrospinning of polycaprolactone and polylactide mixtures from chloroform/acetone solutions rendered microfibers suitable for evaluation of release in a hydrophilic medium and antibacterial effect of a hydrophobic drug such as triclosan.

Both polymers were well mixed, resulting in loss of the characteristic lamellar stacking of the polycaprolactone homopolymer when samples were prepared from mixtures with a polylactide content higher than 25 wt%. The unidirectional fiber orientation induced by electrospinning favored cold crystallization of polylactide during a subsequent heating process

Triclosan was effectively incorporated during electrospinning and affected the thermal behavior and crystallinity of the polycaprolactone and polylactide phases.

Triclosan release experiments performed in hydrophilic media based on Sörensen solutions and under static conditions to reach equilibrium demonstrated that the series of PCL/PLA fibers had an affinity with the drug that could be tuned according to their composition. All studied samples showed a certain tunable antibiocide effect when assayed with *E. coli* and *S. epidermidis* bacteria, which was in agreement with the triclosan release data. The surface of electrospun samples became rough when triclosan was added, resulting in slightly enhanced cell adhesion. Cell proliferation was affected by the triclosan content, which had a toxic effect when it was close to 1%.

Acknowledgements This research has been supported by CICYT and FEDER grants (MAT2009-11503). We are grateful to Drs. François Fauth and Ana Labrador of the CRG BM16 beamline staff of CELLS (Consortium for the Exploitation of the Synchrotron Light Laboratory). We are also grateful to Dr. Trifon Trifonov for FIB micrographs.