Essential oil-loaded coaxial wet-spun fibers for potential wound therapies

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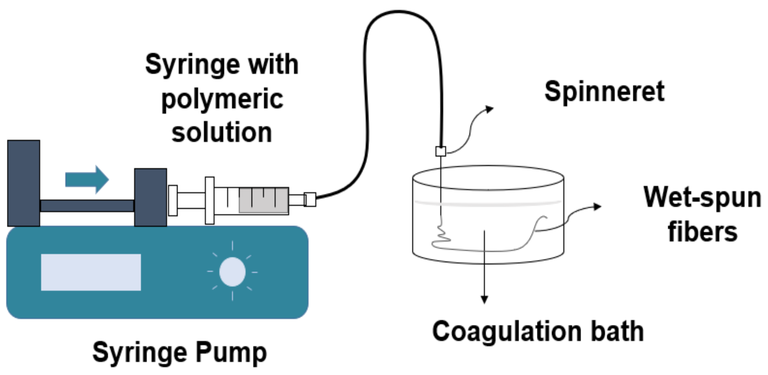
Introduction

Chronic wounds (CWs) can greatly impact the health and quality of the patients' lives. The excessive use of antibiotics has led to a significant development of antibiotic-resistant microorganisms, making it crucial to think of alternative solutions. Considering these issues, a drug delivery system made of coaxial wet-spun fibers loaded with essential oils (EOs) was proposed. Coaxial structures were produced using the wet-spinning technique, in which polycaprolactone (PCL - a synthetic polymer with excellent mechanical properties and elastic behavior) solution was loaded at the core and mixed with three EOs – Clove Oil (CO), Cinnamon Leaf Oil (CLO) and Tea Tree Oil (TTO). The shell was composed of a blend of cellulose acetate (CA - a natural polymer which has been reported to offer good structural integrity) solution, mixed with polyethylene glycol (PEG - a synthetic polymer endowed with high elasticity and porosity), so pores could be opened in the outer layer, allowing for a sustained release of the EOs loaded at the fibers' core. Physical, chemical, thermal and biological characterizations were performed. Results confirmed the potential of the engineered coaxial wet-spun fibers for wound healing applications. Still, further characterization on the fibers is necessary, including cytocompatibility tests to assure non-toxic profiles of the fibers when in contact with fibroblasts and keratinocytes.

Wet-spinning

Technique based on a non-solvent-induced phase inversion process, including a polymeric solution extrusion into a coagulation bath composed by a poor solvent or a non-solvent/solvent mixture to form a coagulating filament that will solidify as a continuous polymeric fiber.

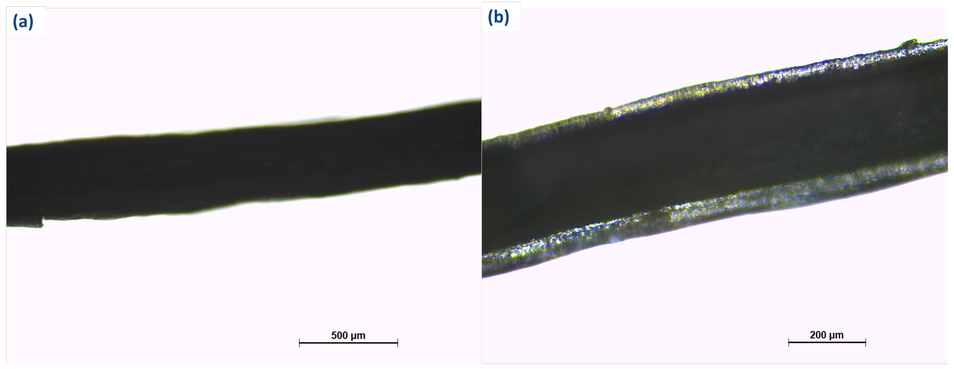


Goal of Each Microfiber Component:
CA: generate porosity and maintain fibers' structural integrity
CO/CLO/TTO: antimicrobial activity
PEG: provide elasticity to the fibers
PCL: maintain fibers' structural integrity

***MBC**: Minimum Bactericidal Concentration

Produced fibers:
- **SA hollow** (core: coagulation bath; shell: SA);
- **SA-NCMC hollow** (core: coagulation bath; shell: SA combined with NCMC);
- **PCL** (core: PCL; shell: coagulation bath);
- **PCL-AAPV** (core: PCL combined with AAPV; shell: coagulation bath);
- **SA-PCL** (core: PCL; shell: SA);
- **SA-PCL-AAPV** (core: PCL combined with AAPV; shell: SA);
- **SA-NCMC-PCL** (core: PCL; shell: SA combined with NCMC);
- **SA-NCMC-PCL-AAPV** (core: PCL combined with AAPV; shell: SA combined with NCMC)

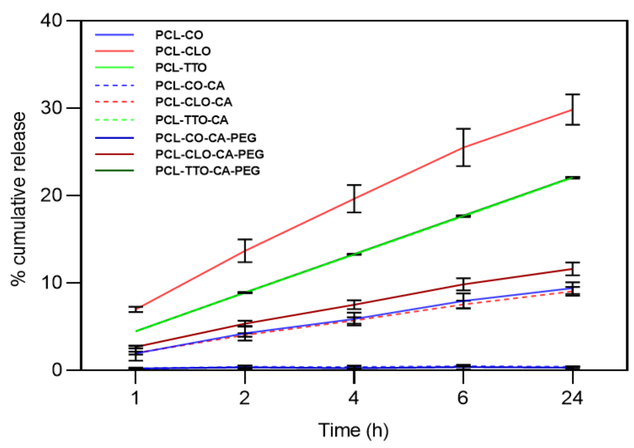
Fibers morphology



Successful production of coaxial system

Figure 1. Microscopic observations of (a) monolayered and (b) coaxial wet-spun fibers.

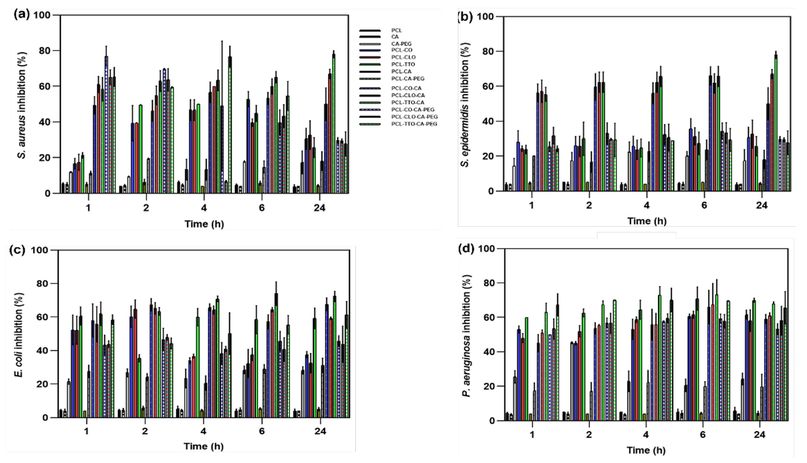
Release kinetics of EOs



All EO-loaded fibers presented controlled and sustained release profiles for the three tested EOs

Figure 2. Cumulative release profile of EO-loaded wet-spun fibers. Data are reported as mean ± SD (n=3).

Antimicrobial activity



All EO-loaded fibers presented antibacterial properties

Figure 3. Percentages of inhibition of (a) *S. aureus*, (b) *S. epidermidis*, (c) *E. coli* and (d) *P. aeruginosa* bacteria in contact with all wet-spun fibers incubated in PBS for 1, 2, 4, 6 and 24 h. Data are reported as mean ± SD (n=3).

Conclusions

The potential of the engineered coaxial fibers to serve as controlled release platforms for CO/CLO/TTO was demonstrated, along with their antibacterial activity against *S. aureus, S. epidermidis, E. coli* and *P. aeruginosa*. Data confirmed the potential of this system to function as a stepwise, pH-triggered delivery platform, suitable for wound healing applications. With this investigation, a step further was taken in establishing wet-spun constructs for drug delivery in CW care.

Acknowledgments

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