

The effect of propolis addition on the physicochemical properties of electrospun polycaprolactone nonwovens

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Statement of Purpose: The properties of some polymers, particularly their biocompatibility and biodegradability, enable them to serve as carriers for active substances or antibiotics. One technique for producing polymeric materials with added active substances is electrospinning, which allows for the production of nonwoven materials. This starting material has high porosity and surface area, which influence the substance's release rate. Using a biocompatible, biodegradable polymer, it is possible to create nonwovens that can be implanted into the human body or directly onto diseased tissue, enabling targeted drug delivery to a specific site. One natural compound with broad-spectrum activity is propolis, which exhibits strong antibacterial, anti-inflammatory, and antioxidant properties. Thanks to its properties, it plays a significant role in tissue regeneration and provides protection against infections. For this reason, propolis is a promising addition to electrospun mats used for wound healing. The aim of the work was to produce and determine the physicochemical properties of electrospun nonwoven fabrics made from poly(ϵ -caprolactone) (PCL) with varying propolis concentrations.

Methods: The research material consisted of four electrospun nonwoven fabrics made of PCL (Capa 6500 by TRiISO, $M_n = 49,000 \pm 2,500$ g/mol) with different propolis concentrations (5%, 10%, 15%) and a control nonwoven fabric made of PCL only. The nonwovens were produced using a TONG LI TL-BM-700 electrospinning machine with a static collector, at a solution flow rate of 20 cm³/h and an electric field strength ranging from 100 kV/m to 2500 kV/m. The intensity was varied to stabilise the process. The ambient temperature was approximately 23 °C during the process.

In work, the surface wettability (SURFTENS UNIVERSAL, OEG GmbH) and absorption (RADWAG MA 50.R moisture analyser) were tested for the produced nonwoven fabrics. The release of the active ingredient from the polymer fibers was examined using an ultraviolet-visible (UV-VIS) spectrophotometer (Thermo Scientific EVOLUTION 220). The nonwoven fabric morphology and fiber diameter were assessed using a scanning electron microscope (FEI Quanta 250 FEG). The nonwoven fabric's thermal stability was determined using differential thermal analysis (DTA) and thermogravimetric analysis (TG) (Netzsch STA 449 F3 Jupiter). The nonwoven fabric absorbency tests were performed after one day of exposure to the PBS (CAPRICORN) solution. The amount of propolis released from the nonwoven fabric into the PBS solution was determined after 1 hour, 1 day, and 3 days.

Results: The resulting nonwoven fabrics were characterised by variable fibre diameters (2.2-4.1 μ m) depending on the propolis content and were hydrophobic. Depending on the propolis content, the contact angle ranged from 100 to 134°. The addition of propolis increased the nonwoven fabric's PBS absorption capacity, ranging from 70% to 455%. After three days of exposure to PBS, the amount of propolis released was dependent on the propolis content in the nonwoven fabric, with values of 6.9 μ g/cm³, 50 μ g/cm³, and 68.8 μ g/cm³ for 5%, 10%, and 15%, respectively. The highest propolis release kinetics were observed after 1 hour. Furthermore, the addition of propolis was observed to affect the thermal stability of the fibres, lowering the initial mass-loss temperature and reducing the mass-loss rate. Increasing the propolis content in polycaprolactone fibres lowers their degradation temperature (420.9 °C – 416.2 °C).

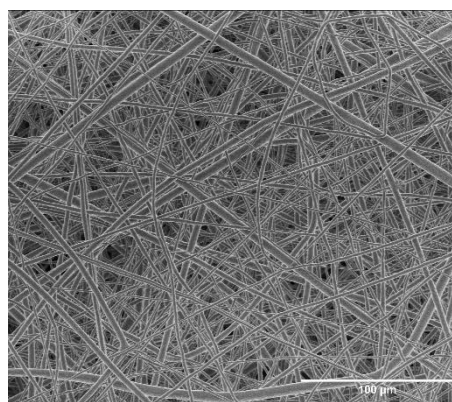


Figure 1. PCL nonwoven fabric with 10% propolis added (SEM)

Conclusions:

- Increasing the propolis content in PCL fibres reduces their diameter.
- The addition of propolis to PCL nonwoven fabrics increases its hydrophobicity.
- Increasing the propolis content in PCL nonwoven fabrics enhances their water-absorption capacity.
- After three days of exposure of nonwoven fabrics containing propolis to a PBS solution, propolis was released only from the fibre surface.
- Propolis lowers the onset temperature of nonwoven fabric mass loss and reduces mass loss during thermal decomposition.

Generally, the results indicate the possibility of using nonwoven fabrics in modern third-generation dressings.