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Optimization of the mechanical properties of biopolymer films by nanofibrous coating

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Introduction & Aim

- Biopolymers from renewable raw materials are a sustainable alternative to polymers from finite raw materials
- Their mechanical properties are often reduced in comparison with crude oil-based polymers
- Here, we prepared biopolymer films from potato starch, corn starch, chitosan, and casein with optimized wet thickness
- Afterwards, all biopolymer films were coated by wire-based electrospinning

→ The composites from biopolymer and nanofibrous coating showed significantly improved tensile strength, as compared to the pure biopolymer, for all materials under investigation

Materials and methods

Materials:

- 4 g isolated potato starch + 50 mL ultrapure water + 2.0 mL 50% glycerol
- 2.5 g corn starch + 50 mL ultrapure water + 2.0 mL 50% glycerol
- 1 g chitosan + 50 mL 2 mol/acetic acid, preparation at T = 50 °C
- 4 g casein + 50 mL ultrapure water + 2 mL 2 mol/L sodium hydroxide + 2 mL 50% glycerol, preparation at T = 50 °C

Film preparation:

- Tests with doctor blades, using different wet layer thicknesses (0.12 mm / 1.02 mm / 3.05 mm)
- The thickest films were used for subsequent mechanical tests

Electrospinning:

- Spinning solution: 16% polyacrylonitrile (PAN) in dimethyl sulfoxide (DMSO)
- Electrospinning in a wire-based machine “Nanospider Lab” (Elmarco)
- Spinning directly on the prepared films (Fig. 1)
- Spinning parameters: voltage 80 kV, nozzle diameter 0.9 mm, relative humidity 32-33%, spinning duration 30 min

Characterization:

- Tensile tests in a universal testing machine (Kern & Sohn GmbH, Balingen-Frommern, Germany) (Fig. 2)

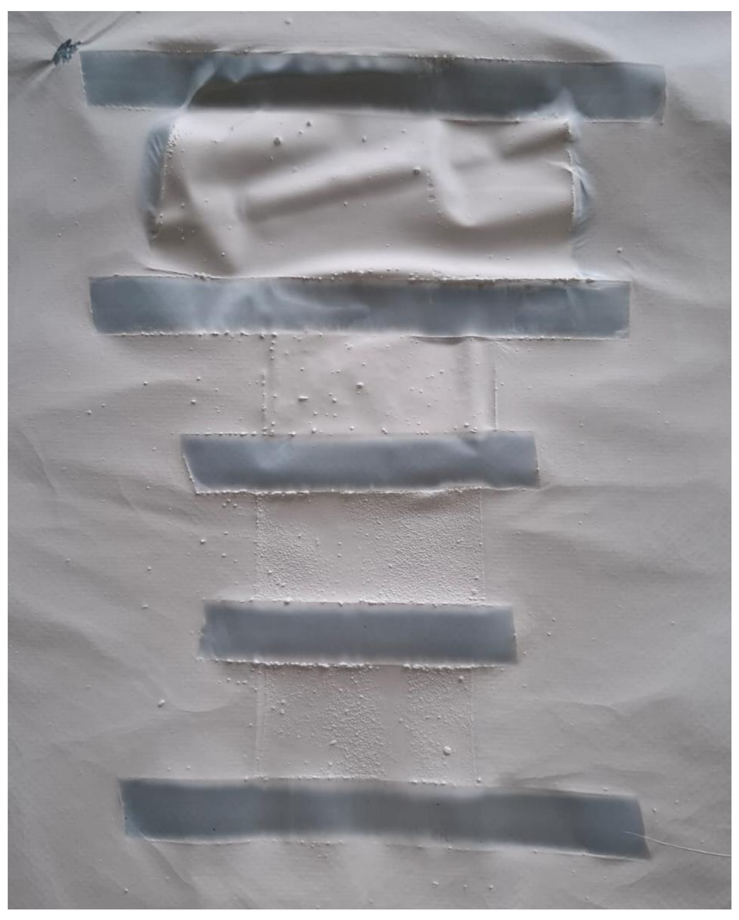

Fig. 1. Films after electrospinning.

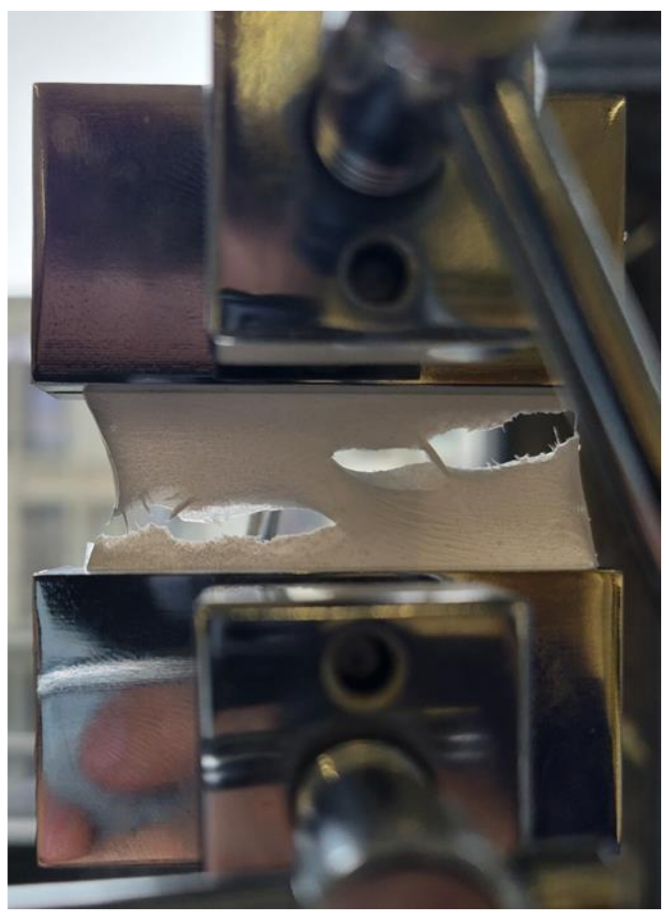

Fig. 2. Tensile testing machine.

Results

Film surfaces:

Fig. 3. Casein film

Fig. 4: Chitosan film

Fig. 5. Potato starch film

Fig. 6 Corn starch film

Mechanical characterization:

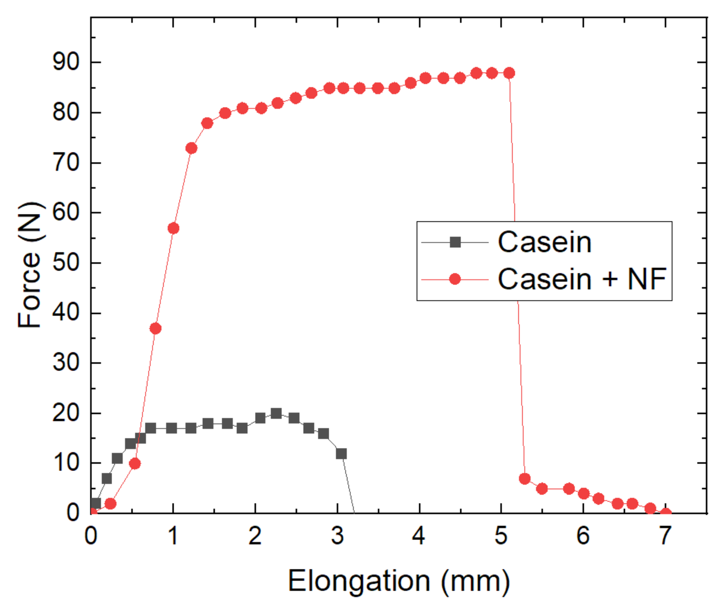

Fig. 7. Casein film

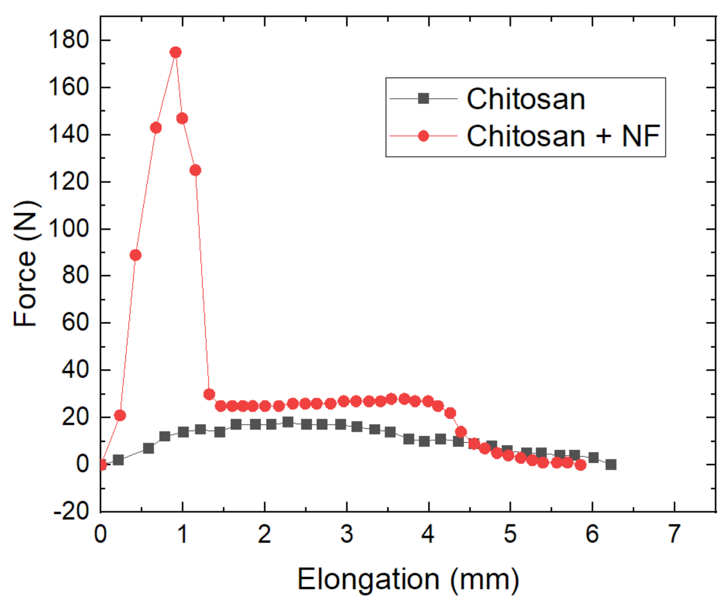

Fig. 8: Chitosan film

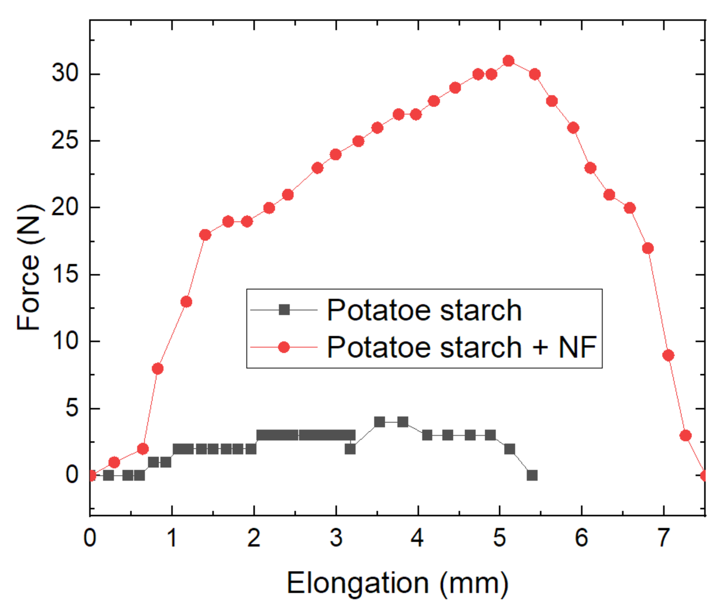

Fig. 9. Potato starch film

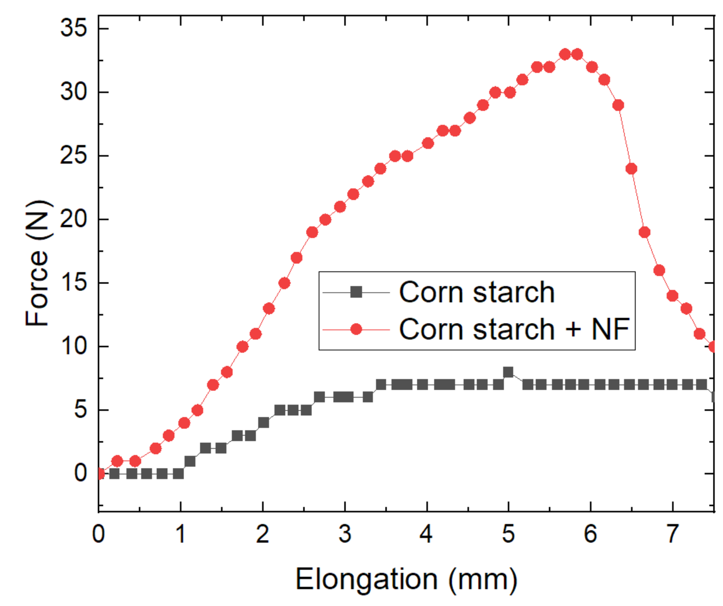

Fig. 10 Corn starch film

Conclusion and Outlook

- Thin films are hard to detach from the substrate without breaking them
- Thicker films showed stronger shrinkage during drying
- Significantly improved tensile strength, as compared to the pure biopolymer, for all materials under investigation

→ Further test with different spinning parameters planned

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