Polysaccharide-based biodegradable films for agricultural mulching

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In the last 20 years, the global population has blowout growth from 6.0 billion to 7.2 billion and will reach over 8.0 billion around 2046 [1]. Consequently, food shortage has drawn attention, and the demand for agricultural products has increased annually. To meet this need, the excessive and prolonged use of mulching films based on low-density polyethene resulted in significant environmental pollution events, leading to serious side effects on human health [2]. Due to the thickness of the plastic film and the difficulty of recovery, some mulch films were discarded in agricultural soils intentionally or unintentionally. Mulch film residue is a direct source of farmland meso- and microplastics (MMPs), which constitute a global environmental issue, as they accumulate even in the food chain [3]. MMPs' further degradation into nanoscale particles can endanger human health [4]. To provide agricultural sustainability, there is a great interest in developing biodegradable bio-based polymeric films for agriculture mulching, which can be tilled directly into the soil after use. Based on the above issues, this study aims at (i) the preparation and characterisation of biodegradable bio-based composite films and (2) their enrichment with plant nutrients, which could be efficiently released into the water to sustain their application as mulch films on the soil.
Sodium carboxymethyl cellulose (CMC), chitosan (CS) and sodium alginate (SA) were combined in the presence of glycerol as a plasticiser to produce composite films by solvent casting. Composition (i.e., concentrations and mass ratios between the precursors) and cross-linking agent ($CaCl_2$) effects on films' properties were evaluated. In the first stage, we investigated the structure of the formed films through Attenuated Total Reflection Fourier Transform Infrared (ATR-FTIR) spectroscopy, the thermal and mechanical properties by thermogravimetric analysis (TGA) and dynamic mechanical analysis (DMA), and some water-interaction properties (degree of swelling and solubility in water). This approach allowed identifying the best quality films, which were enriched with $NH_4H_2PO_4$, as N and P are generally the most deficient nutrients in the soil. Moreover, the release kinetics in the water of this salt was studied. The latter aspect is of great importance as the release of N and P helps to improve the nutrient supply to the soil, thus reducing the use of synthetic fertilisers.

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