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Properties Optimization of Keratin Films Produced by Film Casting and Compression Moulding

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Abstract : Every year ~6 million tonnes of feathers are produced globally. Due to feathers' low density and possible contamination with pathogens, their disposal causes health and environmental problems. The extraction of keratin, which represents >90% of feathers' dry weight, could offer a solution due to its wide range of applications in the food, medical, cosmetics, and biopolymer industries. One of these applications is the production of biofilms which can be used for packaging, edible films, drug delivery, wound healing etc. Several studies in the last two decades investigated keratin film production and its properties. However, the effects of many parameters on the properties of the films remain to be investigated including the extraction method, crosslinker type and concentration, and the film production method. These parameters were investigated in this study. Keratin was extracted from chicken feathers using two methods, alkaline extraction with 0.5 M NaOH at 80 °C or sulphitolysis extraction with 0.5 M sodium sulphite, 8 M urea, and 0.25-1 g sodium dodecyl sulphate (SDS) at 100 °C. The extracted keratin was mixed with different types and concentrations of plasticizers (glycerol and polyethylene glycol) and crosslinkers (formaldehyde (FA), glutaraldehyde, cinnamaldehyde, glyoxal, and 1,4-Butanediol diglycidyl ether (BDE)). The mixtures were either cast in a mould or compression moulded to produce films. For casting, keratin powder was initially dissolved in water to form a 5% keratin solution and the mixture was dried in an oven at 60 °C. For compression moulding, 10% water was added and the compression moulding temperature and pressure were in the range of 60-120 °C and 10-30 bar. Finally, the tensile properties, solubility, and transparency of the films were analysed. The films prepared using the sulphitolysis keratin had superior tensile properties to the alkaline keratin and formed successfully with lower plasticizer concentrations. Lowering the SDS concentration from 1 to 0.25 g/g feathers improved all the tensile properties. All the films prepared without crosslinkers were 100% water soluble but adding crosslinkers reduced solubility to as low as 21%. FA and BDE were found to be the best crosslinkers increasing the tensile strength and elongation at break of the films. Higher compression moulding temperature and pressure lowered the tensile properties of the films; therefore, 80 °C and 10 bar were considered to be the optimal compression moulding temperature and pressure. Nevertheless, the films prepared by casting had higher tensile properties than compression moulding but were less transparent. Two optimal films, prepared by film casting, were identified and their compositions were: (a) Sulphitolysis keratin, 20% glycerol, 10% FA, and 10% BDE. (b) Sulphitolysis keratin, 20% glycerol, and 10% BDE. Their tensile strength, elongation at break, Young's modulus, solubility, and transparency were: (a) 4.275±0.467 MPa, 86.12±4.24%, 22.227±2.711 MPa, 21.34±1.11%, and 8.57±0.94* respectively. (b) 3.024±0.231 MPa, 113.65±14.61%, 10±1.948 MPa, 25.03±5.3%, and 4.8±0.15 respectively. A higher value indicates that the film is less transparent. The extraction method, film composition, and production method had significant influence on the properties of keratin films and should therefore be tailored to meet the desired properties and applications.

Keywords : compression moulding, crosslinker, film casting, keratin, plasticizer, solubility, tensile properties, transparency
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