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Development and characterization of biodegradable films of cornstarch filled with methylcellulose and gelatin

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Synthetic plastics play a vital role in many applications such as packaging, electrical, electronics, medical, textiles, furniture, and structural applications due to desirable properties like light-weight, high strength, flexibility, and chemical inertness. However, when the products made from many synthetic plastics are discarded to the natural environment it takes a very long time for degradation. This results in environmental pollution. Therefore, the use of biodegradable plastics in place of non-degradable plastics has gained significant interest as one of the main plastic waste management methods. However, biodegradable plastics such as starch and Polylactic acid do not show desired mechanical properties. In this research, it was expected to synthesize biodegradable films with improved mechanical properties using cornstarch (CS) filled with methylcellulose (MC). Microcrystalline cellulose (MCC) was extracted from cotton fibers through alkali treatment and bleaching, followed by sulphuric acid hydrolysis. Then, MCC was converted to MC using dimethyl sulfate in the presence of acetone as the solvent. This conversion was analyzed by Fourier transform infrared spectroscopy (FTIR). Their FTIR spectra showed significant differences in the regions 2960-3650 cm^{-1}, 2780-2950 cm^{-1}, and 960-1160 cm^{-1}, which indicates that the conversion has occurred. The degree of substitution of the methyl group for H in MCC was determined by an acid-base titration and the resulting value was 1.36 ± 0.02. Then, an aqueous solution of MC (0.5 g/100 mL) was prepared. In the presence of water, CS (4% w/v) was dissolved in different amounts of the prepared MC solution in order to have six solutions with the ratio of MC to CS as 0.00%, 0.625%, 1.25%, 3.125%, 6.125%, 12.125% (w/w). Acetic acid (1% v/v) was added to all these solutions. Afterwards, two series of solutions, series 1 and 2, were prepared by mixing 1% and 2% (v/v) of glycerol, respectively, into the resulting solutions. Similarly, the third series was prepared by mixing glycerol (1% v/v) and gelatin (1% w/v). Three series of films were prepared using these solutions following the casting method. The dried films were characterized on physical, chemical, mechanical, and thermal properties. The film with 0.625% (w/w) MC in series 3, showed the highest tensile strength of 14.06 MPa. Films with MC-1.25% (w/w) in each series showed the lowest water absorptivity, swelling, and solubility properties. All the films produced were transparent. The films tend to twist and swell when treated with chemicals such as NaOH, HCl, NaCl, and ethanol. Also, the transparency of some of the films was reduced after this chemical treatment. FTIR analysis, thermo-gravimetric analysis, and differential scanning calorimetry were performed on the films having optimum properties. These films showed thermal degradation between 323-335 °C, melting temperatures between 267-293 °C, and glass transition temperatures between 84-120 °C. The biodegradability of films was determined by performing a soil burial test. After three months, the films had disappeared. It can be concluded that the biodegradable films developed in this study have the potential to replace polyethylene in some short-term packaging applications.

Keywords: Biodegradable, Cornstarch, Gelatin, Methylcellulose, Packaging films