Effect of citric acid induced substitution and crosslinking on physicochemical properties of corn starch and its applications on active starch film making

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Abstract

The objective of this study is to investigate the effect of citric acid (CA) combining heat-moisture treatment on the physicochemical properties of normal corn starch (NS). The NS was modified with CA with various concentrations (0, 10 and 20%) at either pH 2.5 or 4.5 under two-stage heating process. A low temperature heating process at 60 ℃ for various time periods (0, 4, 6 and 8 hr) was first applied to the starch slurry (20%), followed by dry-heating at relatively high temperatures (130, 140 and 150˚C) for 1.5, 3.0 and 5.0 hr. The results of pasting properties analyzed with rapid-visco analyzer (RVA) indicated that the desirable reaction condition for the first stage is heating NS at 60˚C with 20% CA at pH 4.5 for 4 hr. Under this condition, the peak viscosity (PV) was relatively high due to the substitution of CA without serious degradations of starch molecules. As the heating temperature and time period of the second dry-heating stage increased, the PV dramatically decreased, which was attributed to the elevation of cross-linking degree. This was also evidenced by the results of Fourier transform infrared spectrometer (FTIR) that the ester bonds were detected around 1720 cm-1 and the increase of the values of degree of di-esterification (DDE). The solubility and swelling power of CA-modified corn starch decreased with the increase of DDE. The thermal properties obtained from differential scanning calorimeter (DSC) and X-ray diffractometer

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(XRD) patterns suggested that the alteration of the internal structure and physicochemical properties of modified starch with various degrees of mono- and di-esterification affected crystallinity. To enhance the amount of solubles in film forming solutions, 0.5 and 1.0 meq of NaOH were added during gelatinization. The results of mechanical properties of starch film indicated that the Young' s modulus, tensile strength and elongation at break decreased with the increase of DDE because the CA-modified corn starches with newly-formed ester bonds tended to be large molecules, which hindered the entanglement of dissolved starch molecules while film forming. The lower water vapor permeability values were obtained when the films made of CA-modified corn starches with higher DDE, which was attributed to the replacement of hydrophilic hydroxyl groups with hydrophobic ester groups.

Keywords: citric acid; corn starch; two-stage heating process; substitution; cross-linking.