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Functional Properties of Corn Starch Treated with Corona Electrical Discharges

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Summary: Starch is one of the biopolymers widely used as a raw material in various industries, its usage being based on its functional properties. Corona electrical discharges treatment is one of the newest methods among the physical methods to modify starch. Thus, the paper deals with the behavior study of some functional properties of corn starch exposed to corona electrical discharges. The apparent viscosity of corn starch increased while the solubility, gel consistency and clarity of pastes have been reduced with the increase of exposure time.

Keywords: biopolymers; corona; crosslinking; functional properties; modification

Introduction

Starch is one of the biopolymers widely used as a raw material in several fields such as food, pharmaceutical, paper, textile and other industries.[1] It is used both in its native and modified form and the usage of them is based on the functional properties as viscosity, freeze-thaw stability, gel consistency and paste clarity. The plasma discharge treatment is one of the newest methods among the physical methods to modify starch. Worldwide there were initiated studies on starch using various plasma discharges with different time exposure; the results showed that the starch became highly crosslinked[2] or depolymerized to dextrins with various molecular weights[3,4] depending on the experimental conditions (atmosphere, pressure, time exposure, etc.). In this paper we have proposed to study the behavior of some functional properties of corn starch exposed to corona electrical discharges (CED) mainly taking into account that this method can be a facile tool to treat starches.[4]

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Methodology

Material

Corn starch purchased from the Romanian market was used for the experiments.

Exposure to Corona Electrical Discharges

The experiments were carried out in a special set-up for repetitive pulsed electrical discharges which operated with the current intensity of 60 A. The electrical pulses had 25 kV amplitude and 50 Hz pulse repetition frequency with pulse duration of 100 ns. The exposure times were: 5, 10 and 30 min.

Determination of the Solubility

Starch was dispersed in water at room temperature (25 °C) by stirring for 30 min and the mixture was centrifuged ($1200 \times g$/15 min), and then the supernatant was collected. The supernatant was evaporated at 130 °C and weighed. The solubility was the ratio in weight of the dried supernatant to the initial weight of the starch.

Gel Consistency Measurement

Gel consistency determination was carried out according Tang method cited by Wu.[5] Gel consistency was measured for cold starch pastes 5% in 0.2 N KOH solution as the length of the cold gel in a test tube held horizontally for 1 hour.

Apparent Viscosity Determination

Rheoviscosimetric measurements were carried out on 5% corn starch suspensions using a rotational HAAKE VT® 550 viscometer at different shear rates (0–541 s^{-1}). The apparent viscosity (η_a) was measured at different temperatures: 25, 55, 75 and 95 °C.

Determination of Paste Clarity

Paste clarity was determined for 1% aqueous dispersions of starch and expressed as transmittance (%T) at wavelength of 640 nm. The measurements were carried out in a Cary 100 Bio spectrophotometer and were repeated after 24, 48 and 72 hours for the same samples stored at room temperature.

Freeze-Thaw Stability

Freeze-thaw stability was measured on 1% aqueous starch pastes and expressed as the absorbance measured at wavelength of 700 nm before each freeze-thaw cycle. The freeze-thaw process consists of 18 hours storage in a freezer, followed by 6 hours storage at room temperature.

The data reported are average of duplicate measurements, except freeze-thaw stability determination.

Table 1.
Solubility and gel consistency of corn starch as a function of CED exposure time.

Exposure time	Solubility	Gel consistency
min	%	cm
0	4.62 ± 0.34	11.60 ± 0.14
5	3.05 ± 0.12	10.65 ± 0.07
10	2.01 ± 0.10	10.05 ± 0.07
30	1.98 ± 0.20	9.95 ± 0.21

Results and Discussion

The solubility at room temperature represents non-sedimented starch. Native corn starch showed about 4% solubility and this low value could be attributed to the more rigid structure of the corn starch.[6] The CED treatment had effect on the soluble fraction of the starch and this can be observed from the solubility of CED treated starch which decreased slowly with the increase of the time exposure (Table 1).

Also, the treatment with CED of the corn starch lead to the changes in gel consistency (Table 1) which decreased in the same manner as the solubility.

Native corn starch is non-Newtonian flow type for shear-thinning fluids (Fig. 1). The CED treatment of starch did not

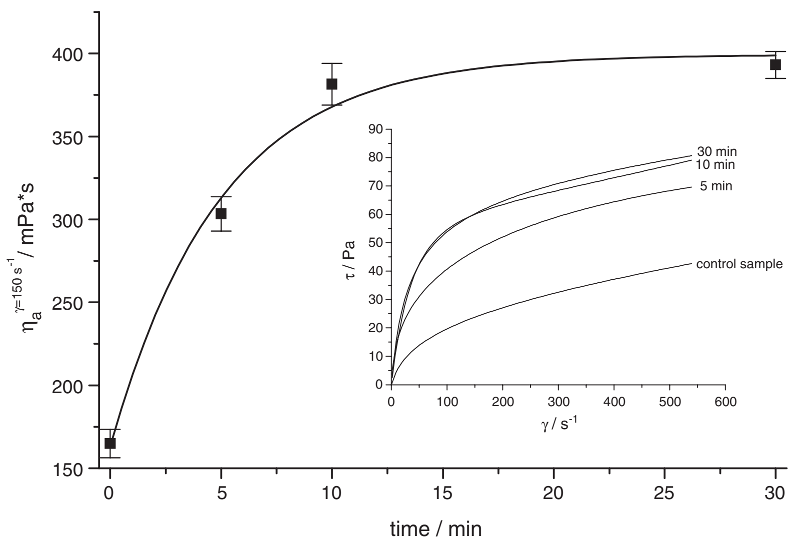

Figure 1.
Rheoviscosimetric behavior of native and treated corn starch.

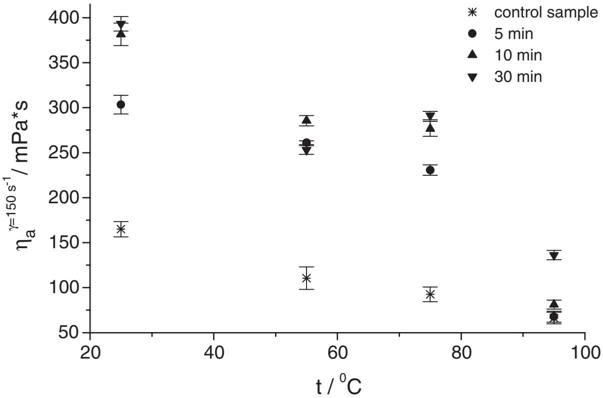

Figure 2.
Apparent viscosity of native and treated corn starch vs. temperature.

modify the behavior fluid even after 30 min exposure, but the apparent viscosity of the starch pastes increased exponentially with the increase of exposure time (Fig. 1). However, after 15 min exposure did not appeared significant changes in viscosity value. The increase of the apparent viscosity suggests that the starch suffered a crosslinking phenomenon.

Both of the native and CED treated starch showed an unstable apparent viscosity with the increase of the temperature. Thus, we observed that the viscosity decreased significantly with the increase of the temperature and this behavior appeared to all samples (Fig. 2).

The clarity value of native corn starch paste was about 7%. Immediately after CED treatment of starch, the clarity of the pastes was insignificantly lower than that of control sample. During storage time, the clarity value increased spectacularly for control sample; the clarity value after 48 hours from preparation was approximately 39%. A similar behavior presented the CED treated starch samples (Fig. 3) but

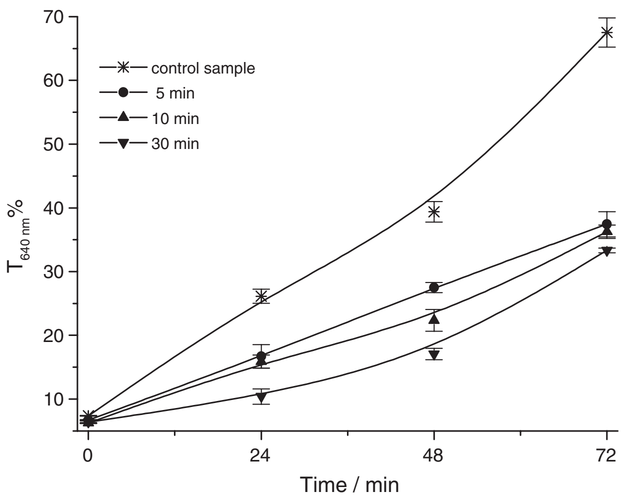

Figure 3.
Clarity of native and treated corn starch pastes.

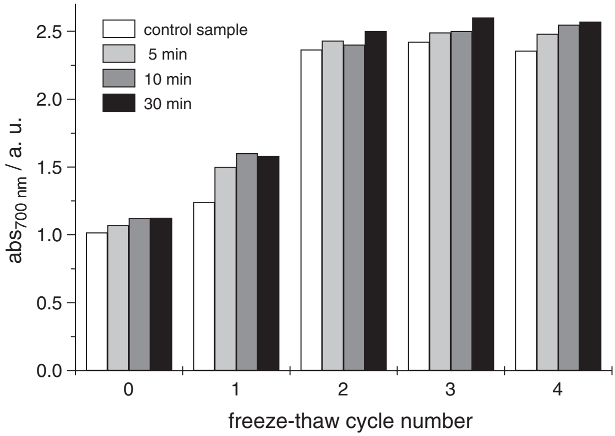

Figure 4.
Freeze-thaw stability of native and treated corn starch pastes.

without so spectacularly increase. Therefore, the clarity of CED treated starch pastes showed instability during storage time. The results of clarity were correlated with the solubility and we could notice that as more soluble was the sample, more transparent the paste.

The behavior of native starch as well as CED treated starch pastes in freeze-thaw process showed the instability by the increase of the absorbance (Fig. 4). This aspect could be caused by retrogradation of either the amylose and/or amylopectin.[7]

Conclusion

Some functional properties of corn starch can be modified by corona electrical discharges. Thus, apparent viscosity of corn starch can be increased probably due to the crosslinking which occurs by CED treatment. Solubility, gel consistency and clarity of the corn paste were reduced with the increase of exposure time. The CED treatment did not modify the behavior of corn starch during the freeze-thaw process. Further studies on structural characteristics of corn starch treated by will be performed in order to understand better the changes which occur in its functional properties.

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