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Analysis of thermal pasting profile in corn starch rich in amylose and amylopectin: Physicochemical transformations, part II

Natalia Rincón-Londoño[a], Beatriz Millan-Malo[b], Mario E. Rodríguez-García[b,*]

[a] Posgrado en Ciencias e Ingeniería de Materiales, Centro de Física Aplicada y Tecnología Avanzada, Universidad Nacional Autónoma de México, Campus Juriquilla, Querétaro, Qro, C.P 76230, Mexico
[b] Departamento de Nanotecnología, Centro de Física Aplicada y Tecnología Avanzada, Universidad Nacional Autónoma de México, Campus Juriquilla, Boulevard Juriquilla No. 3001 C.P. 76230, Juriquilla, Querétaro, A.P. 1-1010, Mexico

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ABSTRACT

This work focused on the study of the behaviors of the apparent viscosity profiles of isolated corn starches rich in amylose and amylopectin, through the physicochemical and morphological changes that take place during the thermal profile and the gel formation. Frozen dry samples were studied at different stages along the pasting profile. Changes in the structural properties of the samples were studied using X-ray diffraction, and the morphological changes were followed using scanning electron microscopy, differential scanning calorimetry was used to analyze the thermal changes. The changes in the pasting profile (curve of apparent viscosity) were associated with structural, thermal, and morphological changes of the starch-water suspension. From the results obtained, a new interpretation of the parameters measured with the pasting profile is introduced. In this work does not show evidence of retrogradation at the end of the cooling process for starch rich in amylopectin and that starch rich in amylose does not develop viscosity.

1. Introduction

Starch is an ingredient used in the food industry, and the most important applications are as agent thickening, gelling, colloidal stabilizer, bulking agent, water retention agent and adhesive [1,2]. For use of starch in food products, is important the understanding of the physicochemical and structural properties, such as thermal resistance, decomposition and tendency to retrogradation [3]. But so far, there exists a controversy about the changes that take place during a pasting profile of corn starch from different sources as well as starches with different composition regarding amylose and amylopectin.

When starch granules are in contact with water and these are heated, the starch swelling, as well as changes in the morphology, play a significant role in the rheological properties of the starch-water suspension. These properties are also affected by the amylose/amylopectin ratio in starch granules [3–5]. The behavior of the pasting profile varies according to the source, and amylose/amylopectin ratio of the starch. Blazed and Copeland [6] reported the difference between the pasting profiles of three wheat starches: waxy (2% amylose content), normal (34% amylose), and high amylose (43%). They described the characteristic process of the starch granules in water applying heat and shear rate, but they did not take into account the structural and morphological changes during the pasting profiles of the studied starches, to explain their different behaviors.

In the previous work (see part I), it was studied in detail the structural, morphological, and thermal changes that take place during a pasting profile. It was performed an interpretation of the phenomena that occur in the starch-water suspension as a result of the heating and shear rate. In this study, the pasting profile for corn starch rich in amylopectin (18% amylose content) and corn starch rich in amylose (38% amylopectin) are carried out.

The objective of this work was to study the structural, morphological and thermal changes that take place during a pasting thermal profile of isolated starches rich in amylose and amylopectin, and to explain the changes observed in the pasting profile as a function of the starch composition (amylose/amylopectin ratio).

* Corresponding author.
E-mail addresses: marioga@fata.unam.mx, mariorodga@gmail.com (M.E. Rodríguez-García).

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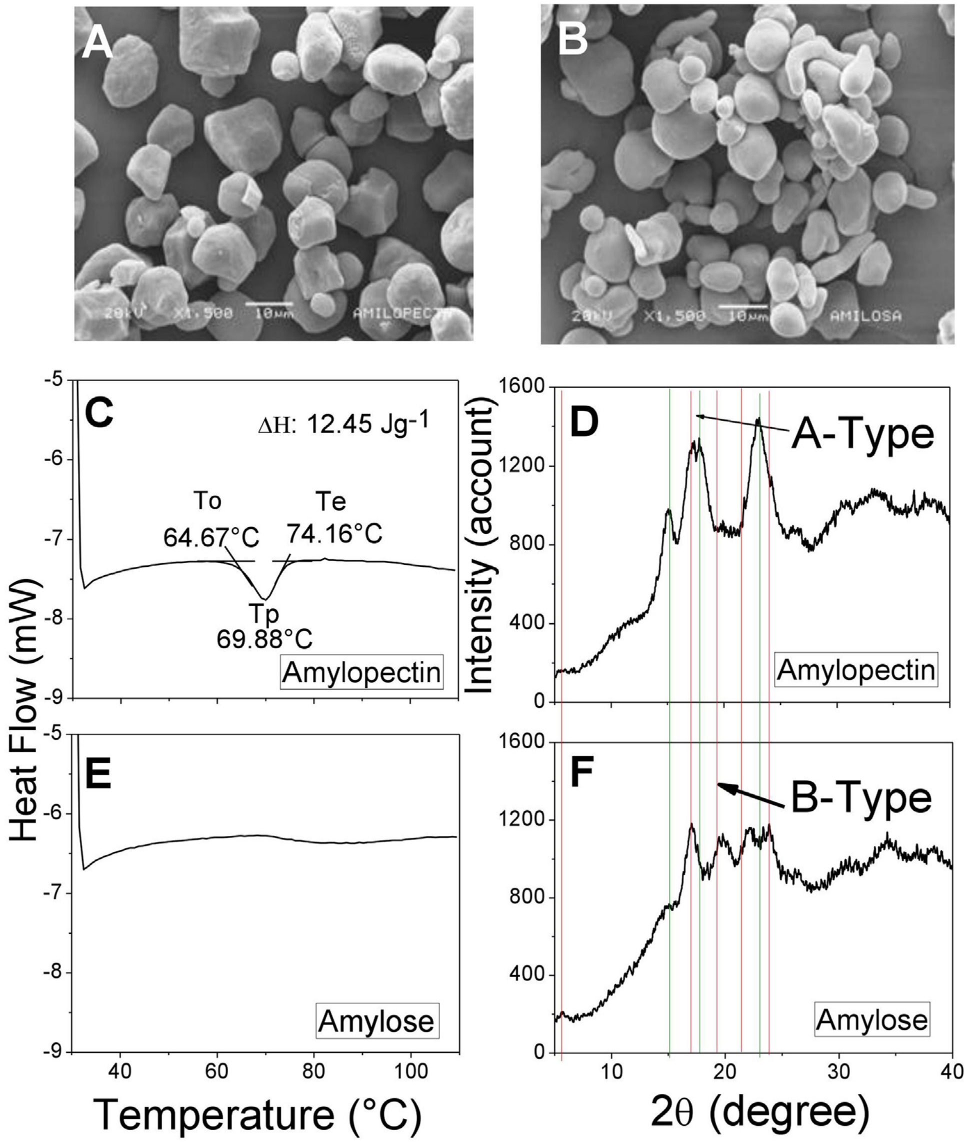

Fig. 1. (A) and (B) SEM images of isolated corn starch rich in amylopectin and amylose, respectively; (C) and (E) thermal profile of isolated corn starch rich amylopectin and amylose, respectively; and (D) and (F) shows their diffraction patterns.

2. Material and methods

2.1. Materials

The samples used to study the pasting profile were: Amylopectin (pcode: 100952946) and Amylose (lot: 64H1025, A-7043) from Sigma-Aldrich (Germany). Fig. 1(A) and (B) shows the SEM images of starches rich in amylopectin and amylose respectively, taken at 1500×. Corn starch rich in amylopectin is characterized by an irregular polyhedral morphology and some spherical granules between 4–12 μm. Granules with spherical and tubular morphology between 4–15 μm are forming the starch rich in amylose. Through direct inspection of these images, it is evident that amylose and amylopectin (Sigma-Aldrich) are in fact, starches rich in amylose and amylopectin. For starch rich in amylose the proximate analysis was: 0.60 ± 0.08% protein, 0.22 ± 0.06% fat and fiber was not detected. For starch rich in amylopectin 0.33 ± 0.05% protein and 0.22 ± 0.04% fat, and fiber was not detected. Fig. 1(C) and (E) shows the thermograms of amylopectin and amylose. In the case of corn starch-water suspension, there is a characteristic endothermic transition called gelatinization. For amylopectin (corn starch rich in amylopectin) it was found T_o = 64.67 °C, T_p = 68.88 °C, and T_e = 74.16 °C while for starch rich in amylose, this transition was not found.

Fig. 1(D) and (F) shows the X-ray diffraction patterns of amylopectin and amylose that are taken as references to study the structural transformation in these samples, as a result of a thermal process during the pasting profile. According to this analysis the starch rich in amylopectin (Fig. 1(D)) shows a semi-crystalline phase, that corresponds to the A-type reported in the PDF# 43-1858 [7], while amylose (Fig. 1(F)) presents a B-type reported in the PDF# 31-1536 [8].

2.2. Measurement of pasting profile

The pasting profiles of the starch aqueous suspensions were determined using a starch cell of an Anton Paar model MCR 102 rheometer (St Albans, United Kingdom). The starch was adjusted to 12% moisture content. 3 g of starch and 18 ml of distilled water were used for the pasting profile that was carried out under the following conditions: Initially, the temperature of the system was 50 °C, and it remained constant for 1 min. The sample was heated