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RHEOLOGICAL BEHAVIOUR OF SOME STARCHES TREATED WITH ELECTRON BEAMS

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Abstract
The aim of the paper is to discuss the influence of the electron beam irradiation on the rheological behaviour of the rice, potato and maize starches. The rheological behaviour of the starches was studied before and after electron beam irradiation with doses up to 50 kGy. The shear stress (τ) and apparent viscosity (η_a) of the gelatinised suspensions were analysed at different shear rates ($\dot{\gamma}$) and irradiation doses (D), by using a rotational viscometer HAAKE VT® 550 with co-axial cylinder NV. The results showed the electron beam treatment lead to the changes in the rheological behaviour as the reduction of the apparent viscosity.
Keywords: ionizing radiation, starch, apparent viscosity.

1. Introduction

Starch is the most important natural biomacromolecule and it is used in various applications such as food, pharmaceutical, textile and adhesives industry, etc [1-3]. Lately there are studied different new processes to modify native starches in order to improve its qualities [1, 4-6] and consequently to extend their industrial applications. Taking into account that electron beam irradiation is a well-known method to modify polymers [7], the purpose of this paper is to discuss the effects of the electron beam irradiation on the rheological behaviour of some starches with different origin sources. These effects are studied in order to obtain a better understanding of the radiation influence on starch.

2. Method and samples

Potato (moisture of 14.9%), rice (moisture of 13.4%) and maize (moisture of 10.9%) starches were used for the experiments. Moisture content measurement was carried out at 105^0 C for 90 min using a Denver IR-200 moisture analyser.

Electron beam (e-beam) irradiation has been performed by a linear accelerator facility (electron beam mean energy 6 MeV) at room temperature and atmospheric pressure. The samples were irradiated in plastic boxes with doses up to 50 kGy.

Rheoviscosimetric measurements were carried out using a rotational HAAKE VT® 550 viscometer with co-axial cylinder NV at different shear rates in the range of 0 – 541 s^{-1}. Starch suspensions, 5% concentration, was cooked for 30 min and then cooled to 25^0 C for 1 hour. Apparent viscosity and its stability in time were measured at 25^0 C at 5, 10, 20 and 30 min after the first measurement. Apparent viscosity was determined also at different temperatures (55, 75 and 95^0 C) to evaluate its behaviour with the temperature increase.

3. Results and Discussion

The rheological analysis showed the modification of the main rheological parameters, the shear stress and apparent viscosity, with the irradiation dose.

The studied starch pastes showed non-Newtonian flow type characteristic for shear-thinning fluids (Fig. 1). This behaviour became obviously Newtonian after 10 kGy irradiation for potato starch (Fig. 1a) and after 20 kGy and 30 kGy for rice starch (Fig. 1b) and maize starch (Fig. 1c), respectively.

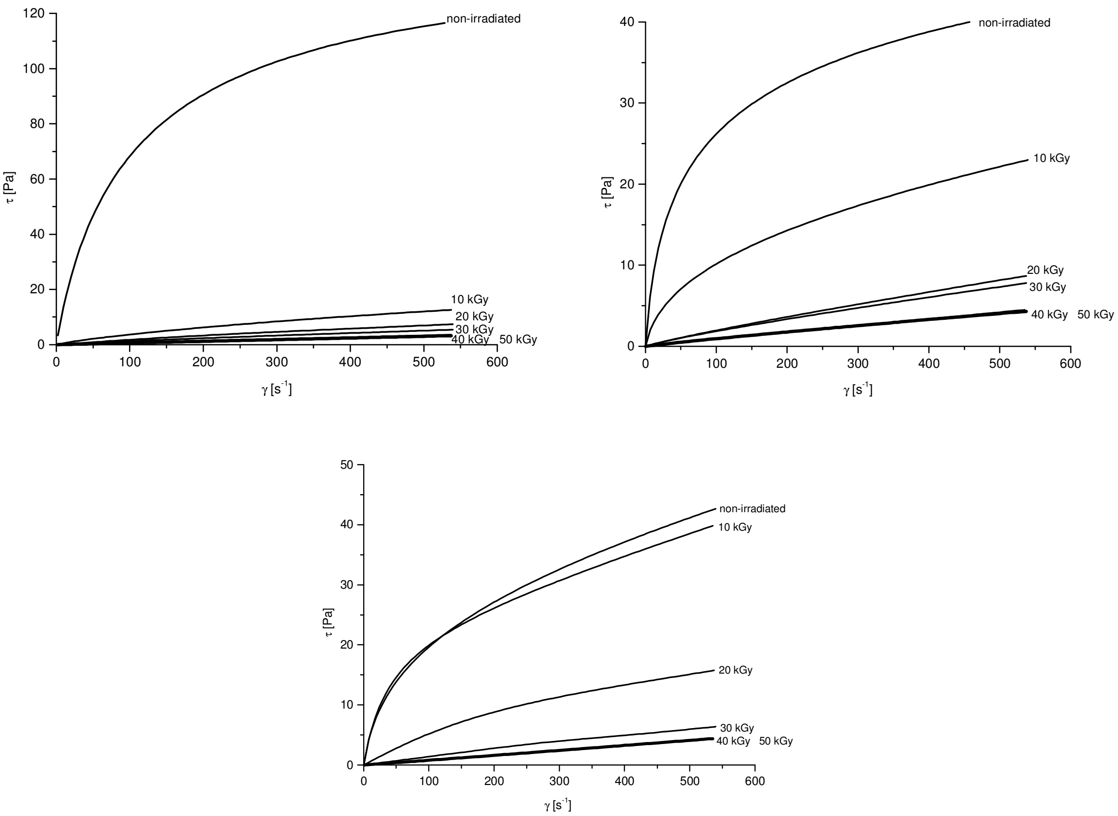
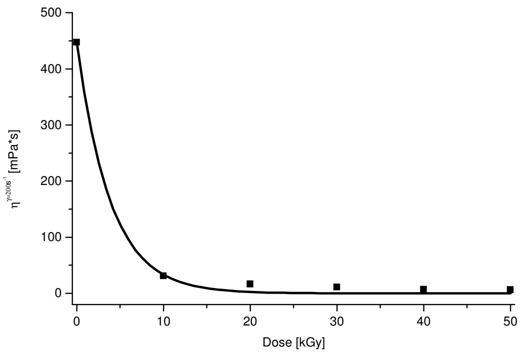


Fig. 1. Flow curves for (a) potato, (b) rice and (c) maize starch pastes

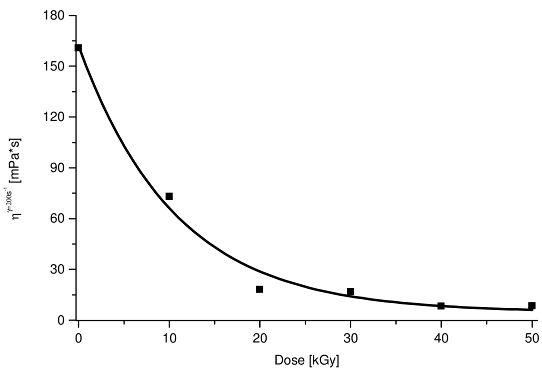
The apparent viscosity of the potato starch paste, which is the highest in the studied starch viscosities, decreased dramatically after 10 kGy irradiation (Fig. 2a). However, no important changes were noticed at high irradiation doses.

The apparent viscosity of the rice starch paste decreased with the increase of irradiation dose (Fig. 2b). The viscosity decrease has been smooth in comparison with that of the potato starch.

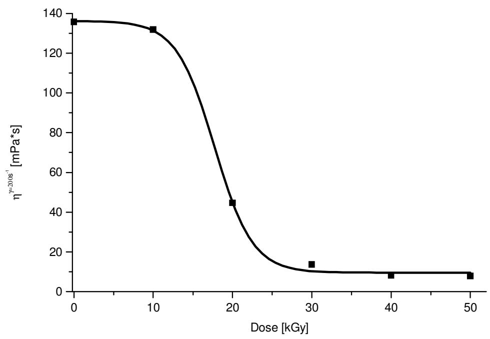
In the case of the maize starch, it was observed a different behaviour in comparison with the other two studied starches. Thus, the irradiation with 10 kGy did not cause any significant change of the viscosity, but the viscosity value decreased drastically after 20 kGy irradiation.



a



b



c

Fig. 2. Apparent viscosity for (a) potato, (b) rice and (c) maize starch pastes

These results suggest that the molecular structure of the starch plays an important role in this behaviour and a depolymerization of this structure appears by irradiation.

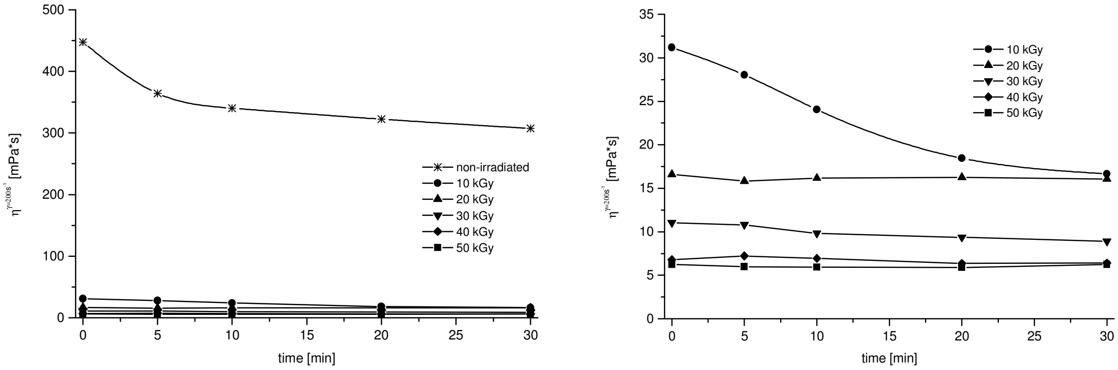
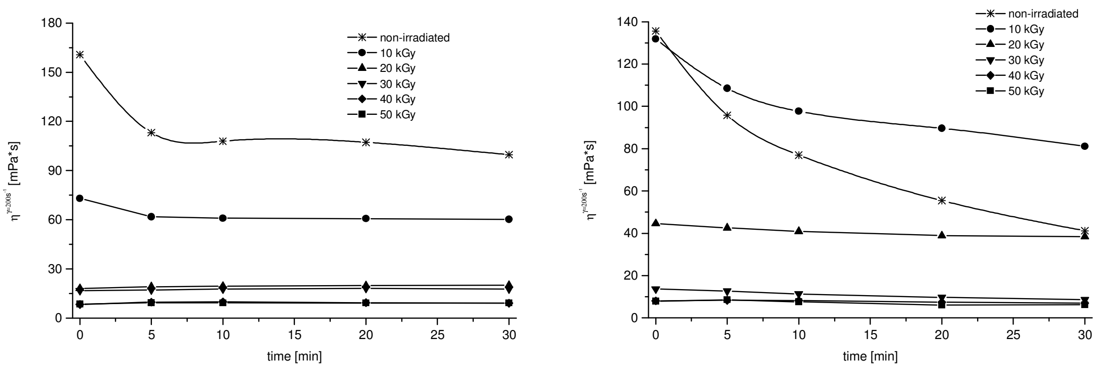


Fig. 3. Apparent viscosity vs. time for potato starch paste

The apparent viscosity of the native starches at 25^0 C decreased in time (Figs. 3 and 4) indicating no stability of the suspension viscosity. E-beam irradiation with doses higher than 20 kGy led to the stabilization of the apparent viscosity in time for all three starches.



a   b

Fig. 4. Apparent viscosity vs. time for (a) rice and (b) maize starch pastes

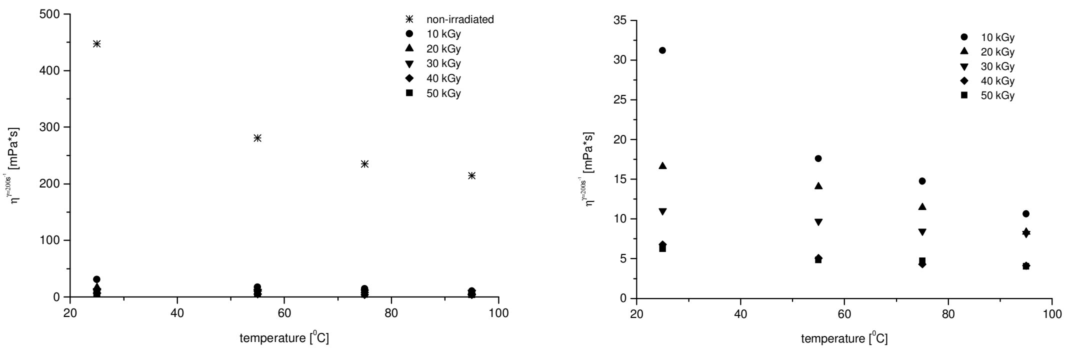
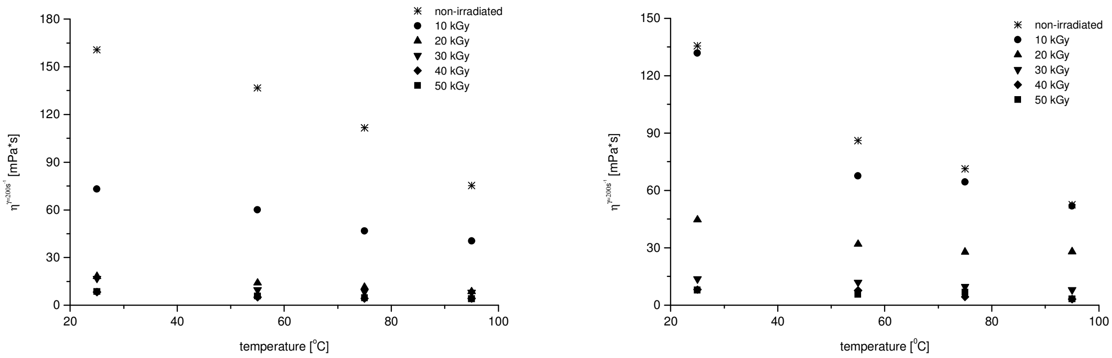


Fig. 5. Apparent viscosity vs. temperature for potato starch paste

The rheological analysis of the starches at different temperatures revealed that the apparent viscosity values decreased certainly with the increase of temperature for doses up 30 kGy (Figs. 5 and 6). From this irradiation dose the differences between viscosities values were insignificant.



(a) (b)

Fig. 6. Apparent viscosity vs. temperature for (a) rice and (b) maize starch pastes

4. Conclusions

The rheological behaviour of starch paste depends on the origin source of starch and it is modified by electron beam treatment of the starch.

Electron beam irradiation causes the depolymerization of the starch structure: the most sensitive to e-beams is potato starch while the maize starch is the most resistant which suggests that it has a rigid structure.

References

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