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POLYMER COMPOSITE FILMS BASED ON POLY(VINYL ALCOHOL) AND GROUND EGGSHELLS

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Highlights

- ✓ In this work, polymer composite films based on poly(vinyl alcohol) (PVA) and grounded eggshell powder (ES), as calcium-rich biofiller, were prepared and characterized.
- ✓ Fourier transform infrared spectroscopy (FT-IR) was utilized to provide insight into effect of the eggshell addition on the structural properties of PVA. Eggshell was successfully incorporated into PVA matrix, without affecting its chemical structure.
- ✓ Diferential scanning calorimetry (DSC) was used to determine characteristic transitions parameters. Eggshell did not alter glass transition temperature nor melting temperature of the PVA, confirming its suitability as inert biofiller.
- ✓ Thermal stability of composites was evaluated by non-isothermal thermogravimetric analysis (TG). Upon addition of eggshell in PVA matrix, a decrease of degradation temperatures was observed. However, composites show a comparable good thermal stability up to the range of 270 °C.
- ✓ PVA/ES based biocomposite films can potentialy replace petroleum-based polymer composites in packaging industry [1].

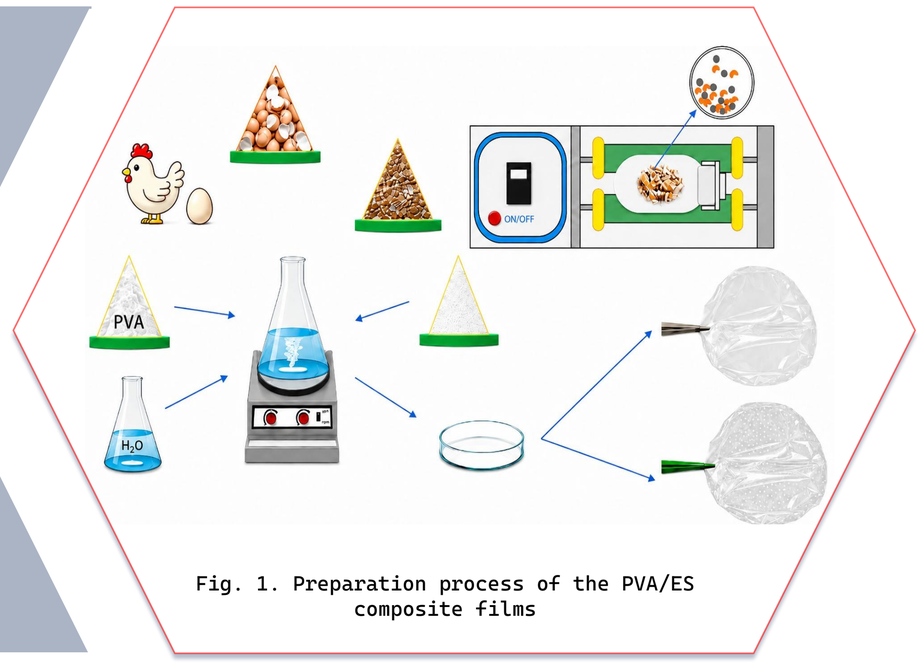


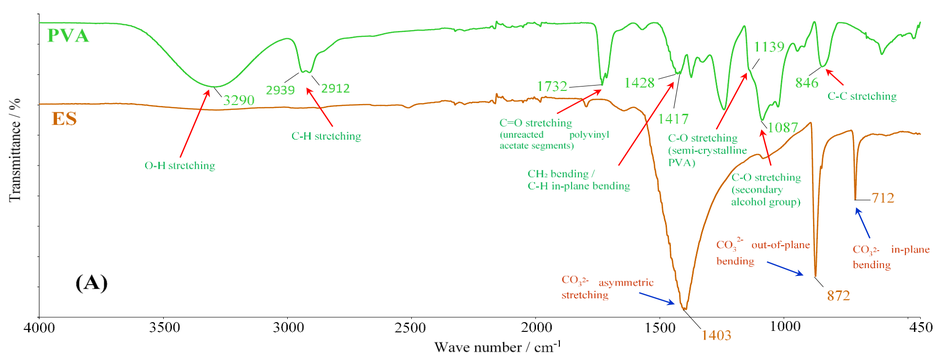
Fig. 1. Preparation process of the PVA/ES composite films

FT-IR results and discussion

FT-IR spectra of PVA/ES composite samples are shown in Fig. 2, where characteristic absorption bands of PVA and ES are highlighted. The peaks at 712 and 874 cm^{-1} confirmed incorporation of eggshells into PVA matrix.

On the other hand, the specific interactions in the PVA/ES composites are usually attributed to the hydrogen bond between the –OH and CO_3^{2-} groups.

Upon ES addition, there are not major changes of shape and position of the characteristic absorption bands of PVA.



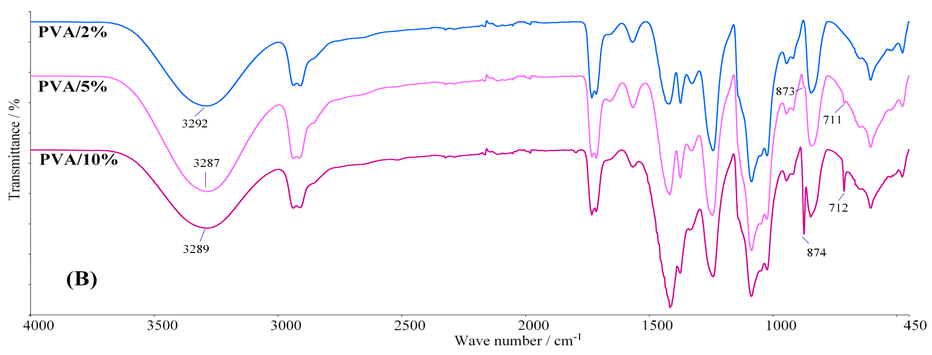


Fig. 2. FT-IR spetra of neat PVA and ES (A) and corresponding composites (B).

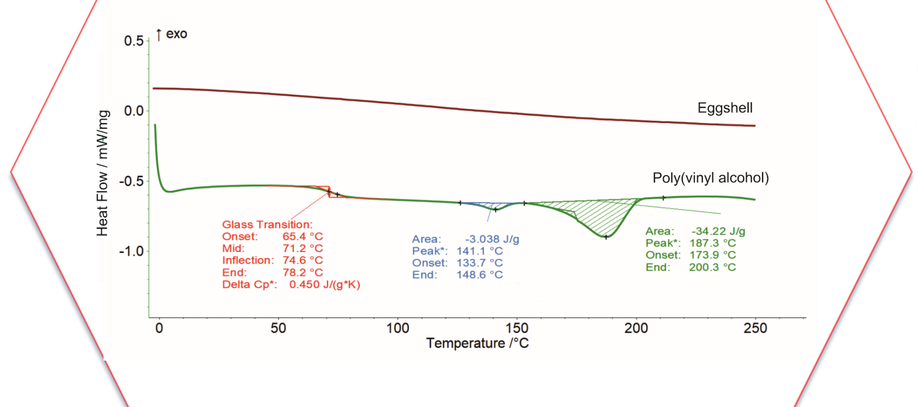


Fig. 3. Normalized DSC curves of neat PVA and ES.

Materials and preparation

Materials used in this work were poly(vinyl alcohol) (PVA), degree of hydrolysis 86-89% (Thermo Scientific) and grounded eggshell (ES). The PVA/ES composites of different mass fraction of eggshell (2, 5 and 10 wt %) were prepared via solution casting method, Fig. 1.

DSC results and discussion

The neat PVA is characterized by glass transition temperature at 71.2 °C and by melting endotherm at 173.9 °C. The endothermic peak within the temperature range 125-150 °C is due to the evaporation of water bounded to the polymer. Normalized DSC curves of eggshell did not show any specific thermal transition (Fig. 3).

The DSC curves of PVA/ES composites (Fig.4) show three charateristic transitions which correspond to the neat PVA. The addition of ES did not affect thermal properties of the PVA matrix.

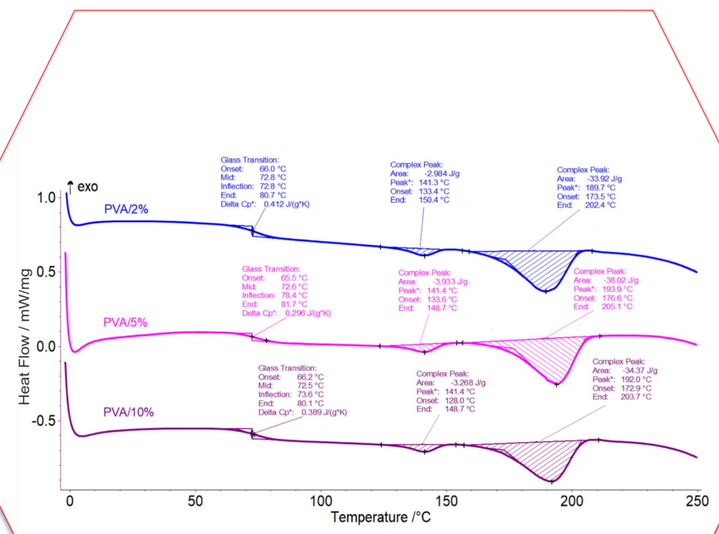


Fig. 4. Normalized DSC curves of of PVA/ES composites.

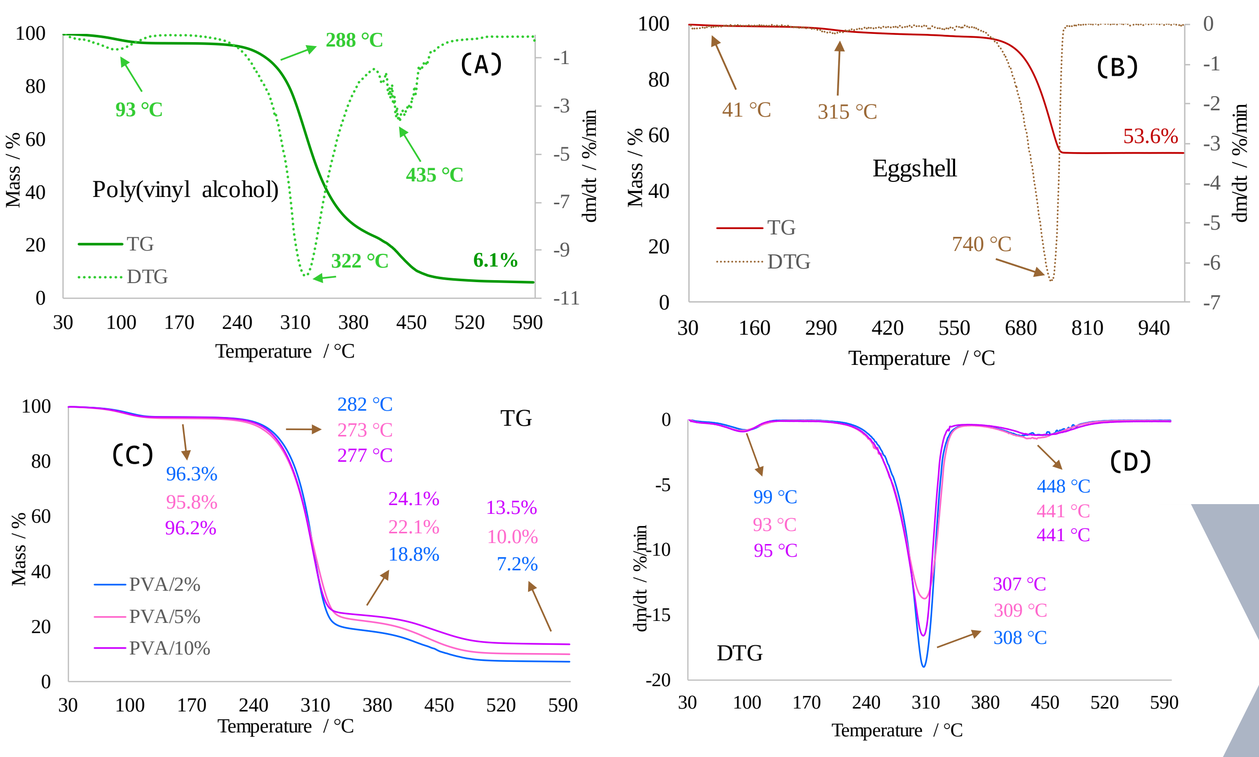


Fig. 5. TG and DTG curves of the thermal degradation of the neat PVA and ES (A, B) and corresponding composites (C, D) at the heating rate of 10 °Cmin^{-1}.

TG results and discussion

The Fig. 5 present TG and DTG curves of the neat PVA and ES, as well as investigated composites. Thermal degradation of PVA unfold through three degradation stages [2]. On the other hand, thermal degradation of eggshell was performed in wider temperature range (30 – 1000 °C) and three characteristic peaks are visible [3].

As in the case of neat PVA, a three-stage degradation pattern is seen for all PVA/ES composites. In the second (main) degradation stage, upon increase of concentration of ES in PVA matrix, a decrease of degradation temperatures (T_{onset} and T_{max}) was observed.

[1] H. Wu, D. Xiao, J. Lu, T. Li, C. Jiao, S. Li, P. Lu, Z. Zhang, Preparation and Properties of Biocomposite Films Based on Poly(vinyl alcohol) Incorporated with Eggshell Powder as a Biological Filler. J Polym Environ 28 (2020) 2020–2028.
[2] H. AlFannakh, S.S. Arafat, S.S. Ibrahim, Synthesis, electrical properties, and kinetic thermal analysis of polyaniline/polyvinyl alcohol-magnetite nanocomposites film, Sci Eng Compos Mater, 26 (2019) 347–359.
[3] W. Sutapun, P. Pakdeechote, N. Suppakarn, Y. Ruksakulpiwat, Application of Calcined Eggshell Powder as Functional Filler for High Density Polyethylene, Polymer-Plastics Technology and Engineering, 52 (2013) 1025–1033.

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