Degradability of polymeric composites (ENR/PLA) from renewable resources composites

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ABSTRACT

Biopolymers are polymers are generated from renewable natural sources, which are often biodegradable and nontoxic. The relative importance of macromolecular materials based on renewable resources suffered thereafter a gradual setback first with the rapid surge of coal-based chemistry starting from that period and later with the petrochemical revolution of the 20th century. The growing number of publications on biodegradable materials indicates persistent interest in and demand for this type of materials. Hence, it seems advisable to continue the studies aimed at the preparation of biodegradable composites. The equally relevant aspects related to the use of renewable resources to produce a remarkable variety of chemicals through the implementation of the biorefinery strategy have been recently assessed in a series of comprehensive reviews. The specific area dealing with self-assembled biological soft materials is also gaining relevance but is not dealt with here [1-6].

In our research, we reported on biodegradable composites exhibiting specificity properties by melt blending of polylactide (PLA), one of the commercially available biodegradable material, and epoxidized natural rubber (ENR). Blending of ENR with different types of polymers will also exhibit different properties of the blends with respect to the concentration of each polymers, concentration and types of cross-linking agents. Blending hydrophilic natural polymers and aliphatic polyesters is of significant interest, since it could lead to the development of a new range of biodegradable polymeric materials. The final aim in the present study is to use ENR and poly(lactide) to design composite from renewable resources with controlled degradation.

Keywords: ageing, polyphenols, polymer, stabilization

1. Object and methods of studies

Rubber blends were prepared using a laboratory mixer of Brabender with a front-roll rotation speed of Vp = 60 rpm and friction of 1.1. The average temperature in the Brabender mixer was approximately 120°C, and the mixing time was 30 minutes.The vulcanization of rubber blends was carried out with the use of steel vulcanization molds placed between the shelves of electrically heated hydraulic press. A teflon film was used as spacers preventing the adherence of blends to the press plates. Samples were vulcanized at a temperature of 180oC, under a pressure of 15 MPa for 60 min. The density of crosslinks in the vulcanizates network was determined by the method of equilibrium swelling according to standard PN-74/C-04236. The vulcanizates were subjected to equilibrium swelling in toluene for 48 h at room temperature. The swollen samples were then weighed on a torsion balance and dried in a dryer at a temperature of 60oC to a constant weight and after 48 h they were reweighed. The cross-linking density was determined on the basis of Flory-Rehner's equation.The tensile strength of vulcanizates was tested according to standard PN-ISO 37:1998 by means of a ZWICK tester, model 1435, for dumbbell w-3.Ageing characteristics were determined according to standard PN-82/C-04216. Samples were subjected to the action of air at elevated temperature (383 K) for 10 days in a dryer with thermo-circulation. UV ageing was performed by means of an UV 2000 apparatus from Atlas. The measurement lasted for 288 h and consisted of two alternately repeating segments with the following parameters: daily segment (radiation intensity 0.7 W/m2, temperature 600 C, duration 8h), night segment (no UV radiation, temperature 500C, duration 4 h). Climatic ageing was carried out using a Weather-Ometer (Atlas; Ci4000). The test was based on two variable segments simulating day and night conditions, and the samples were subjected to two different cycles. Daily cycle (radiation intensity 0.4 W/m2, temperature 600 C, duration 240 min, humidity 80%, water of rain was on), night cycle (no radiation, temperature 500C, humidity 60%, duration 120min). The ageing coefficient was calculated according to the relationship: S= [TS'*EB']/[TS*EB], where TS – tensile strength, EB – elongation at break, TS', EB' – corresponding values after ageing.

Results and discussion

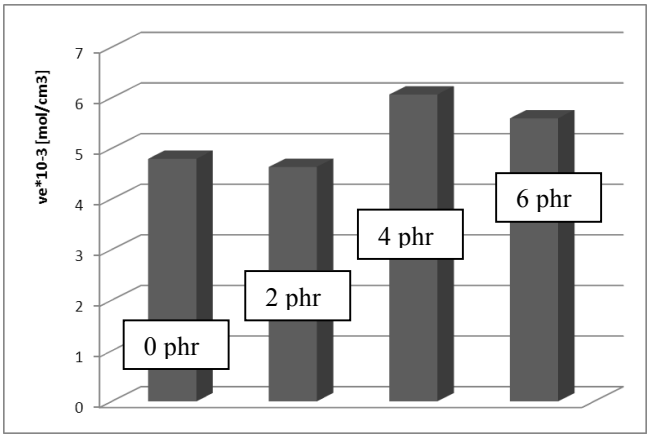

Fig 1. Density of the cross-links (ν) of the ENR/PLA (epoxidized natural rubber/polylactide) composites containing nanocellulose (2-6phr).

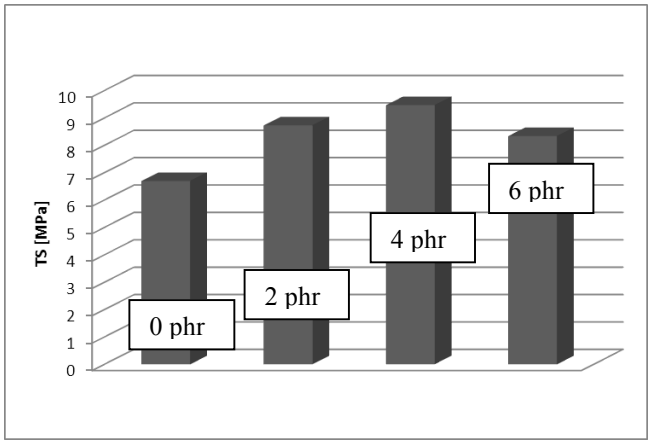

Fig. 2 Tensile strength (TS) of the ENR/PLA (epoxidized natural rubber/polylactide) composites containing nanocellulose (2-6phr).

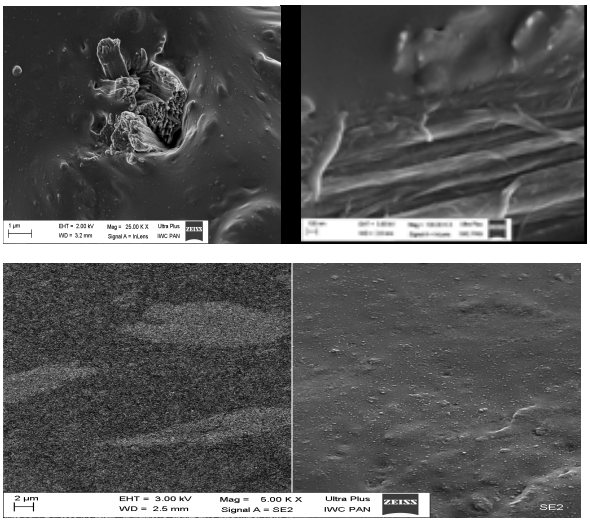

Fig. 3 Morphology of ENR/PLA composites containing nanocellulose measured by the method of SEM (scanning electron microscopy).

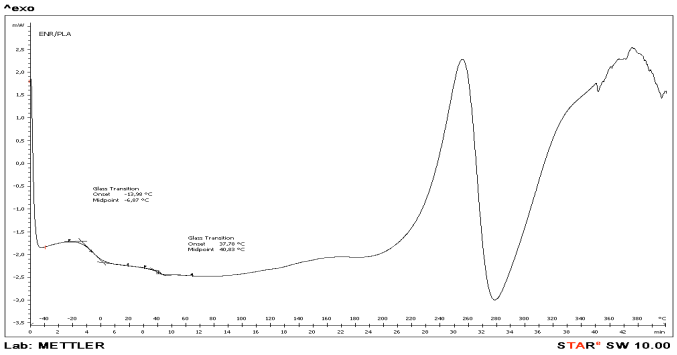

Fig. 4 DSC curve of the ENR/PLA (epoxidized natural rubber/polylactide) composites containing nanocellulose.

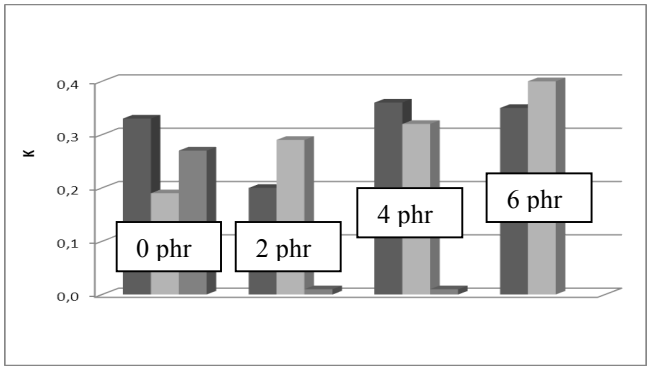

Fig. 4 The ageing coefficient (K) (after UV, weathering, thermooxidation) of the ENR/PLA (epoxidized natural rubber/polylactide) composites containing nanocellulose (2-6phr).

The addition of amorphous epoxidised natural rubber to the crystalline polylactide can cause a considerable decrease in the crystalline phase of such a composite. ENR/PLA composites are from renewable resources and are characterized by controlled degradation.

The biocomposites ENR with PLA described in this paper are suitable for many applications because of their very good functional properties and their resistance to ageing. The proecological character of biocomposites derived from renewable materials allows for their widespread application in various products while meeting current ecological requirements.

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