DEGRADATION OF COMPOSITES BASED ON RAW MATERIALS FOR ORTHOPEDIC EQUIPMENT

Barbara Szaraniec*, Anna Morawska-Chochół, Ewa Stodolak-Zych

AGH-University of Science and Technology, Faculty of Material Science and Ceramics, Department of Biomaterials, Krakow
*MAILTO: szaran@agh.edu.pl

Abstrtact

Eco-composites based on natural raw materials such as polylactide and plant fibres (e.g. flax, hemp, jute) show many important features which enable them to be used as potential materials for biomedical engineering. Availability of the raw materials and low costs of production, capability to enhance mechanical parameters and also controlled time of degradation in the environment allow considering them as materials for rehabilitation equipment, orthopedic supplies or materials for medical packages. Such materials due to the presence of the natural fibres provide higher comfort during their utilization and then they undergo safe biodegradation which is non-harmful for the environment [1,2].

The work presents attempts on fabrication of composites based on polylactide (PLA, Ingeo 3051D, Nature works, USA) reinforced with short flax and jute fibres. The fibres were mechanically comminuted to the length of 1÷2 mm. Preparation of PLA/fibres mixture took part in two stages. The first one consisted in drying of the polymer granulate and the fibrous filler at 60oC for 2 h. The second stage the granulate/fibres mixture was homogenized using vertical screw injection moulding machine (Multiplas). The obtained mixture was mechanically comminuted with a laboratory grinder (Testchem). Volume fraction of the fibres was nit higher then 5 %. The granulates were used to prepare PLA/natural fibres composites in the form of paddle-shaped samples (according to PN-EN ISO 527) by the injection method. The injection took place at 165°C and pressure of 80 kg/cm^2. The samples were subjected to hydrolytic degradation tests (incubation in distilled water at 37°C, 15 weeks) and biological degradation (composting in an eco-composter, TERMO-410 with the addition of Radvit activator which contains composting bacteria and selected fungi cultures which support biodegradation and accelerate degradation of organic wastes, 15 weeks). The effect of the degradation environment on the composite material was determined on the basis of changes of its mechanical properties (tensile strength, Young's modulus) using an universal testing machine (Zwick 1453). The degradation process was monitored by FT-IR spectroscopy of the composite samples (transmission method, BioRAD 60FT). Changes related to the polymer chain degradation were assessed on the basis of viscosimetric measurements (Hoppler method).

The carried out investigations proved, that during both the composting and the incubation in water a gradual degradation of the material takes place. Its visual effect was decrease of the tensile strength of the composites for about 70% for PLA/5% jute and for c.a. 10% for PLA/5% hemp and their Young's modulus for about 25 % for PLA/5% jute and for c.a. 10% for PLA/5% hemp. The changes were caused by decrease of molecular weight (Mn) of the polymer matrix from 100 to 28 kDa for PLA/5% hemp, and from 136 to 48 kDa for PLA/5% jute. The change of the polymer structure was faster in the case of degradation in water environment. This effect was related to facilitated migration of medium (water) inside the material and possibility of washing out and transport of products of the polymer chain disintegration. Additionally, the present fibrous phase which is characterized by high water absorbability may became a reservoir of both the medium and the degradation products. Biodegradation in the compost heap was slower and it was an example of synergic effect of hydrolytic degradation and biodegradation caused by the microorganisms. This process could be observed on the FT-IR spectra recorded during degradation in the compost heap, where longer composting time led to increasing disproportion between bands indicating increasing fraction of hydroxyl, carboxyl and carbonyl groups in relation to groups characteristic for PLA chain. In the case of biodegradation the process progress is related to such variable factors as: amount and type of the bacteria and fungi cultures, humidity and temperature.

In conclusion, it may be stated that the proposed PLA/natural fibres composite materials are an alternative solution for many fields of biomedical engineering especially for rehabilitation and orthopedic provision.

[Engineering of Biomaterials, 116-117, (2012), 147]

Acknowledgments

This work has been financially supported from the project no. POIG.01.03.01-00-092/08 by European Regional Development Fund and Polish Budget Founds.

References

[1] Shah A. A, Hasan F., Hameed A., Ahmed S.: Biological degradation of plastics: A comprehensive review. Biotechnology Advances 26 (2008) 246-265.
[2] Chłopek J., Morawska-Chochół A., Szaraniec B.: The influence of the environment on the degradation of polylactides and their composites, Journal of Achievements in Materials and Manufacturing Engineering 43 (2010) 72-79.