Composites Part B 92 (2016) 1–8

Contents lists available at ScienceDirect

Composites Part B

journal homepage: www.elsevier.com/locate/compositesb

New class of shear oriented, biodegradable packaging material

Stanislaw Frackowiak*, Joanna Ludwiczak, Karol Leluk, Marek Kozlowski

Wroclaw University of Technology, Faculty of Environmental Engineering, Wybrzeze Wyspianskiego 27, Wroclaw 50-370, Poland

ARTICLE INFO

Article history:
Received 15 July 2015
Received in revised form
11 February 2016
Accepted 16 February 2016
Available online 24 February 2016

Keywords:
A. Polymer-matrix composites (PMCs)
A. Nano-structures
B. Directional orientation
D. Thermal analysis
E. Extrusion

ABSTRACT

Reducing waste amount from plastic packaging materials is in the scope of interest of many scientific groups in the world. One of the most important biodegradable polyesters with good mechanical properties, high transparency and good processability is poly(lactic acid). It can be modified with various additives (plasticizers, chain extenders etc.) or by preparing blends with other polymers. Such blends can be further modified by addition of functional fillers in order to improve final properties. In the paper an anisotropic polymer composite was developed based on poly(butylene succinate)/poly(lactic acid) matrix with carbon nanotubes as a filler. Anisotropy was achieved due to the orientation process induced during extrusion.

To fully characterize a new material the rheological, thermal and mechanical measurements were performed, completed with morphology observations.

1. Introduction

Nowadays packaging represent a great part of plastics waste. According to the European Union directive [1], the best methods to deal with plastics waste is to prevent or reduce their occurrence and recycle. Recycling has become an important pillar of European economy (annual turnover over 10 billion euro) with a high potential to further growth due to the ecological legislation. Mechanical recycling is prevailing, however a chemical and organic recycling should be considered for the plastic waste management.

In order to increase sustainability of plastic packaging, many attempts were made by different scientific groups all over the world. That can be done by reducing the weight of packaging by foaming, by introducing new eco-friendly materials like natural fillers (wood flour or cellulose fibers) or biodegradable polymers [2–9].

One of the most promising approaches is to implement biodegradable polymers, that are expected to disintegrate at the end of their life cycle. Poly(lactic acid) (PLA) is a biopolymer, derived from renewable resources (e.g. corn starch) and currently being in the scope of many companies and scientific groups. Another biodegradable polymer is poly(butylene succinate) (PBS), but contrary to PLA it is made from fossil raw materials [10–13].

Application properties of biodegradable polymers frequently are under that of commonly used petro based polymers and therefore need improvement. Several attempts have been made by means of filler addition [14–16], modifying processing conditions, or melt blending with other polymers [17–20]. This approach is promising but difficult as polymers pairs are usually immiscible and tend to form separate phases during production [21,22]. Such heterogeneous structure weakens the material and is a significant drawback in achieving desired properties of packaging material.

The purpose of this study was testing the rheological, thermal and mechanical properties of PLA/PBS (60/40) blends. Moreover, attempts were made to enhance the mechanical properties of the blend by addition of carbon nanotubes (CNT) and by means of the cold orientation during processing. As a result, a biodegradable anisotropic polymer nanocomposite has been manufactured which can be implemented as a packaging material. Rheological, mechanical and thermal properties have been evaluated with a special interest focused on application at low temperature.

2. Experimental

2.1. Materials and composites preparation

Composites were prepared by melt mixing of polymers e.g. PLA 3052D from NatureWorks, with PBS PBE003BB from NaturePlast at

* Corresponding author. Tel.: +48 713204686.
E-mail addresses: stanislaw.frackowiak@pwr.edu.pl (S. Frackowiak), joanna.ludwiczak@pwr.edu.pl (J. Ludwiczak), karol.leluk@pwr.edu.pl (K. Leluk), marek.a.kozlowski@pwr.edu.pl (M. Kozlowski).

http://dx.doi.org/10.1016/j.compositesb.2016.02.036
1359-8368/

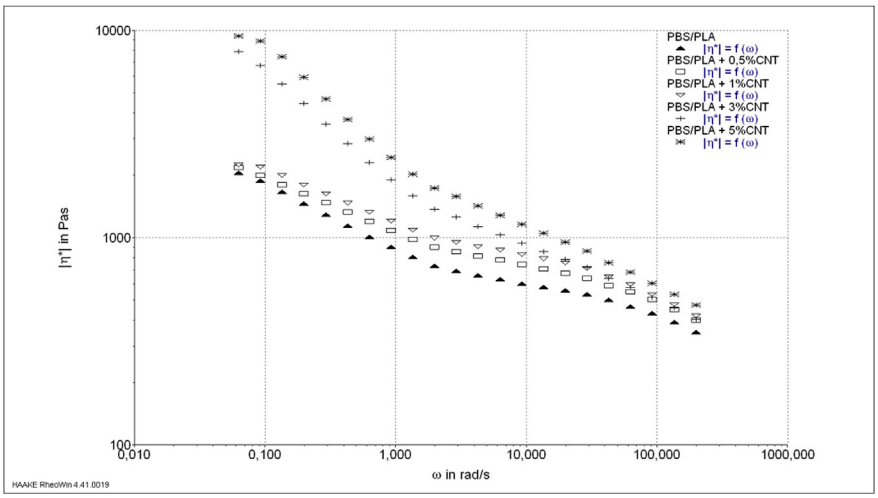

Fig. 1. Complex melt viscosity for PBS/PLA filled with carbon nanotubes.

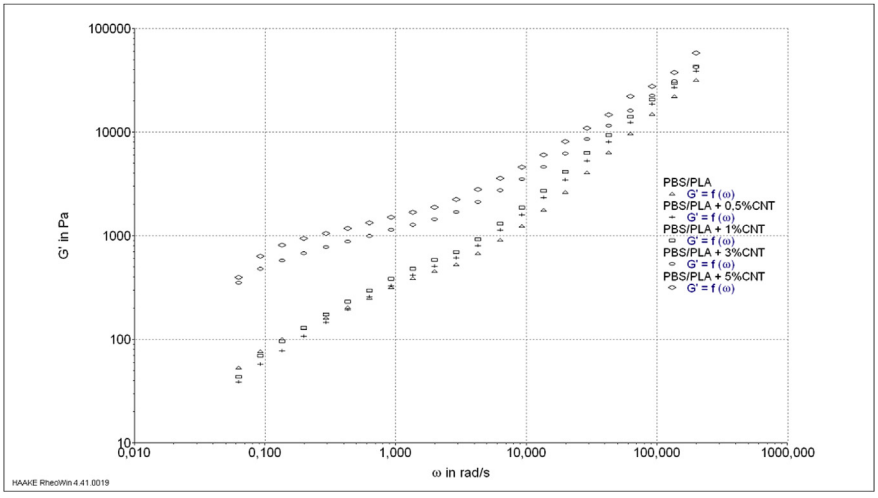

Fig. 2. Storage modulus for PBS/PLA filled with carbon nanotubes.

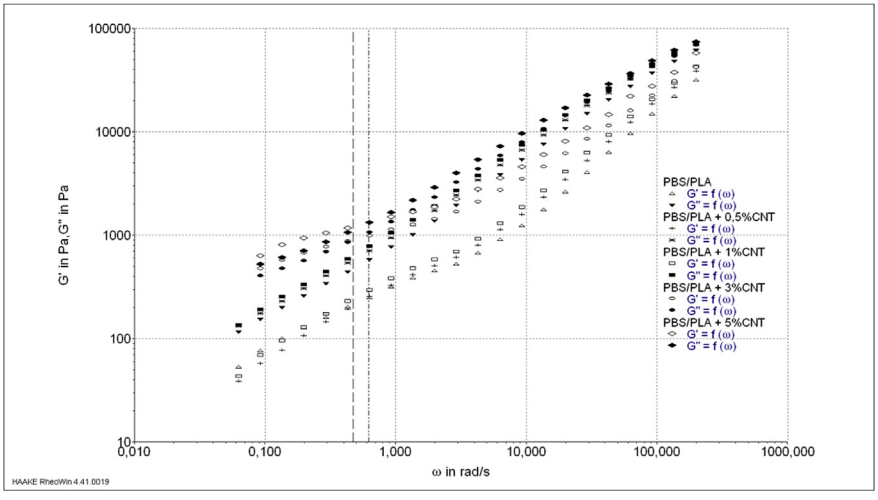

Fig. 3. Storage and loss modulus for PBS/PLA filled with carbon nanotubes. Dashed line is for crossover point of PBS/PLA +3%CNT and dash-dot line is for PBS/PLA +5% CNT respectively.