Composites: Part B 68 (2015) 414–423

Contents lists available at ScienceDirect

Composites: Part B

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

Heat treated wood–nylon 6 composites

Deniz Aydemir [a,b,1], Alper Kiziltas [a,b,*], Esra Erbas Kiziltas [a,c], Douglas J. Gardner [a], Gokhan Gunduz [a,b]

[a] Advanced Structures and Composites Center (AEWC), University of Maine, Orono, ME 04469, USA
[b] Department of Forest Industry Engineering, Faculty of Forestry, University of Bartin, 74100 Bartin, Turkey
[c] The Scientific and Technological Research Council of Turkey (TUBİTAK), Tunus Cad, Kavaklıdere 06100, Ankara, Turkey

ARTICLE INFO

Article history:
Received 27 April 2014
Received in revised form 17 August 2014
Accepted 20 August 2014
Available online 3 September 2014

Keywords:
A. Wood
B. Rheological properties
E. Heat treatment
E. Thermoplastic resin

ABSTRACT

Heat treatment is a relatively benign modification method that is growing as an industrial process to improve hygroscopicity, dimensional stability and biological resistance of lignocellulosic fillers. There also has been increased interest in the use of lignocellulosic fillers in numerous automotive applications. This study investigated the influence of untreated and heat treated wood fillers on the mechanical and rheological properties of wood filled nylon 6 composites for possible under-the-hood applications in the automobile industry where conditions are too severe for commodity plastics to withstand. In this study, exposure of wood to high temperatures (212 °C for 8 h) improved the thermal stability and crystallinity of wood. Heat treated pine and maple filled nylon 6 composites (at 20 wt.% loading) had higher tensile strengths among all formulations and increased tensile strength by 109% and 106% compared to neat nylon 6, respectively. Flexural modulus of elasticity (FMOE) of the neat nylon 6 was 2.34 GPa. The FMOE increased by 101% and 82% with the addition of 30 wt.% heat treated pine and 20 wt.% heat treated maple, where it reached maximum values of 4.71 GPa and 4.27 GPa, respectively. The rheological properties of the composites correlated with the crystallinity of wood fillers after the heat treatment. Wood fillers with high crystallinity after heat treatment contributed to a higher storage modulus, complex viscosity and steady shear viscosity and low loss factor in the composites. This result suggests that heat treatment substantially affects the mechanical and rheological properties of wood filled nylon 6 composites. The mechanical properties and thermogravimetric analysis indicated that the heat treated wood did not show significant thermal degradation under 250 °C, suggesting that the wood-filled nylon composites could be especially relevant in thermally challenging areas such as the manufacture of under-the-hood automobile components.

1. Introduction

Incorporation of lignocellulosic fillers (wood and natural fibers) as reinforcement elements into polymer matrices has received considerable interest from both academic (increasing number of publications and funding sources) and industry (construction and automotive industries) for environmental and economic benefits [1,2]. Lignocellulosic fillers as raw materials for polymer reinforcement presents many advantages compared to mineral fillers, glass fibers and carbon fibers such as low cost, low density, high specific strength and modulus, ease of fiber surface modification, relative non-abrasiveness, renewability and biodegradability, process friendly characteristics, good thermal and acoustic insulating properties, recyclability and world-wide availability [3–8]. A broad range of potential applications of lignocellulosic fillers to high-performance sustainable composites have been developed and these applications are expected to open up opportunities that would allow the replacement of conventional petroleum based-composites with new and improved material properties [9]. However, despite active research activities and their attractive properties, there are several obstacles to overcome for the use of lignocellulosic fillers, including (1) the issue of compatibility between hydrophilic lignocellulosic fillers and hydrophobic polymers, (2) hygroscopicity and dimensional changes because of its hydrophilic nature, (3) uniform dispersion and extreme agglomeration and (4) low thermal stability, limiting its applications in engineering thermoplastics which have high melting points [9–11].

Engineering thermoplastics are playing a growing role in "under-the-hood" components for automobiles that are competing

* Corresponding author at: Advanced Structures and Composites Center (AEWC), University of Maine, Orono, ME 04469, USA. Tel.: +1 207 249 5948; fax: +1 207 581 2074.
E-mail addresses: deniz.aydemir@bartin.edu.tr (D. Aydemir), kiziltasalper@gmail.com (A. Kiziltas).
[1] Tel.: +90 378 223 5087; fax: +90 378 223 5062.

http://dx.doi.org/10.1016/j.compositesb.2014.08.040
1359-8368/