Dynamic Mechanical Thermal Analysis (DMTA) of Nanocellulose Reinforced Urea-Formaldehyde Resin

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Abstract

Cellulose is one of the most abundant natural biopolymers in the world. Urea-formaldehyde is the most commonly used adhesive in wood-based panel industry of Turkey. Nanocellulose has an important potential to be used in a variety of applications because of its enhanced properties. Thus nanocellulose has an increasing attention from researchers from all over the world (Candan 2012, Eichhorn et al. 2010, Klemm et al. 2011). The objective of this present study was to determine effect of nanocellulose on dynamic mechanical thermal characteristics of urea-formaldehyde resin. Commercial urea-formaldehyde resin was reinforced with nanocellulose at different loading levels. Storage modulus, loss modulus, and tan delta values of the neat and nanocellulose reinforced resins were determined. The results obtained in this work revealed that the storage modulus, loss modulus, and tan delta values of the urea-formaldehyde resin were affected by the nanocellulose reinforcement. It could be concluded that the resins having enhanced mechanical properties could be used as a novel adhesive for wood-based panel industry.

Objectives

- To determine performance properties of nanocellulose reinforced UF resin
- To evaluate effect of nanocellulose on DMTA properties of UF resin
- To investigate its feasibility in manufacturing of wood composite panels

Introduction

Turkey is the world's 4th largest producer of wood composite panels. UF is the most used adhesive in the wood composite panel industry (Candan, 2012).

Nanotechnology has been identified as a technological revolution by scientists from all over the world. Nanoscience and nanotechnology also have numerous advantages for wood or other composites (Candan, 2012; Roughley, 2005). The National Science Foundation of the United States predicts that within a decade, nanotechnology will be a 1 trillion dollar market (Jones et al. 2005).

Cellulose is one of the most abundant renewable nanobiomaterials in the world. Nanocellulose can be used in many areas from medicine to engineering applications. Research conducted by universities, research institutes, and industries in developed countries focus on nanocellulose. It was started to use to reinforce wood adhesives by researchers.

Combination of great industrial importance and limited mechanical properties makes urea formaldehyde an ideal candidate for reinforcement by fibrous fillers. Pure natural cellulose offers outstanding mechanical properties with a modulus of elasticity of approximately 140 GPa (Sakurada et al. 1962; Nishino et al. 1995).

Materials and Methods

Nanocellulose Reinforcement

The commercial urea-formaldehyde resin was reinforced with nanocelulose at loading levels of 1%, 2%, and 10%. All the reinforcement procedure were carried out in the Nanotechnology Laboratory at IU.

Dynamic Mechanical Thermal Analysis (DMTA)

All samples were performed in 3-point bending at a controlled heating rate of 5°C/min from 20 °C to 250 °C at an oscillatory frequency of 1 Hz. Storage modulus, loss modulus, and tan delta values were calculated by the DMTA instrument (located in the Thermal Analysis Laboratory at IU) analysis software as a function of temperature. Three to five samples were analyzed for each resin group.

Results

Effects of nanocellulose reinforcement on the DMTA characteristics of UF resin are shown in Fig. 1, 2, and 3.

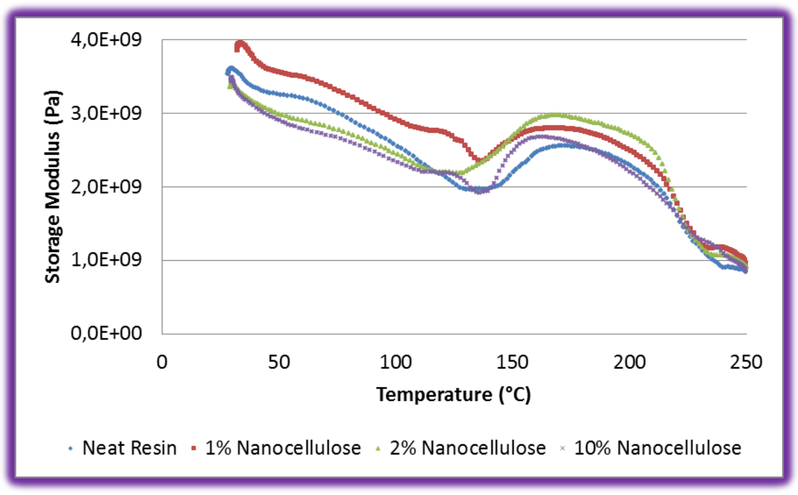

Figure 1: Storage modulus results of the neat and nanocellulose reinforced resins

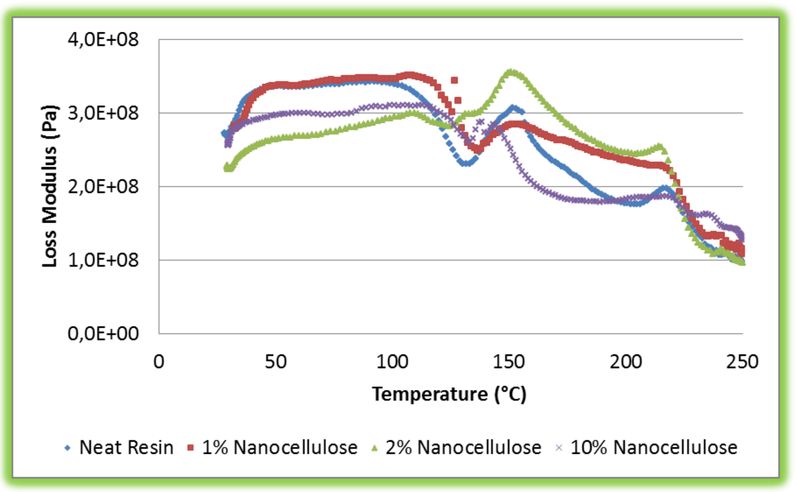

Figure 2: Loss modulus results of the neat and nanocellulose reinforced resins

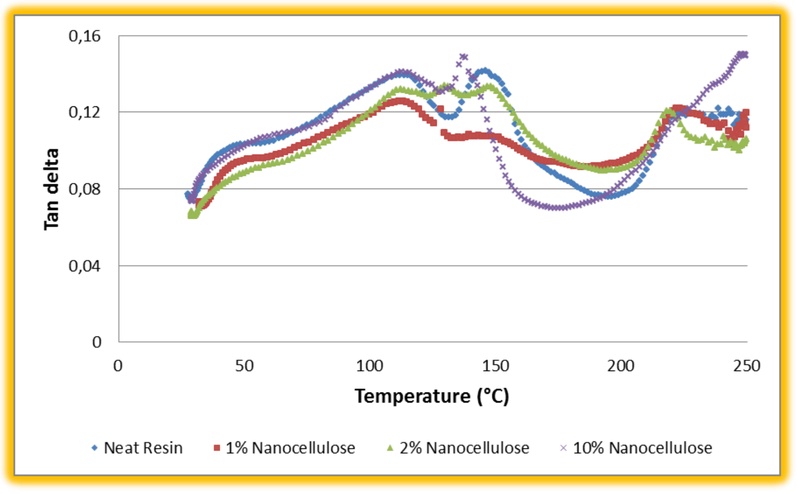

Figure 3: Tan delta results of the neat and nanocellulose reinforced resins

Conclusions

- As a thermosetting resin, urea-formaldehyde could be reinforced with nanocellulose at a proper loading level.
- Nanocellulose had a positive effect on the storage modulus values of the urea-formaldehyde resin.
- Wood composites having enhanced performance could be manufactured by using nanocellulose.

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