Nanocellulose Reinforced Adhesives for Wood Composites

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Abstract

Urea formaldehyde, melamine formaldehyde, and phenol formaldehyde resins are commonly used in manufacture of wood composite panels such as plywood, particleboard, fiberboard, and oriented strandboard. Nanoscience and nanotechnology can play an important role for forest products industry. Cellulose is one of the most abundant natural biopolymers in the world. 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. Nanocellulose could be used to reinforce the adhesives which use in manufacture of wood composites. Investigating physical/mechanical properties of nanocellulose reinforced thermosetting adhesives and wood composite panels made from the adhesives was objected in this work. For this aim, previous studies have been scanned and reviewed in this work. In addition, opportunities of using nanocellulose in wood composite panels industry have been discussed.

Objectives

✓ To investigate performance properties of nanocellulose reinforced adhesives

✓ To investigate influence of nanocellulose on physical and mechanical properties of wood composite panels

✓ To discuss its feasibility in wood composite panel industry

Introduction

Nanotechnology is defined as the manipulation of materials measuring 100 nm or less in at least one dimension. It is expected to be a critical driver of global economic growth and development in this century because it is a multi-disciplinary field of research (Jones et al 2005).

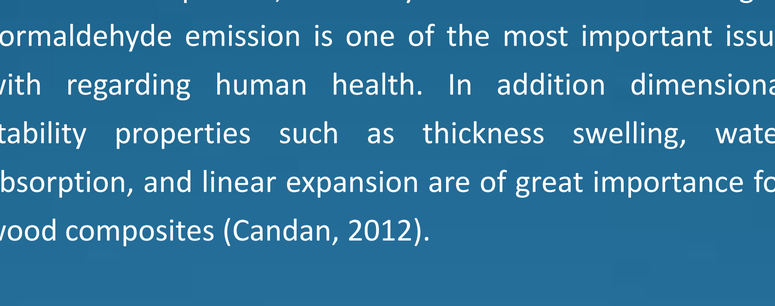
Nanotechnology can be applied to many areas of research and development, from medicine to manufacturing to computing, and even textiles and cosmetics. It is attracting more public funding than any other area of materials technology, estimated at around 6 billion dollars worldwide in 2010 (Shand, 2010). The National Science Foundation of the United States predicts that within a decade, nanotechnology will be a 1 trillion dollar market and provide 2 million new jobs (Jones et al 2005). 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).

Nanocellulose Reinforced Composites

Turkey is the world's 4th largest producer of wood composite panels, while the biggest producer of MDF in Europe. 55 Plywood producer, 28 particleboard producer, 18 MDF producer, and 2 OSB producer are available in Turkey. All the wood composite production capacity is over 10.000.000 m^3/year by 2013. UF, MF, and PF as thermosetting resin are generally used in the wood composite panel industry. However the resins provide enough performance properties for wood composites, but they have some disadvantages. Formaldehyde emission is one of the most important issue with regarding human health. In addition dimensional stability properties such as thickness swelling, water absorption, and linear expansion are of great importance for wood composites (Candan, 2012).

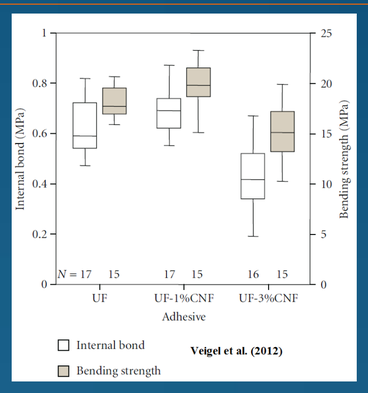
Cellulose is one of the most abundant renewable nanobiomaterials in the world. Nanocellulose can be used in many areas from medicine to engineering applications. Research conducted by universities, research institutes, and industries in developed countries focus on nanocellulose. It was started to use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

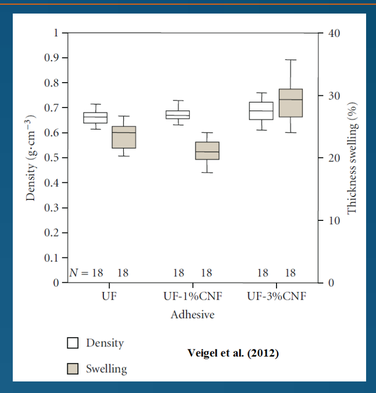
Combination of great industrial importance and limited mechanical properties makes urea formaldehyde an ideal candidate for reinforcement by fibrous fillers. Pure natural cellulose offers outstanding mechanical properties with a modulus of elasticity of approximately 140 GPa (Sakurada et al. 1962; Nishino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



Zhang et al. (2011) reinforced urea formaldehyde resin with modified nanocellulose and manufactured plywood panels. It was stated that formaldehyde emission values of the plywood panels decreased with increasing nanocellulose content up to 1.5%. It was also indicated that bonding strength of the plywood panels increased as nanocallulose content increased up to 1.0%.

Veigel et al. (2012) studied the properties of the particleboard and oriented strandboard panels bonded with cellulose nanofibers reinforced UF or MUF resin. It was reported that thickness swell values of the particleboard panels bonded with UF adhesive containing 1% nanocellulose were lower than the panels bonded with unreinforced UF adhesive. Further increase in nanocellulose loading level (3%) increased thickness swelling values of the particleboard panels. It was also concluded that the particleboard panels bonded with UF adhesive containing 1% nanocellulose had higher bonding strength and modulus of rupture values than the particleboard panels with neat UF adhesive. Similarly, when the nanocellulose content increased to 3%, both of the strength values decreased in UF bonded particleboard panels. The authors also stated that OSB panels had similar results with particleboard panels.





Water resistance of plywood panels bonded with nanocellulose reinforced soybean adhesive decreased by 20% (Gao et al. 2012).

Conclusions

✓ Wood composite panels having reduced formaldehyde emission along with enhanced mechanical performance could be developed by using nanocellulose with a proper type or loading level.

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