Development of Low Formaldehyde-Emitting Furniture Components by Nanocellulose and Boric Acid Reinforcement

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Abstract

Formaldehyde emission from wood-based composite panels such as plywood, particleboard, medium-density fiberboard, oriented strandboard, laminated veneer lumber, etc. is of great importance since it could affect human health. The major raw material of furniture production is particleboard panel. It is also used for interior design and architectural applications. Developing low formaldehyde-emitting particleboard panels as an environmentally friendly material by nanotechnology application was objected in this work. Urea-formaldehyde adhesive used to produce particleboard panels was reinforced with various loading levels of nanocellulose and boric acid. Formaldehyde emission analysis was carried out according to EN ISO 9397-1997. The findings showed that the formaldehyde emission of the urea-formaldehyde adhesive improved by all the nanocellulose and boric acid used in this study. It is determined that boric acid has no significant effect on free formaldehyde, while increasing the amount of nanocellulose slightly decreases it. By using nanocellulose reinforcement, it is possible to produce low formaldehyde-emitting particleboard panels so that environmentally friendly furniture could be manufactured.

Introduction

The formaldehyde emissions of wood-based composite panels due to their formaldehyde-based resin content are a disadvantage in many applications. Formaldehyde emissions are very important issue to consider for particleboard panels that will be used in furniture and decoration. Formaldehyde emissions are a toxic gas known to be carcinogenic by many health organizations in the world (Candan et al., 2014; National Cancer Institute 2012; Roffael 2006; Salthammer et al. 2010).

The use of nanotechnology in the production of particleboard panel is of critical importance to overcome the formaldehyde emission problem (Candan 2012; Candan 2014; Ciraci 2005; Jones et al. 2005; Roughley 2005).

Objectives

- ✓ To evaluate influence of nanocellulose and boric acid on the formaldehyde emission of UF resin.
- ✓ To develop UF resin with low formaldehyde-emitting furniture components .

Materials & Methods

Reinforcement of UF Resin with Nanocellulose and Boric Acid

Urea-formaldehyde (UF) adhesive used to produce particleboard panels was reinforced with NC at loading level of 0%, 1%, 3%, BA at loading level of 0%, 1%, 3% and %5. The reinforcement process was carried out in the Nanotechnology Laboratory at Istanbul University-Cerrahpasa.

Figure 1. Resin modification

Formaldehyde Emission Analysis

Formaldehyde emission analysis was carried out according to EN ISO 9397-1997. The free formaldehyde was determined by an oximation reaction with hydroxylamine hydrochloride. The formed hydrochloride acid from this reaction has been determined by potentiometric titration using sodium hydroxide solution. Samples were taken from the reaction mixture and poured into a beaker. Then, they were dissolved by 50 ml of a mixture using a magnetic stirrer. The solution was adjusted to pH 3.5 with 0.1 M HCl. Twenty-five milliliters of hydroxylamine hydrochloride solution was stirred for 10 min. The sample was then back-titer to pH 3.5 with 0.1 M NaOH (DIN EN ISO 9397, 1997).

Results

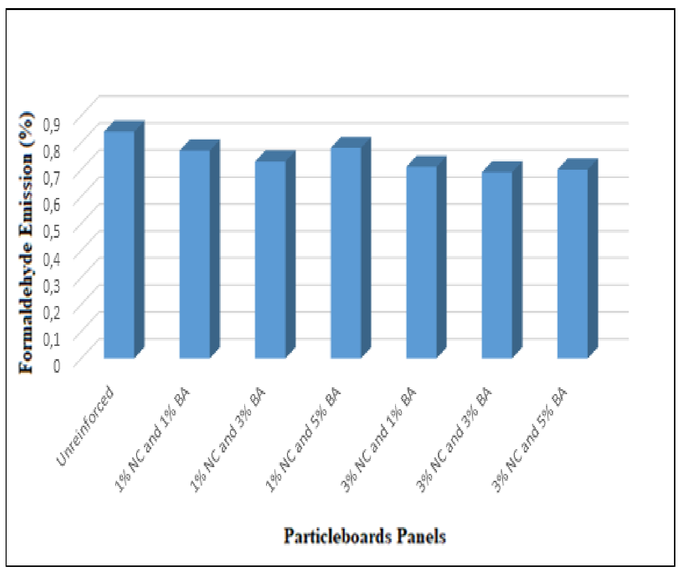

Figure 2. Formaldehyde emission results of the NC and BA reinforced particleboard panels.

Conclusions

- ✓ As a thermosetting resin, urea-formaldehyde could be reinforced with nanocellulose and boric acid at a proper loading level.
- ✓ Nanocellulose had a positive effect on the formaldehyde emission values of the urea-formaldehyde adhesive.
- ✓ Particleboard panels having low formaldehyde-emitting could be manufactured by using nanocellulose and boric acid.

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References

Candan, Z., (2012) Nanoparticles use in manufacture of wood-based sandwich panels and laminate flooring and its effects on technological properties, Ph.D. Thesis, 289 pp., Istanbul University, Istanbul, Turkey.

Candan, Z. (2014). Environmentally friendly wood composites by nanocellulose. COST FP1205, October 15 – 16, SPAIN.

Candan, Z., Akbulut, T. (2014). Low formaldehyde-emitting wood composites by nanotechnology. 57th Society of Wood Science and Technology International Convention, June 23 – 27, Zvolen, SLOVAKIA.

Ciraci, S. (2005). "Science and technology at one of a billionth of a meter," Science and Technique, Tubitak, Ankara, Turkey.

DIN EN ISO 9397., (1997). Determination of free formaldehyde content by hydroxylamine hydrochloride method.

Jones, P., Wegner, T., Atella, R., Beecher, J., Caron, R., Catchmark, J., Deng, Y., Glasser, W., Gray, D., Haigler, C., Joyce, M., Kohlman, J., Koukoulas, A., Lancaster, P., Perine, L., Rodriguez, A., Ragauskas, A., and Zhu, J. (2005). "Nanotechnology for the forest products industry – Vision and technology roadmap," Report Based on Nanotechnology for the Forest Products Industry Workshop, Landsdowne, Virginia, USA, October 17-19, 2004, TAPPI Press, Atlanta, GA, USA.

National Cancer Institute (2012). "Formaldehyde and cancer risk," http://www.cancer.gov/cancertopics/factsheet/Risk/formaldehyde.

Roughley, D. J. (2005). "Nanotechnology: Implications for the wood products industry. Final Report," Forintek Canada Corporation, North Vancouver, Canada, 73.

Roffael, E. (2006). "Volatile organic compounds and formaldehyde in nature, wood and wood-based panels," Holz als Roh- und Werkstoff 64(2), 144-149.

Salthammer, T., Mentese, S., and Marutzky, R. (2010). "Formaldehyde in the indoor environment," Chem. Rev. 110(4), 2536-2572.