

## Effects of Mimosa Bark Usage on Some Properties of Particleboard

Gökay NEMLİ, Gürsel ÇOLAKOĞLU  
Karadeniz Technical University, Faculty of Forestry, Trabzon - TURKEY

Received: 05.04.2004

**Abstract:** The objective of this study was to determine the effect of mimosa bark usage on the formaldehyde emission, physical and mechanical properties of particleboard. Fifteen panels from black locust (*Robinia pseudoacacia* L.) wood containing mimosa bark in a core layer at different ratios were manufactured. Three boards without bark addition were produced as control boards. Formaldehyde emission, modulus of rupture, modulus of elasticity, internal bond strength and thickness swelling of the specimens were tested. It was found that panels made from black locust wood had the highest mechanical properties while panels containing mimosa bark had the lowest. Bark usage significantly improved (decreased) the formaldehyde emission and thickness swelling of particleboard. Based on the findings of this study, it appears that mimosa bark can be used in the manufacture of particleboard panels. Bark content was found to be a raw material parameter influencing the properties of the panels.

**Key Words:** Particleboard, mimosa bark, formaldehyde emission, mechanical properties, physical properties.

### Mimosa Kabuğu Kullanımının Yongalevhanın Bazı Özellikleri Üzerine Etkisi

**Özet:** Bu çalışmanın amacı, mimosa kabuğu kullanımının yongalevhanın fiziksel ve mekanik özellikleri ile formaldehit emisyonu üzerine etkisinin belirlenmesidir. Yalancı akasya (*Robinia pseudoacacia* L.) odunu kullanılarak orta tabakasında farklı oranlarda kabuk ihtiva eden 15 adet levha üretilmiştir. Üç levha kabuk kullanılmadan kontrol amaçlı üretilmiştir. Üretilen levhalar üzerinde; formaldehit emisyonu, eğilme direnci, elastiklik modülü, yüzeye dik çekme direnci ve kalınlığına şişme oranı deneyleri yapılmıştır. Yalancı akasya odunundan üretilen yongalevhalar en yüksek mekanik direnç değerlerine ulaşılırken, kabuk ihtiva eden levhalar en düşük değerleri vermiştir. Kabuk kullanımı formaldehit emisyonu ve kalınlığına şişme oranını önemli derecede iyileştirmiştir. Yapılan çalışmalar sonucu mimosa kabuğunun yongalevha üretiminde kullanılabileceği belirlenmiştir. Kabuk kullanım oranı yongalevha özelliklerini etkileyen bir hammadde faktörü olarak bulunmuştur.

**Anahtar Sözcükler:** Yongalevha, mimosa kabuğu, formaldehit emisyonu, mekanik özellikler, fiziksel özellikler.

### Introduction

Particleboard is a panel material manufactured under pressure, essentially from particles of wood and/or other lingo-cellulosic fibrous materials (for example, wood chips, sawdust and flax shives) with the addition of an adhesive (Nemli, 2000).

The growing demand for wood based panels has led to continuous efforts to find new resources as an alternative wood. Forest residues are potentially usable in different ways (Reineke, 1965). Disregarding any ecological, silvicultural or fuel values of forest residue, this material may have waste value in particleboard manufacture. Manufacturing value added panel products

may be the most efficient use of such waste residues (Lehman and Geimer, 1974). The forest products industry produces large quantities of bark every year, 66% of which is used for thermal energy production. However, a significant amount of bark is still unused (Blanchet et al., 2000).

Because of its reactivity and pungent odour formaldehyde has been regulated in the workplace in numerous countries for many years, and in the 1970's attention was paid to problems of formaldehyde emission from wood based panels into buildings (Vyse, 1993). Nemli et al. (2004) evaluated the effect of impregnating wood particles with mimosa bark extract on some

\* Correspondence to: nemli@ktu.edu.tr

properties of particleboard. In that study, 5% bark extract was prepared from mimosa bark that had been extracted using at 100 °C and was provided by the manufacturer. Particles were soaked for 3 h in the extract. They stated that particleboards made from particles impregnated with mimosa bark extract had lower mechanical, physical and formaldehyde emission values than those of boards made from unimpregnated particles.

The objectives of this study were to determine whether formaldehyde emission and thickness swelling in particleboard can be reduced with the use of mimosa bark in the core layer of particleboard as a raw material and to investigate the effects of bark use on the mechanical properties of particleboard. The difference between this study and that of Nemli et al. (2004) lies in the bark usage method.

## Materials and Methods

Black locust (*Robinia pseudoacacia* L.) trees, with an average diameter at breast height of 20 cm, collected from the Black Sea region of Turkey, and mimosa bark from the Aksu Leather Company in Turkey were used in the production of particleboards.

The raw materials were reduced to chips using a commercial chipper, and a ring type flaker was used to break the chips down to particle size. The particles were dried to 3% moisture content in a laboratory-type dryer and classified into 2 sizes using a vibrating horizontal screen for the core and face layers. Dried particles were mixed with urea formaldehyde resin (55% solid content and 1% ammonium chloride solution as a hardener), 9% for the core and 10% for the face, in a laboratory blender. The shelling ratio, the ratio of the face thickness to the total thickness of the panels, was 0.40 for all experimental panels. The mats (56.5 cm by 56.5 cm by 2 cm thick) were manually formed and were pressed in an electrically heated press using a pressure of 27.5 kg cm<sup>-2</sup>, at 150 °C for 5 min. All the panels were manufactured with an average target density of 0.68 g cm<sup>-3</sup>. Five different types of panel were made using various mixtures of bark. Bark was used only in the core layer of the panels. A total of 15 experimental panels were made in the laboratory.

Thirty samples were prepared for modulus of rupture (MOR), modulus of elasticity (MOE), internal bond

strength (IB), and thickness swelling (TS) tests (2 h immersion) based on EN specifications. These were conditioned at a temperature of 20 °C and 65% relative humidity before any tests were carried out (EN 310, 1993; EN 319, 1993; EN 317; 1993). Formaldehyde emission (FE) was conducted according to the DIN EN 717-3 (1996) standard (WKI-Bottle method). Three specimens were prepared to determine the FE of the panels. The dimensions of the samples were 50 x 450 mm, 50 x 450 mm, 50 x 50 mm, 50 x 50 mm and 25 x 25 mm for the MOR, MOE, IB, TS and FE tests, respectively.

Data for each test were statistically analyzed. ANOVA was used to test for significant differences between factors and levels. When ANOVA indicated a significant difference among factors and levels, a comparison of the means was carried out employing the Tukey test to identify which groups were significantly different from others.

## Results and Discussion

Mean values of MOE, MOR, IB strength, TS and FE, and statistical analysis results are shown in Table 1. Based on EN standards, 11.5 N mm<sup>-2</sup> for general uses, 13 N mm<sup>-2</sup> for furniture manufacturing, and 1600 N mm<sup>-2</sup> for furniture manufacturing are the minimum requirements for the MOR and MOE of particleboard panels, respectively (EN 312-2, 1996; EN 312-3, 1996). All types of panels made in this study satisfied the MOR and MOE requirements for general uses and furniture manufacturing, with the exception of panel types D and E.

The IB strength requirements are 0.24 N mm<sup>-2</sup> and 0.35 N mm<sup>-2</sup> for general-purpose boards and interior fitments, respectively. Except for panel types D and E the other groups were found to comply with IB strength values for general uses and interior fitments (including furniture).

Based on EN standards, particleboard should have a maximum thickness swelling value of 8%. Average thickness swelling of the specimens ranged from 8.23% to 14.47% (Table 1). All the panels had higher thickness swelling values than those allowed by EN 317 standard (max. 8% for 2 h immersion). These high values may be related to the fact that no wax or other hydrophobic substance was used during particleboard manufacture. It

Table 1. Properties of particleboard and Tukey test results.

Panel Type	Bark Usage (%)	MOR* (N mm <sup>-2</sup> )	MOE* (N mm <sup>-2</sup> )	IB* (N mm <sup>-2</sup> )	TS* (%)	FE* (mg CH <sub>2</sub> O)
A	0	14.93 (a)	1804.02 (a)	0.48 (a)	14.47 (a)	1.45 (a)
B	6.25	14.76 (a)	1793.36 (a)	0.46 (a)	14.31 (a)	1.38 (a)
C	12.50	13.48 (b)	1679.94 (b)	0.36 (b)	12.66 (b)	1.05 (b)
D	25	12.24 (c)	1545.33 (c)	0.27 (c)	10.54 (c)	0.83 (c)
E	50	11.07 (d)	1414.25 (d)	0.18 (d)	8.23 (d)	0.66 (d)

\* MOR: modulus of rupture; MOE: modulus of elasticity; IB: Internal bond strength; TS: thickness swelling and FE: Formaldehyde emission.

Note: Different letters in parentheses represent statistical significance while the same letters indicate a similarity of differences ( $P < 0.05$ ).

seems that additional treatment of particles, such as acetylating or heat treatment of particles and coating of the particleboard surfaces with melamine-impregnated paper, would improve the dimensional stability of the particleboards (Volz, 1973; Wisherd and Wilson, 1979; Hall et al., 1984; Hofstrand et al., 1984; Tisler et al., 1986; Nemli, 1995).

The addition of 6.25% bark did not significantly affect particleboard modulus of rupture, modulus of elasticity, internal bond strength, thickness swelling or formaldehyde emission. However, increasing bark content up to 25% statistically reduced the mechanical properties, thickness swelling and formaldehyde emission of the particleboard (Table 1).

The decrease in formaldehyde emission and thickness swelling values may be due to the high amounts of polyphenolic extractives and tannin in the bark. These compounds can react with formaldehyde in the adhesive, even at normal temperatures, to yield condensation products with high bonding potential. In addition, reactions between the phenolic extractives, washed acids in the bark and formaldehyde in the adhesive could cause an improvement in formaldehyde emission.

It has been reported that bark usage improved the formaldehyde emission and thickness swelling of the panels made from various species (Chen and Paulitsch, 1974; Roffael, 1982; Prasetya and Roffael, 1991; Lelis and Roffael, 1995; Kalaycıoğlu and Nemli, 1997). Decreases in mechanical properties may be due to the

porous structure of the bark. This structure causes a higher adhesive absorption ratio than that of wood particles. For this reason, adhesive levels between the particle surfaces are insufficient.

## Conclusions

In this study, various amounts of mimosa bark were used to make particleboard panels. In the light of the preliminary results of this study, mimosa bark could be used in particleboard manufacture. The addition of 6.25% bark did not significantly affect modulus of rupture, modulus of elasticity, internal bond strength, thickness swelling or formaldehyde emission. However, increasing bark content up to 12.50% reduced the mechanical properties and improved the formaldehyde emission and thickness swelling of particleboard. It is suggested that bark levels should not exceed 12.50% in the panels if these are to maintain their desirable properties. It was stated that one of the methods of lowering formaldehyde emission from particleboard was the use of mimosa bark as a raw material in the core.

Further studies should be performed to examine mimosa bark as a raw material in the surface layers to evaluate other panel properties such as screw holding capacity, linear expansion, and overlaying ability with surface coatings. Moreover, different tree barks and mixtures, shelling ratios, and resin contents should also be considered in the production of different panels to better understand manufacture and raw materials.

## References

Blanchet, P., A. Cloutier and B. Riedl. 2000. Particleboard made from hammer milled black spruce bark residues. *Wood Science and Technology*, 34: 11-19.

Chen, T.Y. and M. Paulitsch. 1974. Inhalstoffe von nadeln, ride und holz der fichte und kiefer und ihr einfluss auf die eigenschaften daraus hergesteller spanplatten. *Holz als Roh und Werkstoff*, 32: 394-401.

- DIN EN 717-3. 1996. Holzwerkstoffe bestimmung der formaldehydabgabe Teil 3: formaldehydabgabe nach der Flaschen methode.
- EN 310. 1993. Wood based panels, determination of modulus of elasticity in bending and bending strength. European Standardization Committee, Brussels.
- EN 317. 1993. Particleboards and fiberboards, determination of swelling in thickness after immersion. European Standardization Committee, Brussels.
- EN 319. 1993. Particleboards and fiberboards, determination of tensile strength perpendicular to plane of the board. European Standardization Committee, Brussels.
- EN 312-2. 1996. Particleboards-Specifications-Part 2: Requirements for general-purpose boards for use in dry conditions. European Standardization Committee, Brussels.
- EN 312-3. 1996. Particleboards-Specifications-Part 3: Requirements for boards for interior fitments (including furniture) for use in dry conditions. European Standardization Committee, Brussels.
- Hall, H.J., R.O. Gertjajensen, E.L. Schmidt, C.G. Carled and R.C. DeGroot. 1984. Preservative effect on mechanical and thickness swelling properties of aspen wafer board. Proceedings of a Workshop on Durability of Structural Panels, Pensocola, USA.
- Kalaycioğlu, H. and G. Nemli. 1997. Properties of structural particleboard prepared from the bark of pinus brutia. Proceedings of XI. World Forestry Congress, pp. 50, Antalya, Turkey.
- Lehmann, W.F. and R.L. Geimer. 1974. Properties of structural particleboards from douglas-fir forest resudies. Forest Products Journal, 24: 17-25.
- Lelis, R. and E. Roffael. 1995. Über die reaktivitat von douglasiensplint- und-kernholz und deren heisswasserextrakte gegenüber formaldehyd. Holz als Roh und Werkstoff, 53: 12-16.
- Nemli, G. 1995. Effects of melamine impregnated paper coating on the technological properties of particleboard. MSc. Thesis, Faculty of Forestry, Karadeniz Technical University, 89 pp., Trabzon, Turkey (in Turkish).
- Nemli, G. 2000. Effects of surface coating materials and process parameters on the technological of particleboard. PhD Thesis, Faculty of Forestry, Karadeniz Technical University, 181 pp., Trabzon, Turkey (in Turkish).
- Nemli, G., H. Kirci and A. Temiz. 2004. Influence of impregnating wood particles with mimosa bark extract on some properties of particleboard. Industrial Crops and Products, 20: 339-344.
- Prasetya, B. and E. Roffael. 1991. Untersuchungen über das verhalten extraktstoffreicher rinden in holzspanplatten zur reaktivitat de fichtenrinde gegenüber formaldehyd. Holz als Roh und Werkstoff, 49: 341-344.
- Reineke, L.H. 1965. Use for forest resudies. Res. Note FPL-092. USDA Serv., Forest Products Laboratory, Madison, WI, USA.
- Roffael, E. 1982. Die formaldehydabgabe von spanplatten und anderen werkstoffen. DRW-Werlag, Stuttgart.
- Tisler, V., E. Galla and E. Pulkkinen. 1986. Fractionation of water extract from picea abies bark. Holz als Roh und Werkstoff, 44: 427-431.
- Volz, K.R. 1973. Herstellung und eigenschafteen von fichen-kiefer-und buchrindenplatten. Holz als Roh und Werkstoff, 31: 221-229.
- Vyse, B. 1993. European formaldehyde regulations. European Plastic Laminates Forum, pp. 107-111. Köln-Germany.
- Wisherd, K.D. and B. Wilson. 1979. Bark as a supplement to wood furnish for particleboard. Forest Products Journal, 29: 35-40.