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A Novel Phenol – Based Composite Production: Features and Characterization

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Abstract. The aim of this study is to investigate on manufacturing new tannin phenol-formaldehyde resin as adhesive in paulownia composite. For this purpose, renewable tannin was introduced in the classic adhesive formulation in order to supply a part of phenol–formaldehyde (PF). Variables were substituted tannin with phenol at two levels (0%, 10 % and 20%) and press temperature (150c° and 170c°). plywood panels were manufactured in laboratory. Mechanical (MOR and MOE and) and physical (TS and WA) properties of panels were evaluated according to ASTM standard. Data collected based on factorial design and using SPSS software were analyzed. The Results showed that substitution tannin with phenol had slight effect on mechanical properties but when press temperature increased mechanical properties were improved. Physical properties of plywood panels bonded with tannin–PF resins (20:80) were better than plywood panels PF made.

Introduction

Reduction of big diameter trees in natural forests caused plywood industry to reduce their capacities and some of them forced to stop production. Paulownia from plantations is a light species and very fast grown it would be considered as an alternative for trees from natural forest. On the other hand oil originated adhesive prices is rising up annually so that wood composite products manufactured using this high price adhesive cannot compete in market/3/. Recently tannin has attracted scientist because of its phenolic nature. Dalton (1950 and 1953) started basic research on tannin based adhesive then plamly (1959 and 1966) continued Dalton work and proved that Acasia bark contain material which can be used for manufacturing plywood/5/. Torkaman investigated on extractives of some hardwoods and concluded that extracts of this trees has components which can react with formaldehyde/7/. In this study feasibility of manufacturing plywood from paulownia using tannin based phenol formaldehyde resin was investigated.

Methods and material

Paulownia trees cut from a plantation located in forest of Gorgan university/ Iran. Logs were debarked and converted to layers in local plywood factory. Veneers were dried to 2% in a drier. Commercial resol-type liquid PF resin (P/F = 0.45, which is a plywood binder resin) was supplied by local company. A phenol formaldehyde resol with a solids content of 63% and a viscosity of about 450 cp was prepared using a 2.2:1 formaldehyde phenol ratio and 7.3% (w/w) of NaOH. The adhesives were prepared by copolymerization at room temperature of tannins in variable quantities with resols. Two levels of resin powder were used (10% and 20% based on oven dry weight of resin).

5 ply laboratory plywood panels of dimension 400mm×400mm×15mm were prepared from 3mm thickness Paulownia veneers of moisture content of 2% at a glue mix spread of 120 g/m2 single glue line. Glued layers were assembled and hot pressed under 15bar pressure for 10 minutes. Two press temperatures (150c° and 170c°) were used for hot pressing. Panels were kept in a conditioned room with a relative humidity of 65% and a temperature of 20 C° until they reached equilibrium moisture content. Bending strength and modulus of elasticity values of plywood panels were determined according to EN 310 (1993). Water absorption and thickness swelling (TS) after 2 and 24 h immersion of the samples were determined according to ASTM standards.

Results

The mean values of Physical and mechanical properties of plywood panels are given in Table 1 and 2. In table 1 effect of tannin on modulus of rupture(MOR), modulus of elasticity (MOE), water absorption (WA) were not significant but this effect on thickness swelling (TS) was significant with 95% confidence. The results of effect of press temperature on physical and mechanical properties of paulownia plywood are presented in table 2.

The results obtained for effect of press temperature on MOR and MOE is showed that no differences were noticeable between treatments, but its effect on thickness swelling and water absorption is significant. Interaction effects of press temperature and tannin on water absorption after two 2 and 24 hours immersion is shown in fig.1 and 2.

Table.1 Effect of tannin on physical and mechanical properties of plywood

Value of Tannin(%)	Water adsorption (%)		Thickness swelling (%)		Bending strength (MPa)		Modulus of elasticity (MPa)	
	2h	24h	2h	24h	Parallel-to-grain	Perpendicular-to-grain	Parallel-to-grain	Perpendicular-to-grain
0	27.3	48.82	5.2[b]	6.53[b]	55.13	35.2	10426.5	5364.91
10	27.84	49.74	5.18[b]	6.97[b]	51.44	30.09	9873.94	4673.63
20	26.54	48.29	3.36[a]	4.61[a]	55.83	31.29	9952.89	3928.88
Sig.	ns	ns	*	*	ns	ns	ns	ns

ns: non signification * :sig.95%

Table.2 Effect of Press temperature on physical and mechanical properties of plywood

Temperature C°	Water adsorption (%)		Thickness swelling (%)		Bending strength (MPa)		Modulus of elasticity (MPa)	
	2h	24h	2h	24h	Parallel-to-grain	Perpendicular-to-grain	Parallel-to-grain	Perpendicular-to-grain
150	30.36	52.19	5.39	7.03	50.7	32.42	9475.59	4393.05
170	24.09	45.71	3.77	5.04	57.55	33.95	10693.06	4918.55
Sig.	ns	ns	*	*	ns	ns	ns	ns

ns: non signification * :sig.95%

Water absorption of control panels (0:100 T:P) is lower than all other panels. Addition tannin to PF, its reactivity with formaldehyde increases therefore stronger bond is formed which prevent water penetration inside the panel. When press temperature increased from 150C° to 170C° water absorption of panels decreased more which indicates that bond between layers became stronger. After 24 hours immersion samples the difference between control panels and experimental panels were remained however the difference between other panels removed.

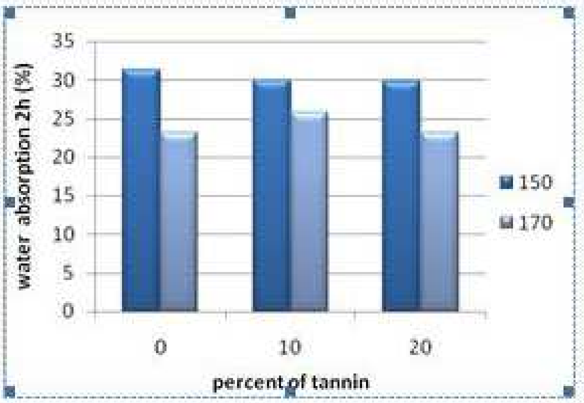

Fig.1. Interaction effects of press temperature and tannin on water absorption after 2h immersion

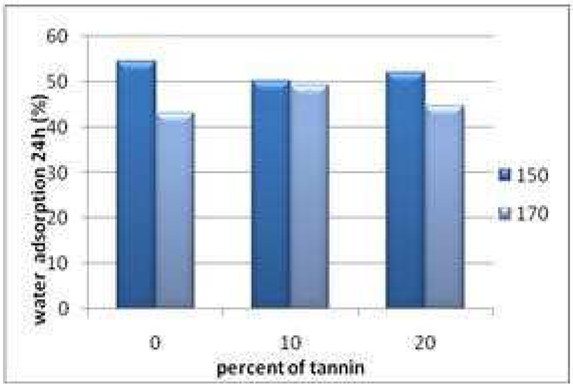

Fig.2. Interaction effects of press temperature and tannin on Water absorption after 24h immersion

Interaction effects of press temperature and tannin on thickness swelling after 2 and 24 hours immersion in fig.3 and fig.4. As seen, effect of tannin on thickness swelling is much outlined. Adding tannin to PF resin causes considerable reduction (40%) in thickness swelling of all experimental panels while thickness swelling of control panels and panels made using 10% tannin and pressed at 150 c° were high (around 6%).

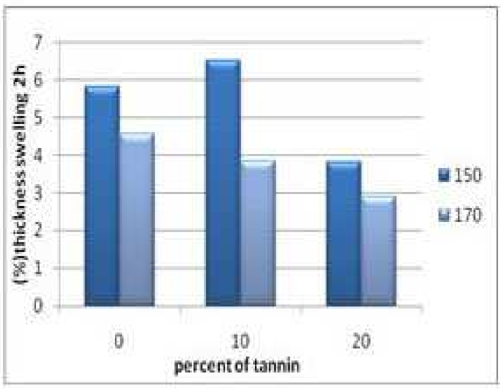

Fig.3. Interaction effects of press temperature and tannin on Thickness swelling after 2h immersion.

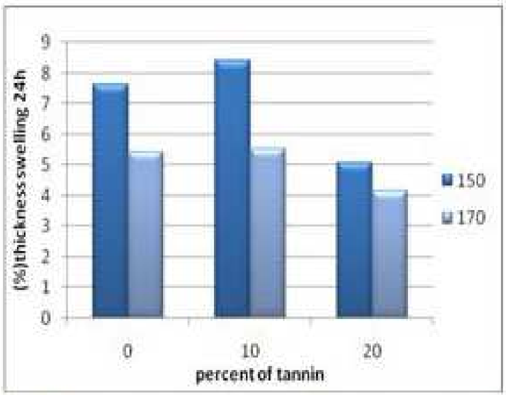

Fig.4. Interaction effects of press temperature and tannin on Thickness swelling after 24h immersion

Effect of tannin and press temperature on MOR of panels when loaded in parallel to grain direction is shown in fig.5. As seen, panels made of PF containing 20% tannin and pressed at 170C° showed the highest MOR which indicates that tannin has significant effect on MOR.

When panels were loaded in perpendicular to grain direction, control panels pressed at 170 c° had the highest MOR (fig.6). Effect of press temperature and tannin on MOE is shown in fig.7. As seen, panels pressed at 170 c° presented higher MOE than those pressed at 150 c° which indicate

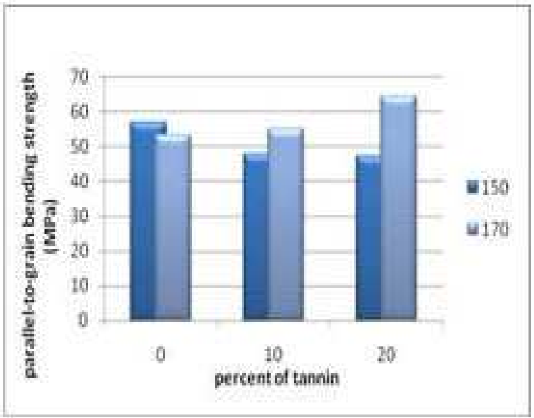

Fig.5. Interaction effects of press temperature and tannin on parallel to grain MOR

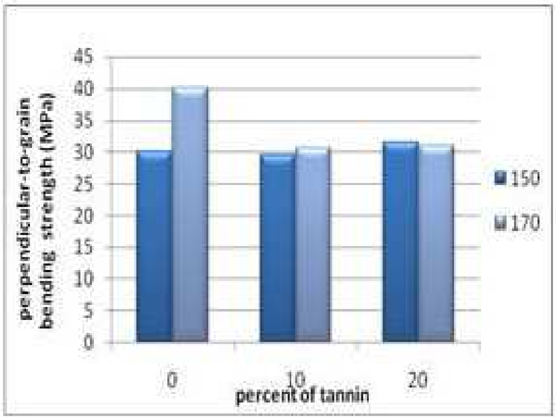

Fig.6. Interaction effects of press temperature and tannin on perpendicular to grain MOR.

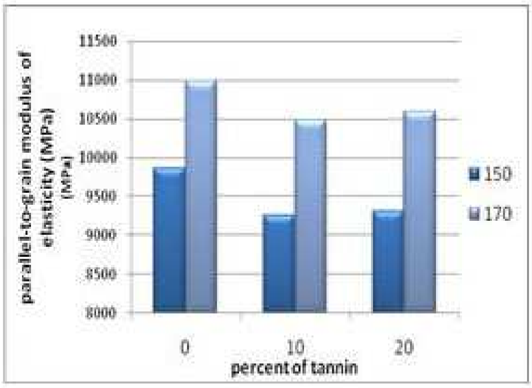

Fig.7. Interaction effects of press temperature and tannin on parallel to grain MOE

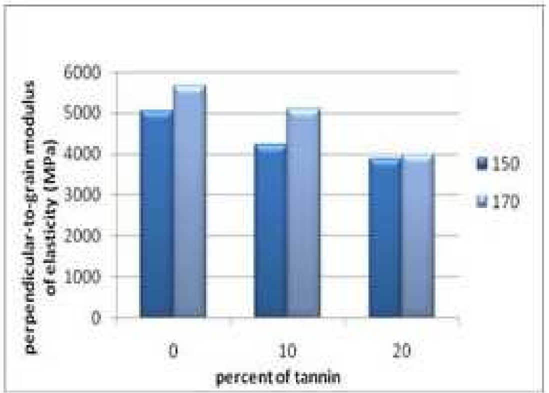

Fig.8. Interaction effects of press temperature and tannin on perpendicular to grain MOE

that effect of press temperature was stronger than effect of tannin. But when panels were loaded in perpendicular to the grain direction effect of tannin became more pronounced. However control panels and panels containing 10 percent tannin present high

Summary

Generally, it can be said that based on results of this study effect of tannin was more pronounced on thickness swelling or dimensional stability. On the other hand mechanical properties of paulownia plywood panels bonded with tannin based PF resin is promising. There is a relationship between increased addition of tannin and reduction in bond strength properties. However, it has been demonstrated that tannin could be used to replace 20% of the PF resins used to bond plywood panels, without adversely affecting bond properties. Panels manufactured using press temperature of 170c° and PF resin containing 20% tannin would meet standard requirements. Petrochemical PF could substitute in resols in industrial applications by addition of tannin extract.

References

[1] Annual Book Of ASTM Standards, West Conshohcken,AA.Vol04,10(2002)

[2] F. Faraji, Investigation On Feasibility Of Producing Moisture Resistant Plywood From Poplar, Research Report. Gorgan University Of Agricultural Sciences.(2005)

[3] S. Kazemi Najafi And K. Doosthosseini. Magazin Of Iran Natural Resources. Vol 23-31. (2000)

[4] L. Jamali Rad, , Doosthosseini, K; And S. A. Mirshokraei. Magazin Of Iran Natural Resources. Vol.60(3) (2007),P981-988.

[5] A. Moubarik, , A. Pizza, A. Allal, And B. Charrier. In: Indestrial Crops And Products,Vol. 30(2009) P.188-193.

[6] P.M. Stefani, C. Pena, R.A. Ruseckaite, J. C. Piter And I. Mondragon.In:Bioresource Technology, Vol.99 Issue13 (2008), p. 5977-5980.

[7] J. Torkaman, K. Doosthosseini, And A.J. Latibari. In: Magazin Of Iran Natural Resources, Vol.57 (2005), p.345-352.

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