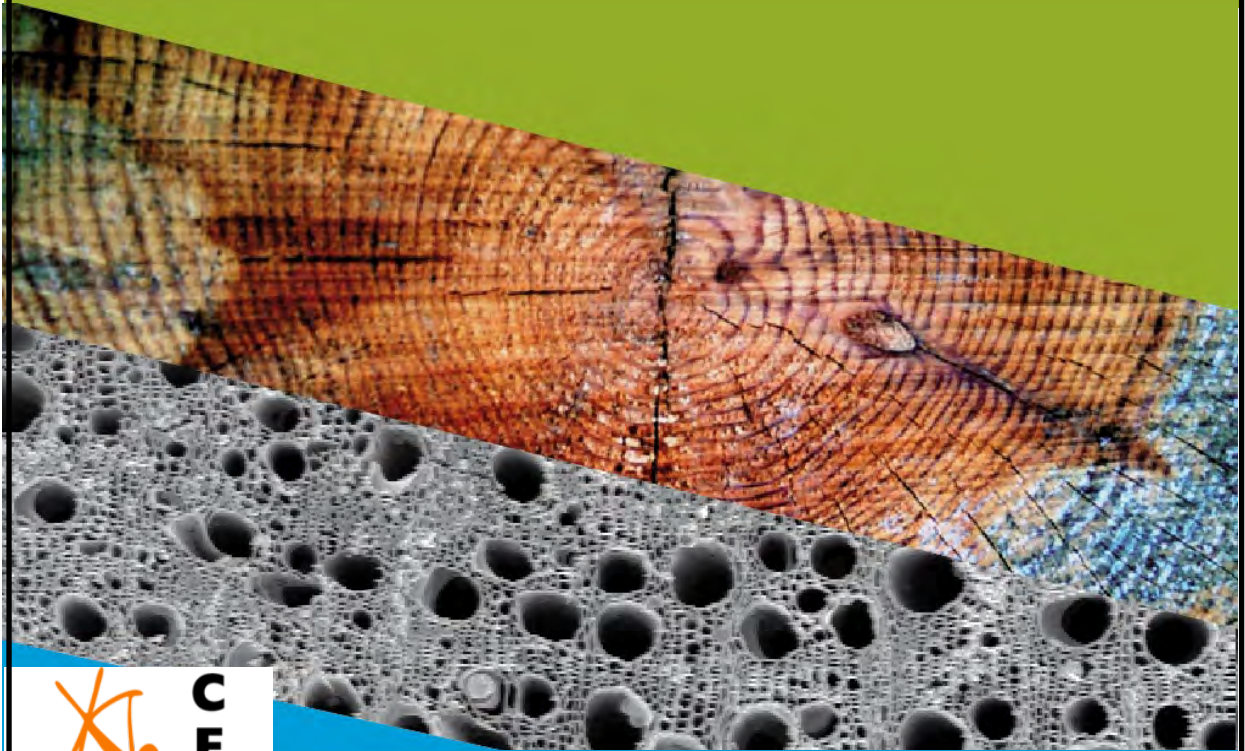


11èmes Journées Scientifiques du GDR3544 Sciences du bois

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Table des matières

Éditorial	3
Comités	4
Soutiens et sponsors.....	5
Programme des Journées.....	6
Groupes de travail.....	8
Visites.....	13
Hommage à Daniel Guitard.....	14
Présentations orales invitées	15
Posters / présentations flash.....	32
Liste des participants	347
Accès	351

Posters et présentations flashes

Session A

Mercredi 16/11

A01	Ali ABDOULKADRI ABDOULLAYE	Agap, Montpellier	Histochimie des poches libériennes accumulatrices de gomme arabique chez l' <i>Acacia senegal</i> (L) Willd.
A03	Kyle AGUILAR	Lermab, Nancy	Production de mycocomposite à partir des déchets de l'industrie bois
A04	Peyman AHMADI	Biowoeb, Montpellier	Improvement of physical and mechanical properties of bagasse particle board by bagasse treatment with tannin/furfural complex
A05	Alaa AL FAYE	UM-msb, Montpellier	Caractérisation par analyse vibratoire des propriétés viscoélastiques d'échantillons de bois dans leur diversité naturelle
A06	Martian ASSEKO ELLA	Pascal, Clermont-Fd	Modélisation rhéologique du comportement mécanosorptif et viscoélastique
A07	Benjamin AUDIARD	Cepam, Nice	Le signal isotopique ($\delta^{13}C$) des charbons de bois préhistorique comme proxy paléoenvironnementale diachronique et spatial ? : Référentiel actuel et résultats archéologiques dans le Sud-Est de la France.
A08	Elham AZADEH	Lermab, Epinal	Furfurylation du bois de hêtre en présence de tanins ou/ou d'acide fulvique
A09	Eric BADEL	PIAF, Clermont-Fd	Chérie, on a agrandi la structure du bois en 3D: un projet collaboratif de science ouverte
A10	Sandrine BARDET	LMGC, Montpellier	Master Sciences du Bois À l'Université de Montpellier : bilan après 1 an
A11	Ingrid BERTIN	Cepam, Nice	Revealing nature and function of prehistoric plant-based artefacts: preservatives removal and biomolecular archaeology
A12	Juliette BOIVIN	Labomap, Cluny	Détermination de la transmittance de la lumière dans des essences locales (hêtre, peuplier, chêne, douglas)
A13	Arthur BONTEMPS	Pascal, Clermont-Fd	Analyse des essais de fluage sur des poutres entaillées de sapin pectiné (<i>Abies alba</i>) à l'état vert en éliminant les effets de rupture
A14	Romain BORDAGE	3SR COMHET, Grenoble	Vers un bois plus fort et plus propre que les composites structuraux actuels
A15	Thomas BOURSAT	LMGC, Montpellier	Mécano-biologie du cambium : influence des interactions mécaniques entre bois et écorce sur la formation du bois
A16	Joseph BRIHIEZ	MNHM, Paris	Des charpentiers dans les forêts. Les perspectives du travail manuel avec du bois vert en charpente.
A17	Romain CHEVALIER	Gascogne Bois, Bordeaux	Numerical multi-scale homogenization of hygro-mechanical properties of pinus pinaster (ait.) Lamellae constituting glued laminated timber
A18	Yi Hien Chin	Pascal, Clermont-Fd	Reduction of wood thermal conductivity by delignification
A19	Julien COLMARS	INSA, Lyon	Patrimoine bois et problèmes de mécanique des structures : deux cas d'étude en restauration de mobilier bois.
A20	Daniele DA COSTA	LIMBHA, Nantes	Expérimentation test d'un outil numérique d'aide à l'apprentissage de l'identification des essences de bois

Improvement of physical and mechanical properties of sugarcane bagasse particle board by bagasse treatment with tannin/furfural complex

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Keywords: bio-composites; tannin; furfural; resin; bagasse waste; physico-mechanical properties

Context and objectives

Wood is an anisotropic material composed of polymers such as cellulose, hemicelluloses, and lignin as primary cell wall components (Sandberg et al 2021). As a result, it is susceptible to moisture-induced dimensional changes, which severely limits its use in a variety of applications (Bergman 2021). Wood-based composites are popular alternatives to solid wood, as they present less disadvantages than raw wood. The increasing trend toward the use of wood and wood-based products has led to an expansion in capacity and diversity of uses (Ali et al 2019). In Iran, difficulties in the supply of raw materials for particleboard production have prompted manufacturers to consider the introduction of a suitable alternative, especially since the implementation of the "Forest breathing plan" that banned wood exploitation (Gilanipoor et al 2021). Meanwhile, agricultural wastes (such as sugarcane bagasse) provide a renewable and environmentally friendly solution to meet this massive demand. Bagasse is a fibrous material that is produced in millions of tons each year in some countries, including Iran. Most of this lignocellulosic waste is either burned as fuel or sent to landfills (Han and Wu 2004). Using bagasse as a raw material for making particleboard is an efficient way to reuse this material and compensate the shortage of wood in the panel industry. However, its use is often limited due to its high moisture absorption capacity (Agustina et al 2019). Therefore, panels made of bagasse particles need to be treated to improve their physico-mechanical properties: using a pre-treatment, during the manufacturing, or with a post-treatment (Reinprecht 2016). The appropriate treatment method depends on the application of the use and the risks involved in service. Various methods have been used to improve the properties of boards, such as acetylation (Jonoobi et al 2010), heat treatment (Carvalho et al 2015), and resin impregnation (Yang et al 2007). The purpose of this research was to impregnate bagasse particles with a suitable tannin-furfural resin (TFu) to improve the bending, internal bonding strength, and physical properties of manufactured particleboards. In addition, tannin-based adhesives were used as environmentally friendly binders to manufacture the panels.

Material and methods

Pre-treatment of tannin and furfural

Quebracho tannin (Persianchimi Company) was dissolved in a 10% w/w NaOH (Neutron Pharmaceutical Chemistry Company) solution to obtain a 20% w/w tannin solution. The tannin

solution was heated to 80°C for 30 minutes before adding 8% NaSO (Neutron Pharmaceutical Chemistry Company) (w/w based on the dry tannin weight). The solution was stirred at 80°C for 30 minutes. The pretreatment for furfural (Behran Oil Company) was done by adding 5% v/v H₂SO₄ (Neutron Pharmaceutical Chemistry Company) (at 20% v/v) to the furfural and stirring for 20 minutes at 21°C (Yi et al 2016).

Resin synthesis

The previously obtained tannin aqueous solutions (20% w/w) were prepared under vigorous stirring to add furfural. Subsequently, 50% of furfural (based on tannin dry weight) was added to the solution. The resin pH was adjusted to 4.5 with NaOH (33% w/w) according to Ahmadi et al (2022).

Bagasse treatment

Anhydrous sugarcane bagasse were treated using an impregnation method with various tannin/furfural resin (TFu) concentrations. Impregnation was done with 5, 10, and 15% w/w formulations of tannin/furfural resin. After the impregnation, the curing operation of the resin was carried out by heating at 120° C. Resin uptakes were calculated with the oven-dried weight of the bagasse before and after impregnation.

Particleboard manufacturing

Tannin-Formaldehyde (TF), Tannin-Formaldehyde modified by Furfural (TFFu), Tannin Hexamine (TH) (all synthesized in the laboratory, according to Tondi (2017), and Melamine-urea-formal (MUF) (Samad Manufacturing and Industrial Company) were used to bond the treated bagasse. After the curing of resin and drying of bagasse, particleboards were prepared with the dimensions of 400×400×10 mm and a target density of 0.650 g/cm³. Each adhesive type was added at 12% (based on the dry weight bagasse) in a rotary blending machine. The bagasse mixtures were hot-pressed at 160°C for MUF and 190°C for tannin-based adhesive (TF, TFFu, TH) with 40 kg/cm² pressure for an 8–12-minutes press closing time (depending on the adhesive). Three boards were produced from each treatment.

Physical and mechanical properties

Bulk density, Water Absorption (WA), and Thickness Swelling (TS) after 2 and 24 h of soaking in water (WA2h and WA24h; TS2h and TS24h, respectively) were determined according to EN 317 (1993). The Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) were investigated according to EN 310 (1993). The Internal Bonding (IB) strength was investigated under dry and wet conditions according to EN 319 (1993). Data analysis was performed by the two-way ANOVA method in SPSS software. The effect of adhesive and resin concentration were investigated.

Results and discussion

The TFu resin uptake increased linearly with treatment concentration (Fig. 1).

Tab. 2 shows the physical and mechanical properties of TFu-impregnated particleboard. The results showed that the impregnation of bagasse with TFu resin prevents water absorption by the boards during the water-immersion procedure. This was possibly caused by the obstruction of vacant cell wall gaps. The particleboard treated showed less thickness swelling than the untreated board. Irrespective of the type of adhesive used, TS decreased significantly, as a result of the loading of resin ($p = 0.000$). The boards saturated by TFu15% swelled the least. Unreachable resin solids in cell walls may improve particleboard water and moisture resistance

(Yang et al, 2007). MUF as an exterior adhesive also performed well in terms of dimensional stability of bagasse particleboard when compared to samples bonded with tannin-based adhesives. The panels bonded with TF adhesive swelled by almost 24% after 24 hours in the water, while the MUF+TFu (15%) panels swelled by less than 8%. The findings also demonstrate that the MOR and MOE values of particleboards TFu-resin-impregnated were higher than those of MUF control particleboards and that the MOE and MOR increased with increasing resin loading. This can be explained by the increase in bagasse density as a result of saturation with the resin. Furthermore, the amount varies between adhesives. With increasing resin concentration for treatment up to a concentration of 5%, the IB strength has increased. However, a higher increase in the concentration of resin reduces internal resistance to adhesion. This is due to the reduction in the quantity of bagasse particles in the boards at constant board density, which in turn reduces the compaction of the boards (Kajita and Imamura 1991).

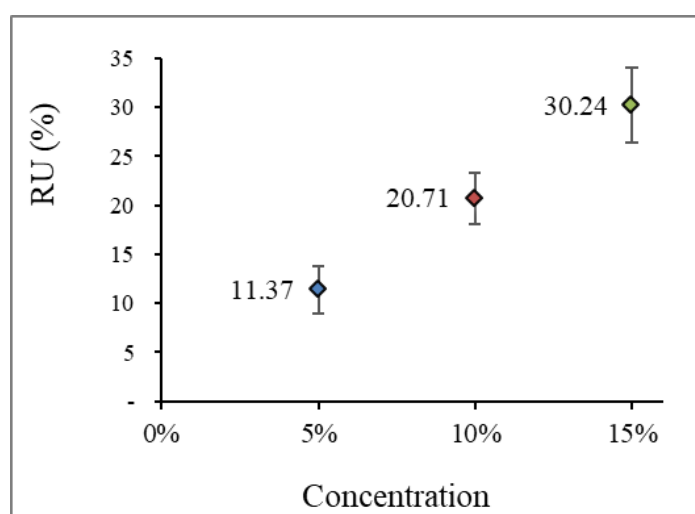


Fig. 1: Resin uptake (RU) content in treatments with different concentrations of TFu (N=3 replicates for each experiment)

The effect of adhesive type, the concentration of resin to impregnation, and the interaction between the type of adhesive and the concentration of resin on different physical and mechanical properties of TFu -impregnated particleboard are summarized in Tab. 3.

Tab. 2: Results of physical and mechanical tests on the different manufactured boards

Description of treatments			Results							
Adhesive Type	TF resin concentration (%)	Bulk density (g/cm ³)	WA (%)		TS (%)		MOR (MPa)	MOE (MPa)	IB (MPa)	
			2 h	24 h	2 h	24 h			DRY	WET
TF	-	0.650	14.43	61.62	9.05	23.96	9.53	1023.4	0.25	-
	TFu(5%)	0.668	12.76	52.10	8.30	20.32	10.43	1143.8	0.27	-
	TFu(10%)	0.695	12.00	43.09	7.03	19.23	11.23	2645.8	0.23	0.05
	TFu(15%)	0.764	10.90	34.12	7.14	12.84	15.73	3234.5	0.21	-
TFFu	-	0.598	15.02	58.10	8.00	19.98	10.09	1425.9	0.25	-
	TFu(5%)	0.737	14.40	39.26	7.01	16.64	13.98	1245.6	0.24	-
	TFu(10%)	0.754	13.01	32.36	6.34	15.28	15.73	3223.5	0.24	0.05
	TFu(15%)	0.781	11.40	28.16	6.01	10.08	16.12	3975.8	0.23	-
TH	-	0.665	14.47	47.04	7.08	18.01	14.32	2013.5	0.27	-
	TFu(5%)	0.702	13.04	31.23	6.15	14.11	15.98	3953.4	0.26	0.05
	TFu(10%)	0.736	9.90	29.40	6.00	13.83	17.59	3684.6	0.27	0.06
	TFu(15%)	0.798	9.37	27.94	5.98	9.09	18.78	4046.8	0.23	-
MUF	Control	0.656	14.40	43.74	6.90	15.96	14.03	2567.9	0.30	0.07
	TFu(5%)	0.718	13.87	35.51	5.15	13.40	20.34	4829.6	0.32	0.04
	TFu(10%)	0.720	10.01	35.05	5.00	9.90	21.65	5013.4	0.27	0.08
	TFu(15%)	0.783	8.04	22.89	4.00	8.00	30.54	5322.4	0.27	0.09

N= 6 replicates for each experiment

Tab. 3. Effect of adhesive type concentration on different physical and mechanical properties of TFu-impregnated particleboard

Properties	density (g/cm ³)	WA (%)	TS (%)	Bonding properties		IB (MPa)	
				MOR (MPa)	MOE (MPa)	DRY	WET
Adhesive type	NS	*	*	*	*	*	*
Concentration	NS	NS	*	*	*	*	*
Adhesive type * concentration	NS	NS	NS	*	*	NS	*

*: Significant difference at the corresponding confidence level is 95%, ($p < 0.05$)
NS: No significant difference ($p > 0.05$)

Conclusion and perspectives

A review of the studies indicates that the impregnation of bagasse particles significantly improves water absorption and dimensional stability values. The TS and WA of particleboard decreased as the TF resin content in the bagasse particles increased. The mechanical properties of boards (MOE and MOR) improved as resin loading in bagasse particles increased. Increased resin loading in bagasse particles up to 5% increases IB strength, but higher values of 10 and 15% result in a significant decrease. This work shows that treating bagasse with tannin-furfural resin to produce particleboard improves their physical and mechanical characteristics.

Acknowledgments

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