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ORIGINAL ARTICLE

Chemical composition of some plantation wood species (*Eucalyptus saligna*, *Cupressus lusitanica* and *Eucalyptus paniculata*) and assessment of compatibility with plaster

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Abstract The aim of this work was to evaluate the chemical composition of some plantation wood and the assessment of their compatibility with plaster. A quantitative analysis of the chemical composition each of the species (*Eucalyptus saligna*, *Cupressus lusitanica* and *Eucalyptus paniculata*) was carried out, followed by chemical compatibility evaluation using different types of wood particles. The quantitative analyses were carried out on wood powder of size between 0.27 and 0.30 mm. The results obtained were 2.4, 3.4 and 1.6% for ethanol–benzene extract (E_{AB}); 2.6, 3.2 and 2.4% for hot water extract (E_E); 12.4, 21.6 and 12.1% for 1% sodium hydroxide extract (E_S); 48.6, 48.4 and 40.4% for cellulose content (C); 34.8, 34.3 and 36.3% for lignin content (L); then 0.1, 0.6, 0.3% for ash content (C_E) respectively of *E. saligna*, *C. lusitanica* and *E. paniculata*. Chemical compatibility C_A was measured from hydration temperature curves as a function of time using the area method. The results showed that compatibility C_A decreased from 100 to 68% as the wood content in the composite increased up to 15% for all species and types of particles used. At this minimum value, the species was still considered as highly compatible in accordance with literature. Although compatibility is good, it decreased in the order *E. paniculata* followed by *E. saligna* and then *C. lusitanica*, the least compatible due to the inhibiting action of extractives.

Keywords Chemical composition · Compatibility · Plaster · Plantation wood species

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Introduction

Plaster is a cheap building material obtained from firing and grinding gypsum. It is used for decoration, molding forms and in the manufacture of pre-fabricated elements such as tiles, panels, etc. The principal disadvantages associated with plaster are its quality degradation by the weather (humidity for example); its fragility and its inability to withstand high loads in bending or in traction (Hamza et al. 2013). One of the way researchers are trying to reduce this fragility is to reinforce plaster with fibre to improve mechanical properties. Researchers have been trying for several years to replace the usual reinforcement agents (glass, asbestos or polymer fibres) with organic reinforcements such as sisal, kraft pulp or cellulose fibres (Ebanda 2012). This has been in a bid to avoid the environmental defects of earlier fibres but also because natural fibres are easily degradable and non-toxic. Composites containing natural fibres have numerous advantages such as low cost, low density, high toughness, acceptable specific strength properties and ease of processing, separation and biodegradability (Lee et al. 2007). Biodegradability is one of the most important criteria in new manufactured materials. Now, researchers are trying to reinforce plaster not only with fibre but with wood particles. In wood composite materials, it is widely accepted that the performance of a composite, a structural material, depends mainly on the quality of the stress

transfer in the interphase, greatly influenced by the chemical compositon of the reinforcing agent and the binder (Lee et al. 2007). However, wood, in addition to macromolecular substances (such as cellulose, hemicellulose and lignin), contains substances of low molecular weight (extractives and minerals substances) which negatively affect the properties of such composites.

In Cameroon, about 600 wood species are listed of which 300 species are marketable but only 80 are so far commercially exploited (Ndikontar 2005). Among these species, plantations species are widely exploited with eucalyptus used as wooden electricity and telephone poles. For each species exploited, there is about 60% waste during harvest and processing, usually in the form of branches, bark, rejects and sawdust. During processing, waste wood is generally burnt as fuelwood or simply abandoned. Given that the wood industry produces such an enormous amount of waste, different presentations of wood particles could be gainfully used. Also, to cope with strong competition from the construction industry, the timber industry tries to increase the performance/cost ratio of its products by valorising waste in the production of material (composites or activated carbon) with good properties.

In Cameroon, this valorisation of waste wood is still in its infancy. Private companies like GTZ/ProPSFE are trying to valorise waste to produce energy by the steam method. At the Research Unit for Macromolecular Chemistry of the Applied Inorganic Chemistry Laboratory in the Faculty of Science at the University of Yaounde I, studies have produced activated carbon for the removal of organic and inorganic pollutants from water (Abuiboto et al. 2013) as well as wood–cement composites for new structural materials (Cheumani 2009; Fan et al. 2012) and useful wood extracts (Saha Tchinda 2015). Dai and Fan (2015) have valorised this waste by wood–gypsum composite materials but few studies have focused on the plaster–wood composites. Researchers have observed that, during the hydration process of wood–cement composites, the inhibiting action of extractives and sugars affects the mechanical properties of the composite realised (Fan et al. 2012).

In this study, the compatibility of plaster with three tropical plantation wood species was investigated in order to valorise the residues obtained from the exploitation of these species for reducing the fragility of plaster. The main objective of our study was to evaluate the chemical composition and the compatibility of three different wood particle presentations (wool, powder and fibres) with plaster in order to determine which fibres are the most suitable for wood–plaster composite boards in the view using this composite to withstand high loads in bending.

All tests were carried out in four replicates.

Materials and methods

Raw materials

Eucalyptus saligna and *Cupressus lusitanica* were obtained from North West Cameroon at latitude 9°–11°E and longitude 5°–7°E where the average temperature is 20 °C. *Eucalyptus paniculata* was harvested in the campus of the University of Yaoundé I situated at longitude 3°51′04″N and latitude 11°29′52″E. The samples were obtained from three trees of each species. The medium characteristics of the trees were: age = 20–30 years, Height = 10–15 m, heartwood diameter = 0.60–0.75 m. Samples were taken between 1.50 and 2.50 m above the ground. All samples were obtained using only heartwood in the length direction. These species were air-dried in the laboratory and reduced to wool, powder and fibre respectively. The various particles of wood were obtained as follows:

- Wood bark was removed and wood was grated with a metal scraper blade. A thin spongy material (called wood wool) of approximatively 1-mm thickness of various lengths was obtained.
- The trunk of wood was chipped using an electric planning machine. The chips obtained were reduced to sawdust using a cutter mill (Retsch SM 100). The sawdust obtained was sieved to retain powder of diameter less than 0.27 mm.
- Fibres were obtained by pulping chips using the nitric acid method described by Ndikontar and Noah Ngamveng (1990). In a flask containing a certain amount of wood chips, a 7.5% nitric acid solution was added to completely immerse the wood chips (2:1 v/m). The flask was then heated under reflux for 4 h in an oil bath at 85 °C. At the end of this step, the flask was cooled to room temperature and the fibres were abundantly washed with distilled water until neutral and returned to the flask for further treatment. A same volume of a 1% sodium hydroxide solution was added and the flask was again heated under reflux for 1 h at 100 °C in the oil bath. At the end of this alkaline extraction, the flask was cooled and the fibres were abundantly washed with distilled water, filtered and stored in distilled water for further use.

Chemical composition of wood species

Quantitative analyses were carried out in accordance with the Technical Analysis for Pulp and Paper Industry (TAPPI) methods. All weighing was done on a Sartorius (1/10,000 g) analytical balance.

Ethanol–benzene extraction (E_{AB})

Ethanol–benzene extraction is used to remove tanins, resins, gums, essentials oils and colorants in wood (Tappi Test Methods 1997). The ethanol–benzene mixture (1:2 v/v) was prepared from 96% ethanol and benzene (d = 0.878). Extraction was realised by lixiviation in a Soxhlet extractor, with a paper cartridge containing a mass of about 6–10 g (m) of wood powder with 220 mL of liquor, regulated in a manner to have six syphons per hour. After 7 h of extraction, time necessary to remove a maximum of extractives (colorless siphon was obtained), extractives were isolated by evaporating the solvent under reduced pressure and drying the crude extract at 50 °C in a vacuum oven for 1 h and then weighing. The yield of extractives (E_{AB}) was calculated as a percentage of oven-dried wood:

$$E_{AB} = \frac{m_{AB}}{m_d} \times 100 \quad (1)$$

where m_{AB} is the mass of ethanol–benzene extract and m_d the mass of oven-dried wood at 105 °C during 72 h (to constant mass). The mass of oven-dried wood was deduced from the mass m of wood weighed at ambient temperature by the formula (2)

$$S_i\% = \frac{m_d}{m} \times 100 \quad (2)$$

where S_i is the wood humidity at ambient temperature used to deduce the oven-dried mass of wood introduced into the cartridge for extraction by the following formula.

$$m_d = \frac{m \times (100 - S_i)}{100} \quad (3)$$

After extraction, the powder in the cartridge was washed with ethanol and ether, then conserved in a desiccator for the water extraction and further tests.

Hot water extraction (E_E)

15 g of dry extracted wood powder (with ethanol–benzene) were introduced into 100 mL of distilled water in an Erlenmeyer. The mixture was heated under reflux while stirring for 7 h. The residue was filtered on a previously weighed sintered glass crucible n° 4, washed with distilled water, dried at 105 °C for 12 h then weighed (Tappi Test Methods 1989). The amount of hot water extractives was calculated as a percentage of the oven-dried mass of sawdust:

$$E_E = \frac{m_d - m_e}{m_d} \times (100 - E_{AB}) \quad (4)$$

where m_e is the mass of the residue after hot water extraction, m_d is the over dried wood mass given by Eq. (3) and E_{AB} is the yield of wood extractives with ethanol–benzene given by the relation (1).

1% sodium hydroxide extraction (E_S)

15 g of dry extracted wood powder were introduced into 100 mL of 1% sodium hydroxide solution in an Erlenmeyer. The mixture was heated under reflux while stirring for 7 h (Tappi Test Methods 2002). The residue was retained on a previously weighed sintered glass crucible n° 4, washed with distilled water, dried at 105 °C for 12 h then weighed. The percentage of 1% sodium hydroxide extract was calculated by the following expression:

$$E_S = \frac{(m - m_s) \times (100 - E_{AB})}{m_d} - E_E \quad (5)$$

where m_s is the mass of wood powder after sodium hydroxide extraction, m_d is the mass of oven-dried extracted wood given by relation (3), E_{AB} is given by relation (1) and E_E is given by relation (4).

Cellulose content (C)

Cellulose was isolated using the Kürschner method (Tappi Test Methods 1989). 2 g of dry extracted wood powder were introduced into an Erlenmeyer containing 50 mL of nitro-ethanol mixture (1:4; v/v) prepared from 96% ethanol and 16 N nitric acid. The mixture was heated in a water bath under reflux for 1 h. The solution was then filtered using a weighed sintered crucible n° 4 and the residue was washed with ethanol, distilled water and ether respectively. The residue was dried for 12 h at 105 °C then cooled and weighed. The cellulose content (C) was calculated by the following expression:

$$C = \frac{m_c}{m_d} \times (100 - E_{AB}) \quad (6)$$

where m_c is the mass of the cellulose residue, m_E is given by relation (3) and E_{AB} is given by relation (1).

Lignin content (L)

Lignin was isolated by the Klason method (Tappi Test Methods 1989; Watanabe et al. 2004). 1.5 g of dry extracted wood powder was introduced into an Erlenmeyer and 30 mL sulphuric acid (H_2SO_4, 72%) were added progressively while stirring. The mixture was stirred for 1 h and then left at room temperature for 24 h. It was then diluted with distilled water to 3% and heated under reflux for 5 h. The residue obtained was separated from the liquid then washed with distilled water and dried at 105 °C. The lignin content was calculated by the following expression:

$$L = \frac{m_L}{m_d} \times (100 - E_{AB}) \quad (7)$$

where m_L is the mass of lignin residue, m_d is given by relation (3) and E_{AB} is given by relation (1).

Ash content (C_E)

A ceramic crucible containing 10 g of dry extracted wood powder was introduced into a furnace (type Nabertherm) at 425 ± 25 °C for 24 h. Then the crucible was cooled in a desiccator and weighed. The ash content (C_e) was calculated by the following expression:

$$C_e = \frac{m_{ce}}{m_d} \times 100 \quad (8)$$

where m_{ce} is the mass of ash residue and m_d is given by relation (3).

Hydration of wood plaster mixtures (calorimetry)

Hydration characteristics of plaster in various wood particles were determined using a double-walled Dewar flask and type K thermocouple connected to an ANRISTU 7200 multipoint recorder to monitor the temperature inside the Dewar flask as a function of time. This method was modified from BS 4550-3.8: 1978—Methods of testing cement—Part 3: Physical tests—Section 3.8 Tests for heat of hydration. The optimum water-to-plaster (W/P) ratio was firstly determined to ensure an optimised hydration process of a locally produced plaster in wood environment. This was carried out by hydrating 200 g of plaster with different volumes of distilled water ranging from 60 to 90 mL and the amount of wood powder of each species was also increased in order to determine the effect of wood content on compatibility. The required mass of all constituents was thoroughly mixed in a small polythene bag and each bag was then wrapped in aluminium foil. The thermocouple probe was pushed to the centre of the mixture using a short copper pipe and the mixture was completely wrapped with styro-foam and placed in the Dewar flask. The temperature versus time curves of cement–water mixture, wood–cement–water mixture and the ambient atmosphere were simultaneously and automatically plotted on the recorder which was able to take six readings simultaneously (Hachmi and Moslemi 1990; Ndikontar 2005; Fan et al. 2012). These parameters were used to plot the hydration curve $T = f(t)$ and to estimate the compatibility factor, C_A by the area method.

$$C_A = \frac{A_{wp} - A_o}{A_p - A_o} \times 100 \quad (9)$$

where A_{wp} is the area under the plaster–wood hydration curve, A_p the area under the pure plaster–water curve and A_o the area under the room temperature curve as a function of time. All mixtures were made in quadruplet and the result reported is a mean. The relative standard deviation of C_A and T was estimated at 5%.

Results and discussion

Chemical composition

Table 1 shows the average chemical composition of wood species unders study (an average of 3 trials). Uncertainties reported are standard deviations.

It was observed that the total amount extractives of wood using ethanol/benzene and hot water varied from 4.0 ± 0.5 to 6.8 ± 0.5% respectively for *E. paniculata* and *E. saligna*. This yield of extractives varied from one solvent to other and from one species to another. The results show that there the amounts of extractives in *C. lusitanica*, *E. paniculata* and *E. saligna* are general low compared to the high amount extractives generally encountered in tropical heartwood. But the values are in agreement with some literature read. In a study carried out on 22 tropical African wood timber species, Huang et al. (2009) found extractive contents between 18.2 and 1.8% but only six of the 22 species had extractive contents higher than 10%. Saha Tchinda et al. (2013, 2014); during the study of five Cameroonian wood species obtained less amount of extractives with water only in the case of padouk and movingui (less than 6%). Neiva and al. (2015) obtained the same results for the water extraction of *E. saligna*. According to Hachmi and Moslemi (1989) during their studies on compatibility of wood with cement cited by Herrera and Cloutier in 2008, if the hot water extractives contained is less than 7% there is good compatibility of wood with inorganic binders and in contrary case (hot water extractive higher than 7%) there is incompatibility with inorganic binders. Based on these results, the three species of wood can be considered to be fairly compatibility with plaster.

1% sodium hydroxide extract was almost the same for the two *Eucalyptus* species but *C. lusitanica* had a higher value of 21.6 ± 0.4. The ash contents in different species were very low (0.027–0.57) compared to 0.8 in *E. saligna* obtained by Neiva et al. (2015). Some species of Eucalyptus such as *Ecalyptus globulus* have very low ash contents (between 0.3 and 0.6%) (Neiva et al. 2014, 2015).

Cellulose contents varied from 40.4 ± 0.7 for *E. paniculata* to 48.6 ± 0.7 for *E. saligna*. This result is in good agreement with literature which states that in tropical wood, the cellulose content varies between 30 and 50% of dry mass of wood (Ndikontar and Noah Ngamveng 1997). The lignin content for the different species varied from 34.3 ± 0.3 for *C. lusitanica* to 38.4 ± 0.3 for *E. saligna*.

Table 1 Chemical composition of wood species

Constituents (%)	*Eucalyptus saligna*	*Cupressus lusitanica*	*Eucalyptus paniculata*
E_{AB}	2.4 (0.3)^{b}	3.4 (0.2)^{c}	1.6 (0.2)^{a}
E_E	2.6 (0.3)^{a}	3.2 (0.3)^{a,b}	2.4 (0.3)^{a}
E_T	5.0 (0.6)^{a}	6.8 (0.5)^{b}	4.0 (0.5)^{a}
E_S	12.4 (0.3)^{a}	21.6 (0.4)^{b}	12.1 (0.5)^{a}
C_E	0.092 (0.007)^{b}	0.57 (0.02)^{c}	0.027 (0.003)^{a}
L	38.4 (0.5)^{b}	34.3 (0.3)^{a}	36.3 (0.2)^{b}
C	48.6 (0.7)^{a,b}	48.4 (0.6)^{b}	40.4 (0.7)^{a}

Average values and SD were obtained on four replicates

The values with the same letter are not significantly different at the 5% significance level according to the student *t* test. The values in parentheses are standard deviations

Similar results were obtained by Dutt and Tyagi (2011) who obtained the values of 29.3 and 33.2% for *Eucalyptus grandis* and *Eucalyptus camaldulensis* respectively.

Globally, the results obtained from the chemical composition of these species are similar to those of tropical wood species. However, it should be noted that the harvest zone, the part of the tree used and the age of the tree can affect chemical composition (Lee and Hong 1987; Govin 2004).

The student *t* test method allowed the classification of the results in categories from a to c, where the letters (a–c) designs the statistical category. Systems not connected with the same letter are largely different, at the 5% level. In can be note that, there is a significant difference of toluene–ethanol extraction. The same observation is made with the two solvents used.

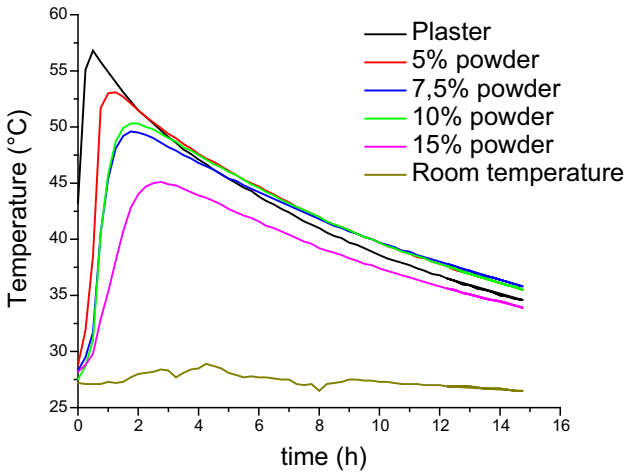


Fig. 1 Plaster–*Eucalyptus saligna* (powder) hydration curve

Evaluation of compatibility of different wood particles with plaster

Influence of wood particle content

The wood particle content was varied between 0 and 15% in order to determine the percentage of wood particles that can give a good compatibility with plaster. Hydration temperatures were measured as a function of time (Fig. 1).

The different types of wood particles used presented the same shape of hydration curve. The results show that whatever the state of particles (powder, wool or fibre) or the species considered, the setting time and maximum temperature of hydration were relatively variable compared to those of pure plaster taken as reference. The hydration time increased when the hydration temperature decreased with an increase in wood content. The same result was obtained by Wei et al. (2000) and Zhengtian and Moslemi (1986). This observation can be explained by the solubility in water of extractives which act as plaster hydration inhibitor. The amount of extractives released in the medium may depend on the amount of wood introduced. 15% of wood certainly generate more extractives than 5% wood and greatly decrease hydration temperature and time. The results of Fig. 1 were used to calculate compatibility by the area method (Hachmi and Moslemi 1990) according to Eq. 9. The compatibility results are presented in Table 2.

For each particle of interest tested (powder, wool and fibre), the compatibility factor was significantly different especially for fibre as wood percentage of *E. saligna* increased. It was generally observed that compatibility reduced as the wood content in wood–plaster mixture increased. The same observation was made by Fan et al. (2012) during the study of compatibility of tropical wood with cement. However, powder and wool seem to have the same compatibility, even though for 5–10% of wood introduced, wood powder showed a compatibility slightly higher than wool. These results can be explained by particle size used. Powder has smaller particles followed by wool and finally by fibre. Adefisan et al. (2012), during the study of the effects of particle size, composite mix and cold water treatment on the compressive strength of *Eremospatha macrocarpa*–cement composites, showed that the composite with smaller particle size was more compatible

Table 2 Maximum temperature, maximum hydration time and compatibility factor of *Eucalyptus saligna*

Eucalyptus saligna	Hydration parameters	Wood content (%)				
		0	5.0	7.5	10.0	15.0
Powder	t (h)	0.50	1.25	1.75	2.00	2.25
	T (C)	56.80	53.10	49.60	50.30	44.70
	C_A (%)	100.00	98.59	92.71	93.78	73.18
Wool	t (h)	0.75	0.75	1.00	1.00	1.00
	T (C)	57.20	54.90	51.30	51.70	48.00
	C_A (%)	100.00	95.70	91.76	92.34	73.88
Fiber	t (h)	0.50	1.00	1.00	0.75	0.75
	T (C)	56.20	48.80	45.70	44.30	40.70
	C_A (%)	100.00	83.74	71.94	70.66	59.18

The error calculation in C_A and T was estimated at 5%

than the composite with larger particle size. The same observation was made by Nasser et al. (2014). Since the compatibility factor of different particle aspects of *E. saligna* followed the pattern powder $\simeq$ wool > fiber, wood powder was used to compare compatibility between species.

Wood at 5, 7.5, 10 and 15% wood contents in plaster were used in mixtures respectively. In general, the results in Table 3 show that the compatibility factor was greater that 68%, which can be considered fairly good between wood and plaster. In fact, based on the C_A parameter, three classes of compatibility have been suggested: "compatible" if $C_A > 68\%$; "moderately compatible" if $28\% < C_A < 68\%$; and "not compatible" if $C_A < 28\%$ (Jorge et al. 2004). Since plaster does not have a dormant phase like cement, it is difficult to use only hydration times as a parameter to show the influence of extractives as in the case of *E. saligna* (powder) Table 2, where the variation in hydration time is significantly different. Therefore, hydration time can be linked to hydration temperature for a good illustration of the effect of extractives on plaster hydration. It has been previously proven that wood content greatly influenced plaster hydration due to specific extractives (Pereira et al. 2006; Boustingorry et al. 2005). Then for *C. lusitanica*, a species with a high extractive content ($E_T = 6.8$), the hydration temperature and compatibility factor were expected to be less than for the others *E. saligna* ($E_T = 5.0$) and *E. paniculata* ($E_T = 4.0$).

In the case *E. saligna*, extractives especially free sugar clearly showed up as plaster hydration inhibitor (Simatupang and Geimer 1990; Govin 2004). T_{max} and C_A decreased as t_{max} and wood content increased. Free sugars affected hydration time (t), hydration temperature (T) and compatibility factor C_A. For all wood species under study, $T_{max} > 40$ °C, $t_{max} < 15$ h up to 15% wood content. These mixtures can be considered as intermediately compatible (Jorge et al. 2004).

Determination of the most compatible species

Figure 2 compares the compatibility against wood powder contents to determine the most compatible species.

When compatibility curves of each species were superimposed, Fig. 2 showed a compatibility factor

Table 3 Maximum temperature and compatibility factor of *Eucalyptus saligna*, *Cupressus lusitanica* and *Eucalyptus paniculata* powder

Powder	Hydration parameters	Wood percentage (%)				
		0	5.0	7.5	10.0	15.0
Eucalyptus saligna (powder) ($E_T = 5.0$)	T (C)	56.80	53.10	49.60	50.30	44.70
	C_A (%)	100.00	98.59	92.71	93.78	73.18
Cupressus lusitanica (powder) ($E_T = 6.8$)	T (C)	58.50	54.40	53.70	52.90	48.50
	C_A (%)	100.00	92.15	90.25	82.86	76.49
Eucalyptus paniculata (powder) ($E_T = 4.0$)	T (C)	57.20	54.90	51.30	51.70	48.00
	C_A (%)	100.00	95.70	91.76	92.34	73.88

The error calculation in C_A and T was estimated at 5%

greater than 60% as wood content increased up to 15%. Figure 2 showed that up to 10% percentage of wood in composite material, it is noted that *E. saligna* is more compatible than *E. paniculata* which is more compatible that *C. Lusitanica*. With the errors, we can conclude that the two eucalyptus have the same compatibility. Nevertheless, *E. paniculata* was most compatible and *C. lusitanica* was least compatible wood with plaster. We noted that as E_E increased, the compatibility between the species and binder decreased. These results confirm those obtained by Hachmi and Moslemi (1989) who showed that, when the yield of hot water extractive is high least the wood is compatible with inorganic binders. Since *E. paniculata* had the lowest hot water extractives, it is most compatible with plaster followed by *E. paniculata* and the least was *C. lusitanica*. However, compatibility factor does not only depend on extractive content, but it can also depend chemical composition of wood extractives (Moslemi and Lim 1984; Herrera and Cloutier 2008). Taking in account the chemical composition of the various species, it was noted from Table 1 that *E. paniculata* had the lowest ash content (0.027), followed by *E. saligna* (0.092) and *C. lusitanica* (0.57). Knowing that ash is made up of mineral substances, one could easily explain why the two *Eucalyptus* species had better compatibility with plaster than *Cupressus*.

Determination of the most compatible particle

As shown in Fig. 3, wood powder had a higher compatibility than fibre. This is due to the fact that fibre is an agglomerate but powder is burst releasing free sugar rapidly, thereby inhibiting plaster hydration.

Conclusion

Quantitative analyses were carried out using TAPPI methods on wood powder of size less than 0.27 mm for every species. The results obtained for *E. saligna*, *C. lusitanica* and *E. paniculata*) were 2.4, 3.4 and 1.6% respectively for the ethanol–benzene (E_{AB}), 48.6, 48.4 and 40.4% for the cellulose content (C), 34.8, 34.3 and 36.3% for percentage lignin (L). 2.6, 3.2 and 2.4% for the hot water extract (E_E), 12.4 0.21.6 and 12.1% for 1% sodium hydroxide extract (E_S) and 0.1, 0.6, 0.3% for the ash content (C_E).

Hydration tests, carried out in plaster with different types of wood particles studied, showed that types could all be considered as highly compatible with compatibility factors $C_A > 68$ as the wood content increased up to 15%. However, some wood species were more compatible: *E. paniculata* > *E. saligna* > *C. lusitanica*. This order could be explained by the inhibiting action of extractives, particularly the sugar or total extractive content (E_T) of each

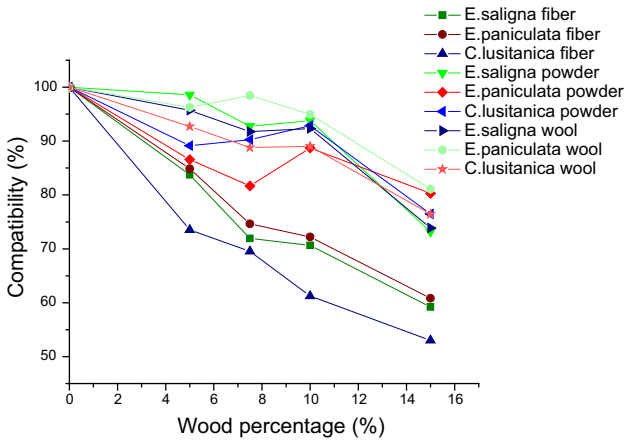
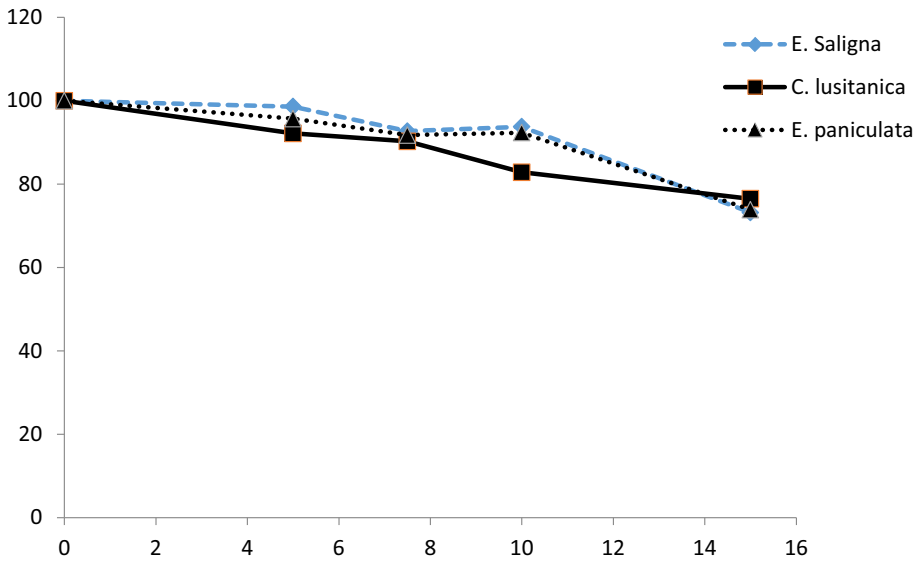


Fig. 3 Compatibility of different wood particles

Fig. 2 Powder compatibility curve



wood species. E_T could therefore be retained as the most important parameter in the classification of compatibility of wood species. As for the particle aspect, compatibility varied in order powder > wool > fibre.

The plantation wood species used in this work are quite compatible with plaster, especially wood powder. These species could constitute a good source for the manufacture of plaster composite materials.

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