Use of lupin protein as bio-based product

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ABSTRACT

As the chemical composition between soy and lupin is very close, formulation of adhesive based in lupin flour were prepared. Initially, lupin flour is denatured with urea at 80º C. Subsequently, the products of denaturalization are bonded with a crosslinking agent. The synthesis was realized in batch system and the characterisations of the dispersion are determined by solids percentage 30-43%, viscosity 100-1100 cPs and pH in the range of 8.0-10. Particleboards (PB) with density 640 kg/m^3 and 15 mm of thickness were made using 8.1% (w/w) of lupin. These PB were used to determine the emissions of formaldehyde, Internal Bond (IB) and swelling. The results were compared to PB made from urea formaldehyde resins (UF). The results indicate that it is possible to obtain PB with very low formaldehyde emission using lupin proteins and the properties are comparable to those obtained from traditional UF resins.

INTRODUCTION

At present the LEED (Leadership in Energy and Environmental Design) legislation and CARB (California Air Resources Board) standards guidance is focalized on technology and quality requirements for PB that are used inside homes in green construction. The orientation is to obtain boards that formaldehyde release would be comparable to that emitted by the pure wood, using raw materials from renewable resources. To answer this guidance the adhesive industry has incorporated new technologies including: innovative gluing systems of resins and chemical additives, advanced technology for resin synthesis and efficient monitoring and control of the synthesis parameters. However, the innovation is mainly based on the development of adhesives, made from biomass or by-products agro-industrials, formaldehyde free, NAF (no added formaldehyde) systems. The first adhesives of this new generation are prepared from proteins presents in soy flour. Similarly, this paper explores the possibility to use lupin proteins for making adhesives without formaldehyde, NAF system, enabling manufacture PB useful for green building.

The Table 1 shows the composition of amino acid reactive present in soy and lupin flour.

Table 1. Amino acid reactive for soy flour and lupin flour.

Soy flour			lupin flour	
Amino acid reactive	%		Amino acid reactive	%
Aspartic/Asparagine	6	-COOH	Aspartic/Asparagine	4,6
Glutamic/Glutamine	9		Glutamic/Glutamine	9,8
Serine	2,8	-OH	Serine	2,2
Theonine	2		Theonine	1,4
Cysteine	0,7	-SH	Cysteine	0,8
Methionine	0,7		Methionine	0,2
Lysine	3,3	AMINE	Lysine	2
Arginine	3,7		Arginine	5,3
Tyrosine	1,7		Tyrosine	2,2
Histidine	1,4		Histidine	0,8
Total Reactive	31,3		Total Reactive	29,3

The Table 1 does not show significant differences in the total amount of amino acid reactive (a.a.r.). The presence of –COOH, –OH, –SH and amine groups in amino-acid can be used to promote reaction with the functional groups of cellulosic component present in wood particles. It can be also used for promote cross linking reaction with specific reactive (PAE). Differences are observed between proportions of each type of a.a.r. The quantity of a.a.r. with -OH and -SH groups are lower in lupin flour, around 25 and 28%, respectively. However, it presents more a.a.r. with –COOH and amine group, around 25% more. This feature should allow the use of lupin proteins as raw material for making adhesive, because the presence of functional group such as carboxylic acid and amine is also very important to produce covalent and no-covalent interactions among the adhesive and functional group present in the components of wood particles. The Table 2 presents the characteristic of adhesive and properties of PB obtained with these adhesive.

Table 2. Characteristics of adhesives and properties of PB.

	UF	Lupin-Urea	Lupin-Urea-PAE
Solid (%)	65	43	32
Viscosity (cPs)	350	1060	108
pH	8,2	10,0	8,3
IB (N/mm2)	0,68	0,20	0,68
Swelling 24h (%)	17,4	57,9	17,7
Emission (mg H2CO/100 g board)	8	-	0,07

The precursor of bio-based product, lupin-urea, has a high viscosity for a relative low percentage of solids, if it is compared with UF adhesive. Similarly, the properties of PB are lower than those obtained with UF. Nevertheless, the addition of crosslinking agent (PAE), allows to use adhesives with lower percentage of solids in order to reach the adequate viscosity. The results of mechanical properties between PB obtained from UF and lupin-urea-PAE do not present significant differences. The difference in swelling essay between the lupin-urea precursor and the lupin-urea-PAE bio-based adhesive is attributed to the presence of PAE. This better response is attributed to the formation of hydrophobic bond promoted by PAE. It is important to note that bio-based adhesive produce PB with emissions 110 times lower than those emitted by PB made with UF. This feature is obviously attributed to the absence of formaldehyde in the formulation.

CONCLUSION

The chemical profile of lupin flour shows that their amino acids are very similar to soy flour protein. This experience demonstrated that lupin could be a very interesting alternative as raw materials from renewable resources for making bio-adhesives. However, according to the results it would be necessary the presence of cross linking agent to improve the properties. Bio-adhesive based in lupin protein can be used to produce wood based panels such as PB with low emission of formaldehyde.