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Improvement of Bondability in Rice Husk Particleboard Made With Sodium Silicate

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ABSTRACT

In this study, rice husk and sodium silicate solution are used to produce particleboard. Sodium silicate is used as a bonding agent in values of 25, 20, 15, 10, 5 and zero percent (based on rice husk dry weight). To improve the mechanism of bondability one percent of Isocyanate resin was added for each five percent decrease in Sodium silicate solution. The effect of Isocyanate resin on bondability was evaluted by measuring of modulus of rupture (MOR), Internal bond (IB), thickness swelling (TS) and water absorption. Data were statistically analysed with Spss softword and comparison of the means was performed employing a Dancan test to identify which groups were significantly different. Generally the results have shown that increasing Sodium silicate replacement with Isocyanate resin improved the mechanical and physical properties of particleboard. In this study the best condition was obtained by the use of 15% Sodium silicate solution with 2% Isocyanate resin to product rice husk particleboard.

INTRODUCTION

Liquid Sodium silicates are solution of water soluble glasses made from varied proportion of sand (SiO2) and soda ash (Na2CO3).The more siliceous silicates (2.8 to 3.2 ratio) have long been used as dependable, low cost adhesives. Sodium silicate adhesives are used for bonding a variety of porous surfaces and materials such as paper,mineral wool(used in insulation), perlite, mica and wood.Liquid silicates are inexpensive,readily available,and convenient. Silicates are nonflammable adhesives. They are odorless and will not impart any taste to the contents of packages in which they are used as adhesives. Sodium silicate is generally recognized as safe by the food and Drug Administration for use as an adhesive in the manufacture of food packaging materials made from paper, paperboard or other materials. Characteristics and a few applications of commercial grades of silicates most commonly used as adhesives are summarized in table 1.

The reason for the higher resin requirement for bonding rice hulls is not completely understood, but a comparison between wood and rice hull showed that rice hull has less holocellulose and a much higher ash content [Houston 1972]. The predominant component of its ash is silica [Luh 1991]. The silica covers almost the entire outer layer of the rice hull surface which also contains the water repellent cuticle [Juliano 1985]. This silica layer and the partially hydrophobic surface of rice hull are incompatible with aqueous urea formaldehyde(UF) or phenol formaldehyde(PF) resins and prevent the formation of a good bond between rice hull surfaces.

Therefore the objective of this study was to investigate on particleboard properties were made with rice husk and Sodium silicate adhesive and also how the mechanism of bondability is improved by polyisocyanate resin. The physical and mechanical properties were evaluted and compared.

Table 1.The uses and properties of Sodium silicate as adhesive.

Na2O %	SiO2 %	SiO2/Na2O Wt.Ratio	Sp.Gr.at 20°C	Viscosity at 20°C ,Poises	Uses
11	31.9	2.9	47	9.6	Sealing cartons, shipping containers ,metal foils ,wall boards ,flooring and trunk making
8.9	28.7	3.2	41	1.8	Corrugated paper board,flooring,paper tubes
9.2	29.5	3.2	42	4.0	Combined board (wall board) plywood
8.3	28.2	3.4	39.7	3.3	Corrugated paper board
6.7	25.3	3.7	35	2.2	Special uses

MATERIALS AND METHODS

Rice husk was obtained from rice mill in Sowmehsara city of Guilan province,Iran. Moisture content of the husk was around 8 percent and after drying it became 3-4%. The particles were then screened according Bison Quality Control 44011 standard.

Table 2.Summarizes the composition of particles based on mesh analysis

Particle size(mm)	S=L/T	J=W/T	A=L/W
L=9.7 W=1.6 T=0.16	60.6	10	6

Table 3.Polyisocyanate properties

Adhesive	Density(g/cm3)	Solid content(%)	Ph	Viscosity(cp)
ISO	1.27	100	-	300

Board Manufacturing

The sodium silicate adhesive was sprayed on the particles in a blender at 25% resin content on the oven-dried weight of particles. In order to improve particles bonding each 5% sodium silicate substitute with 1% polyisocyanate. The hand formed mats were pressed in to 12 mm thick boards using 30 Kp/cm3 bars at 170 °C press temparature and 6 min press time. The board size was 400 ×400 ×12mm with densities 0.7 g/cm2. three boards were made in the same condition. All together 18 boards were made.

Board Testing

Speciments were cut from the boards after conditioning and tested according to the DIN-6871 Standard. The Speciment size for the bending test was 250×50×12 mm.the sample size for the Internal bond (IB) and thickness swelling(TS) tests were 50×50 mm and 25×25 mm respectively. Thickness swelling was determind by measuring the changes of board thickness after immersing in 20 °C water for 2h and 24h.

Data were statistically analysed by using Spss softwords. Grouping of the averages was analysed by a Duncan Multiple Range Test (DMRT) when analysis of variances (ANOVA) showed statistical differences.

RESULTS AND DISCUSSION

The average Static bending,Internal bond,Thickness swelling and Water absorption values are shown in table 4.

Table 4. The average values of static bending, Internal bond, Thickness swelling and Water absorpting for board type.

Board type	ISO Na_2Sio_3 (%) (%)	MOR mpa	IB mpa	Water absorption (%)		Thickness swelling (%)	
				2h	24h	2h	24h
1	50	9.85	0.56	9.99	26.00	2.51	9.05
2	45	7.46	0.45	15.98	39.97	4.69	12.40
3	310	7.63	0.39	27.94	72.00	10.08	18.8
4	215	7.07	0.31	61.12	81.03	13.82	19.30
5	120	3.53	0.16	70.97	93.13	21.03	31.27
6	025	2.43	0.15	136.47	167.77	49.67	64.23

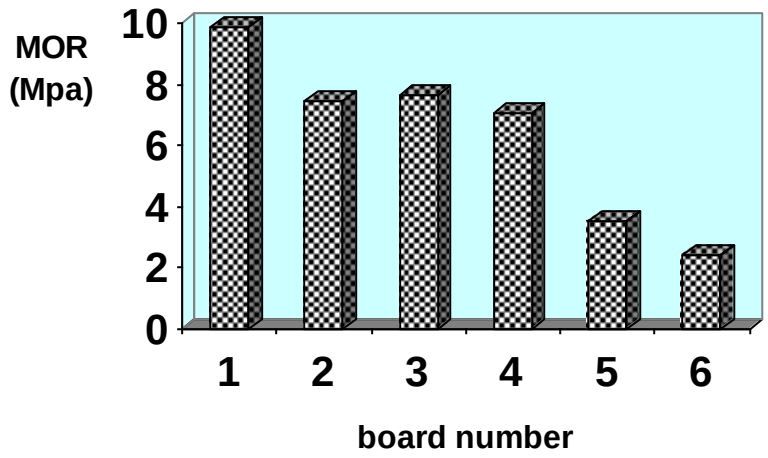

Fig1.Effect of using Iso and sodium silicate resin on Modulus of rupture of rice husk board.

According to table 4 and figure 1. replacement of sodium silicate resin with polyisocynate increased the static bending. The static bending of board made with 5% polyisocyanate resin was fourfold the static bending of board made with 25% sodium silicate resin (9.85 Mpa). Figure 1-4 show that all of the Mechanical and Physical properties of boards which were made with polyisocyanate resin are more than were made with sodium silicate resin. The polyisocyanate resin is expensive and toxic. while sodium silicates are inexpensive, readily available, nonflammable adhesives. More recently, highly reactive polyisocyanate (ISO) has been used to modify uf resin.[Deppe and Ernst 1971; Deppe 1977;Pizzi 1981;Liu and Binglye1992] and Pf resins [Hse 1978, 1980] for board products.

According Dancan grouping, the bending strength of boards (No:2,3 and 4) are in one group and there aren't significant differences between them in 1 and 5 levels of probability. But there are significant differences between number 4 and 5. The board bending strength of number 4 (7.07 Mpa) is twice that of number 5 (3.53 Mpa).

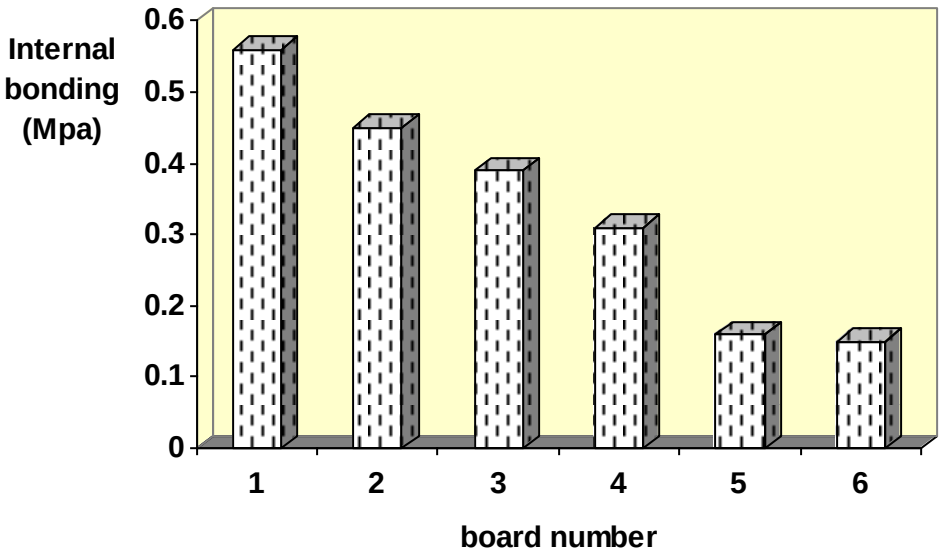

Fig 2.Effect of using Iso and sodium silicate resin on Internal bond of rice husk board.

Similarly, according to table 3 and figure2, the use of ISO resin instead of sodium silicate in board manufacture increased the internal bonding strength. The internal bonding comparison between board numbers 1 and 6 showed that the internal bonding of board made by ISO (0.56 Mpa) obtained almost fourfold of internal bonding of board was made by sodium silicate (0.15 Mpa). There aren't significant differences between board internal bonding of number 3 with 2 and 4. According to Dancan grouping they are in a group. The board internal bonding of number 4 (0.31Mpa) is twice the board internal bonding of number 5 (0.16 Mpa).

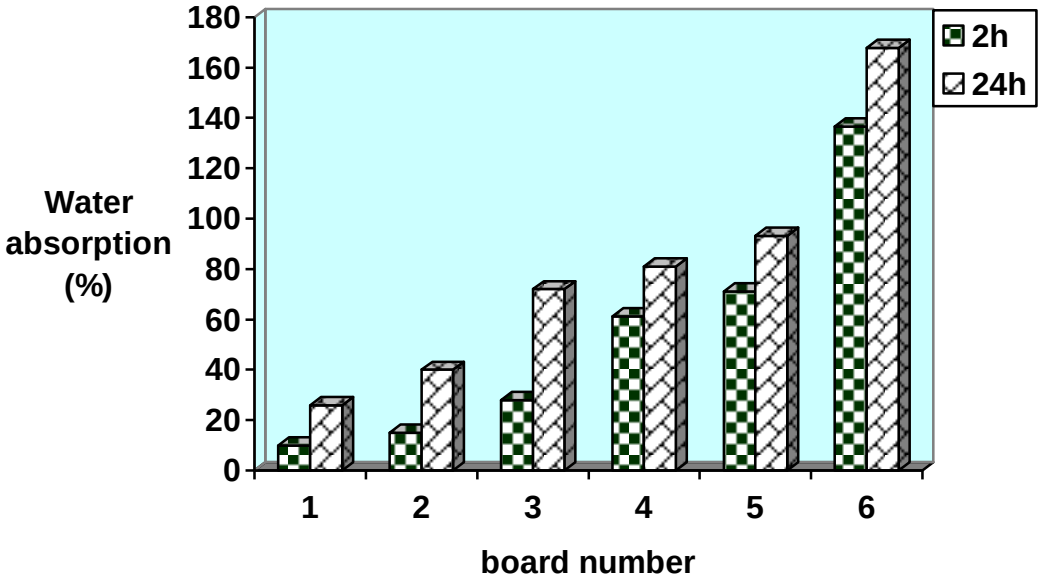

Fig 3.Effect of using Iso and sodium silicate resin on Water absorption of rice husk board.

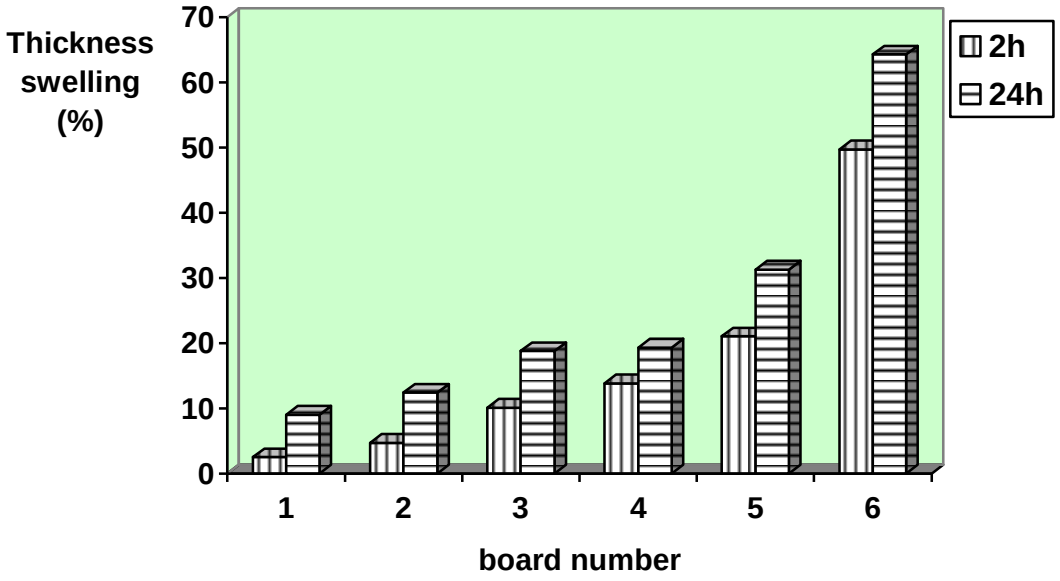

Fig 4.Effect of using Iso and Sodium silicate resin on Thickness Swelling of rice husk board.

According to table 3 and figure 3 and 4.the results of water absorption and thickness swelling after 2 and 24 h immersion illustrated that these factors decrease with increasing polyisocyanate instead of sodium silicate resin.

The comparison between the board numbers 1 and 6 showed the water absorption and thickness swelling of the boards made with sodium silicate are more than the board made with polyisocyanate resin. The sodium silicate is weakest in water. Therefore the replacement of sodium silicate with iso can decrease this problem. Both water absorption and thickness swelling decrease with 2 percent replacement. There aren't significant defferences between the thickness swelling of board numbers 3 and 4 statisticaly both are in a group.

In a study with 60% sodium silicate (based on dry weight of husks); 60 Kgf/cm2 platen pressure,180 °C platen temparature and 10 min press hold time,a board could be prepared which could meet the reqirements of ISI.this board absorbs more water therefore it is not recommended for exterior use(Shukla 1983).

CONCLUSION

Generally,the Mechanical and Physical properties of the boards were made with polyisocyanate resin are better than Mechanical and Physical properties of the boards were made with Sodium silicate resin.since the cost of ISO is much more than cost of Sodium silicate and also the ISO is toxic.there could be substantial economic gains by using Sodium silicate resin as the major component in this system.

In this study,the most better results were obtained in the boards were made with 15% Sodium silicate and 2% polyisocyanate resin. They have superior Mechanical and Physical properties for rice husk boards.

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