2012 International Conference on Environmental, Biomedical and Biotechnology
IPCBEE vol.41 (2012) © (2012) IACSIT Press, Singapore

Using the Solution of Format-Methanol in Order to Shape Wood and Make Particle Board Based on Internal Bond

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Abstract. The main purpose of this study was to make particle board from sawdust, without adding any glue based on internal bond. It has been assumed that by weakening the hydrogen bonds of wood which have been the most important factors in strength of wood, it would be possible to shape and mold it in order to make particle board without adding any glue or using the minimum amount of it. In this study, the Sawdust of Russian Pine and Tabrizi Poplar which were collected from the waste wood of factories and saw mills were used. Also, walnut shell was used. The results of various experiments indicated that solution of Format-Methanol was the best option for weakening the hydrogen bonds of wood. Furthermore, in order to investigate the efficiency of this new method in making particle board based on internal bond, some particle boards were made. The glue was not used at all. The mould size was 20*20cm, press pressure 4 Mpa, press time 6min, and press temperature 160^{oc}. The results of measurements showed that although the particle boards had almost acceptable internal bond (IB) and modulus of elasticity (MOE), they did not have enough strength in order to industrial and commercial usage. So, using a little bit of glue was necessary.

Keywords: Shaping of wood, Weakening hydrogen bonds of wood, Solution of Format-Methanol, Internal bond, Particle boards

1. Introduction

Today trees are cut extensively. Without any doubt it will make a serious problem for environment. In addition, the extensive use of glue, polymer, and resin in order to make chipboard, particle board, MDF and so on , is not only harmful for environment but also is a serious problem for human health. This project was tried to find a new way for eliminating or decreasing the use of these material in wood industrial.

Wood is a natural composite, which has a homogenous structure, and is composed of polymeric chains of cellulose and polymeric networks of hemi-cellulose and lignin. Cellulose builds its skeleton, hemi-cellulose forms the essence of wood, and lignin connects the cells and strengthens the cell walls. Moreover, organic compositions with low molecular weight exist in wood, which are called “extractive substances”. The amount of mineral substances or ashes in wood rarely exceed from 0.1 to 0.5. Due to strong and complicated hydrogen bonds of cellulose, hemi-cellulose and lignin, wood has a very strong structure. In order to weaken the hydrogen bonds of wood, various experiments were done. The results of these experiments proved that the solution of format[1]-methanol[2] was the best option for weakening the hydrogen bonds of wood. In other words, by penetrating in polymeric chains of wood and interfering in hydrogen bonds, format ion caused a spatial crack in strong and complicated hydrogen bonds of wood and weakened it. Creating a spatial crack among polymeric chains of wood made them ready to slip on each other when were heated. As a result, wood could be shaped and moulded. Furthermore, surface molecules of cellulose, lignin and hemi-cellulose of sawdust would be available and would make some new bonds with other particles, so some inner bonds would create between sawdust particles. This phenomenon was used in order to make particle board based on internal bond which present research would like to explain about it.

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2. Experimental Section

In this process, the sawdust of Russian pine and Tabrizi Poplar were used (this wood was chosen because of its availability). The samples were collected from sawmills in Karaj. For unifying the wood particles, Mesh 30 was used. Then, the solution of format-methanol, and sawdust were mixed and were put into reflux process for 1 hour. The temperature was 50 centigrade. Afterward, the solution was filtrated by the use of two-layer of white cotton. For extracting the remainder of format and alcohol from wood, it was washed with hot water. Then, it was dried in open air, far from the sun. In addition, in order to investigate the effect of the solution of format-methanol on wood structure, FT.IR[1] spectra were taken from samples (in this stage sawdust of Russian pine was used). Furthermore, for studying the efficiency of this new method in making particle board based on internal bond, some particle boards were made (in this stage sawdust of Tabrizi polar was used). For this reason, samples initially were put in pre-press and then pressed by flat hot press. The mould size was 20*20cm, press pressure 4 Mpa, press time 6min, and press temperature 160^{oc}. Thence, their Modulus of elasticity (MOE), Static bending strength (MOR) and Internal Bond (IB), based on DIN 68763 standard, were measured (see Fig. 1).

3. Results

The results of various experiments indicted that the solution of format-methanol was the best option for weakening the hydrogen bonds of wood. There were different reasons why it is. Firstly, format was a base with weak strength. Therefore, it did not do any damage to the structure of wood. Using strong bases would do severe damage to the structure of wood. Secondly, the salt of format has been dissolved in water easily. This salt has partially ionised in water and made ion. Also, extracting this salt from samples has quite been easy [1]. Thirdly, due to heating, all bonds of wood especially hydrogen bonds were weakened, and movement of all molecules were increased. In addition, the salt of format were ionised much better. So, because of raising the number of format ion in solution, weakening all bonds of wood, increasing the movement of all molecules, and small size of format ion, format ion were trapped in polymeric chains of wood and caused a spatial crack in strong and complicated hydrogen bonds of wood. This phenomenon helped to create some new hydrogen bonds between the particles of sawdust, which increased internal bond of particle boards, and it caused that wood was shaped and moulded. Fourthly, thanks to existing alcohol groups in the structure of wood, small size of methanol, the solubility of format in methanol, and the ability of methanol in making hydrogen bonds, it was chosen as a solvent. Most importantly, it did not damage to the structure of wood. Fifthly, the solubility of format-methanol in water has been unlimited, so it could easily be extracted from samples by washing with water.

The temperature was 50 centigrade in reflux process. Babicki and his colleagues (1977) investigated the effect of temperature on physical and chemical properties of Beech. Samples were heated in water at both 50 and 100 centigrade. They stated that heating the samples at 50^{oc} did not make any considerable change in strength of wood [2].

Washing with hot water had priority because the solubility of salt in hot water was more than cold one.

PH of solution has had an important influence on the strength of wood. Lignin has been considered as a vital factor on the strength of wood which completely damaged in alkaline solution (PH more than 9).The most suitable PH was between 7.5 and 8.5 because in this PH the lignin of wood was not damaged.

The impact of the remainder solution, after filtration, and main solution on sample was the same. As a result, after filtration, we could continuously use the remainder solution, and this could be economized on using raw materials.

As this procedure was a physical reaction, Mesh 30 was used for unifying the particles of sawdust. This action increased the level of contact between materials and sawdust particles. Furthermore, in the study which was done by Sweart and Lehman (1973), they stated that there was a close relationship between the higher internal bond and the smaller particles. In other words, when the particles were smaller, water vapour could better transfer heat from surface layers to core layers of particle board. Also, increasing the

[1] Fourier transform infrared spectroscopy (Shimadzu 408)

temperature and press time helped to exist of water vapour, and reduce the pressure in middle layers. Thereby, internal bond of particle board was increased [3].

High wood moisture content has had a negative impact on the internal bond of particle boards, although it has improved the quality of surfaces of particle boards. In other words, when the moisture of middle layers of particle boards have been increased, water vapour has more been transferred to core layers during hot press. So, it has made an internal pressure, the more gradient of moisture, the more internal pressure, which has prevented from making bonds between particles in middle layers. Thereby, high wood moisture has caused that particles have separated from each other under hot press [4].

Hot press was used. Hot pressure made the enough contact between particles [5].

Drying the samples was done far from the sunshine because of its unfavourable impacts. The sun ray has created physical and chemical changes [6].

Particle boards were slightly inflated after floating in water for 24 hours. Internal bond has been the most important factor in reducing swelling, when particle boards have floated on water for 24 hours. So, it proved that particle boards had a good internal bond [5].

The surfaces of particle boards were completely flat, and did not need any veneer.

Due to special colour of walnut shell, the mix of walnut shell and sawdust would increase the beauty of particle boards.

3.1. Extracted results from measurements

The result of Static bending strength (MOR) showed that although the particle boards had some strength, they did not have enough strength in order to industrial and commercial usage. As MOR of particle boards which have been used for construction usage has been between 5 - 6.5 Mpa [7], it could be concluded that using a little bit of glue was necessary.

The result of internal bond (IB) illustrated that the solution of format-methanol had a considerable impact on internal bond of particle boards. In a study which was done by Movahedi and Tabarsa (2003), IB of particle boards, which were made from Poplar, were reported 0.079 based on DIN 68763 Standard. Press pressure and temperature were considered 4 Mpa and 160^{oc} in their study. In addition, Urea-formaldehyde was used as binder (10% based on oven dry wood) [8]. As we have seen, all of the parameters in their study, except using of glue, were the same with present study. To summarise, a comparison between the IB of two studies proved the significant effect of the solution of format-methanol on IB of participle boards.

As Modulus of Elasticity (MOE) of particle boards which have been used for construction usage has been between 700-1100 Mpa, it could be stated that the MOE of particle board was acceptable in present study [7].

Variables	Modulus of Elasticity	Static bending strength	Internal bond	Size of sample	Speed of loading
Mean	900.63Mpa	1.98Mpa	0.09Mpa	50*50*13.72mm	10mm/min

Fig. 1**:** the results of measurements, based on DIN 68763 standard. (particle boards were made from Tabrizi poplar).

3.2. Extracted results from FT.IR spectra

First, the similarities between Sawdust of Russian Pine before treatment (sample1A) and after that (Samples1&2) were stated. They were specified in spectra with red circles (see Fig. 2).

- 1049.2, 1249.8 on sample 1A, 1056.9, 1265.2 on sample 1, and 1056.9, 1242.1 on sample 2 for □ C □ O □ Ar in Lignin.
- 1350.1 on sample 1A, and 1373.2 on samples 1 & 2 for rotational bending absorption of CH_3 (sp^3).
- 1627.8 on sample 1A for C=C of Aromatic ring in Lignin, and 1596.9, 1504.4, 1458.1 on sample 1, and 1604.7, 1512.1, 1458.1 on sample 2 for Aromatic ring in Lignin.

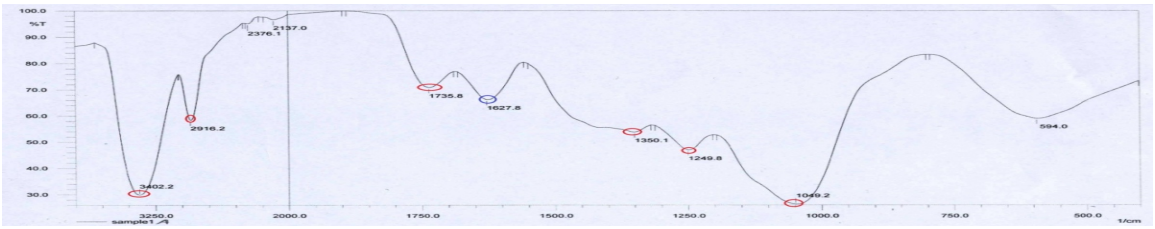
- 1735.8 on samples 1A & 1 & 2 for Carbonyl group in Lignin.
- 2916.2 on samples 1A & 2, and 2923.9 on sample 1 for stretching absorption in Lignin.
- 3402.2 on sample 1A, and 3409.2 on samples 1 & 2 for O □ H group of 1th, 2th Alcohol in both cellulose and Lignin.

According to these similarities, it was obvious that any serious change or damage did not occur in structure of Sawdust of Russian Pine after treatment. On the other hand, there were some new frequencies in samples 1 & 2, which were specified in spectra with blue circles (see Fig. 2). These new frequencies were just seen in samples 1 &2 and illustrated the effect of the solution of Format-Methanol on wood structure.

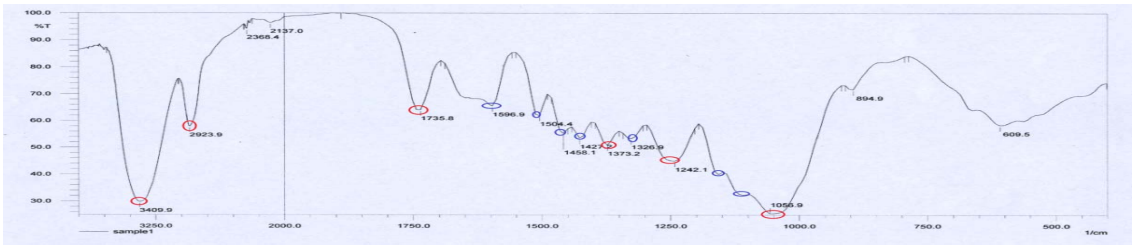
- 894.9, 1120 for C □ O □ C in both Cellulose and Lignin.
- 1157.2 for bending absorption of ketone in Lignin.
- 1218 for C □ O of Phenol in Lignin.
- 1326.9 on sample 1, and 1319.2 on sample 2, probably belonged to stretching absorption of C □ O of quintet ring in Lignin.
- 1427.2 for bending vibration of H in C=C of Aromatic ring.

All in all, it was proposed that theses new frequencies belonged to some inner bonds of wood which were not seen in the spectra of wood before treatment. Furthermore, they proved that some strong and complicated hydrogen bonds of Cellulose, Lignin, and Hemi-cellulose were weakened or opened. So, the solution of Format- Methyl alcohol was able to weaken the hydrogen bonds of wood.

Sample 1A (before treatment)



Sample 1 (after treatment by remainder solution)



Sample2 (after treatment by main solution)

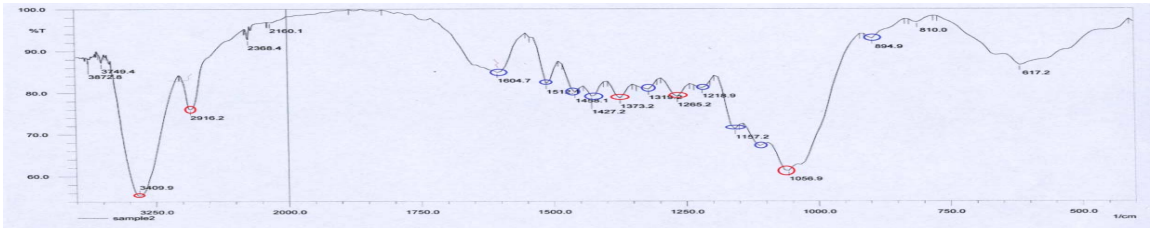


Fig. 2: FT.IR spectra from sawdust of Russian Pine before and after treatment.

4. Conclusion

The FT.IR spectra clearly showed that hydrogen bonds of sawdust were weakened and the polymeric chains a little opened. However, they did not show any damage or considerable change in wood structure. So, the solution of format-methanol was able to weaken the hydrogen bonds of wood.

Although the result of measurement indicated that particle boards did not have a very good quality, it should not be forgotten that any glue was not used in this research. Moreover, the quality of particle board has completely depended on various parameters such as wood moisture content, press time, pressure and temperature, size of particles, kind of wood, and glue that the change in each of them would be made a considerable change in the quality of particle boards. For instance, Movahedi and Tabarsa (2003) investigated the independent effect of press pressure on IB. They calculated that there was a meaningful relationship between press pressure and IB. They stated that by increasing the press pressure from 4 Mpa to 10 Mpa, IB was increased [8]. Indeed, due to increasing the press pressure, all particles were closed to each other. So, strong bonds were made between them. As a result, IB of particle boards would be increased [9]. As has been said, it could be asserted that by increasing the press time, pressure and temperature, and also changing the kind of wood, the quality of particle boards would be improved and they would also be used for industrial usage.

5. Offers

In order to increase the strength of particle boards, there were two ways. Firstly, improving the condition of making them, and secondly the use of glue. As current glues have had harmful effect on environment and human health, using the root of Eremurus Olgae Regel has been offered. Eremurus Olgae Regel is a plant, which is grown in Iran, Russian, Iraq and etc. It is a very useful plant which is used as a medicine, glue, and food. Furthermore, glue has been made from the roots of this plant. For this reason, firstly the roots have been dried. Then, they have been pulverized. At last they have been mixed with water. The glue has contained Inulin 60%, Lulose Suger 20%, water 20%, ash, and minerals [10]. Although this glue is completely harmless for environment and human, it is not resistant to water. So, use of it, is not offered in humid climate. All in all, the more studies are needed for improving the properties of this glue, and using it in wood industrial.

6. Acknowledgements

Finally I would like to appreciate Dr Abdolhossein Massoudi (Advisor, Department of Chemistry, Payamnoor University, Iran, Mashhad), Bijan Abassi (Advisor, Science and Technology Park, Iran, Mashhad), our families and all other who helped us in this project.

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