Effect of Electron Radiations on the Physical Properties of Laminated Particle Boards

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ABSTRACT--- ***In the present work, the particleboards laminated with melamine formaldehyde and Polymer Faced Chipboard(PFC) paper were radiated with different dosages of electron radiations and its impact on the polymerization and other chemical properties were analyzed using characterization techniques such as TGA, DSC and XRD. It was observed that the amount of radiations have effect on the physical and thermal properties of the lamination. The knowledge from the present work will be used to develop new kind of coatings using melamine formaldehyde and PFC polymer and later on radiate it with the electron radiations to improve its thermal and mechanical properties.***

Keywords--- Melamine-Formaldehyde, Urea-Formaldehyde, Lamination, Coating

1. INTRODUCTION

Using of wooden furniture such as chairs, tables, tools, timbers for making houses and so on are growing up, it is impossible to stop exposing them to the environment without covering the external layer, since Wood is a kind of hygroscopic material and its moisture content can be increased easily by exposing in the humid air. [1] Any attempt to cover the wooden object is called lamination either by painting or using polymeric layers. It is clear that the wooden objects can be destroyed easily without lamination. There are different kinds of laminations methods and materials.[2] Most important reason for lamination is to cover the objects and produce a composite system with improved strength, stability and appearance by using two or more materials stacked in multiple layers. Wide range of materials are used to improve the quality and the process of lamination using different methods such as heat, pressure, welding or adhesives.[3]

Due to the insolubility of melamine in cold water, the bonds formed by mixing melamine and formaldehyde are more resistant in hydrolysis process[4] . Earlier the melamine addition to improve water resistance of UF bonds was investigated by Cremonini et al.[5] and Cremonini and Pizzi [3].

Urea–formaldehyde (UF) resin is the most important type of adhesive resins for the production of wood-based panels. The excellent adhesion to lignocellulosics, excellent intrinsic cohesion, ease of handling and application, lack of colour in the finished product, and low cost have led the UF resins to be the most widely used adhesives for bonding wood products. However, lack of resistance to weather and water and their susceptibility to emission of formaldehyde vapours are two main disadvantages of UF resin.[8]. The addition of melamine of 10–11% into the UF glue mixture was concluded to exhibit good water repellency. Hydrolysis of weakly bound formaldehyde from N-methylol groups, acetals and hemiacetals and hydrolysis of methylene ether bridges in more severe cases, also increase the content of emittable formaldehyde [2]. The methylol groups are easily split. In the presence of moisture, UF resin is slightly hydrolysed and the hydrolysis is enhanced under elevated temperatures [9]. Previously the study of heat and mass transfer model [10] and vertical density profile model [11] was developed to improve the understanding of internal process of wood composite. To improve the strength of wood composite, researchers have added aluminium nanoparticles [12],carbon particles[13,14] and multiwalled carbon nanotubes [15] to enhance the mechanical strength of wood composite. Researchers are trying different ways either by addition of some kind of fillers or by improving the lamination through polymerisation and radiations to enhance the properties of wood composite.

2. EXPERIMENTAL

The samples of laminated wood were supplied by the private company MIECO manufacturing company. Irradiating of the samples conducted under different dosage of electron radiation. The properties of the lamination were analyzed before and after the irradiation. The process was repeated for number of species from MIECO manufacturing company in Kuantan Malaysia. In order to investigate property changing due to being under radiation, some different test conducted such as Thermal Gravimetric Analysis(TGA), Differential scanning calorimetry (DSC), X-ray powder diffraction (XRD). Before the experiment, all specimens were divided into two groups which were laminated with two kinds of papers, Melamine-Formaldehyde and PFC. First kind of board called B1 and another kind of boards were called B2. The sample boards are shown in the figure 1.

Figure.1 Two kind of boards B1 and B2

2.1 Characterization of the Fiber and Composites

A number of characterization techniques and tests were carried out to analyze the properties and characteristics of lamination paper. The techniques and tests involved the followings:

- Thermogravimetric Analysis (TGA)
- Differential Scanning Calorimetry (DSC)
- XRD

2.2 Thermogravimetric Analysis (TGA)

TGA measurements were carried out using thermogravimetric analyzer (TA instrument, TGA Q500). Each specimen weighed about 5 ± 2 mg at scanning temperature range of 25 – 600 ^{o}C and heating rate of 20 ^{0}C/min. TGA was conducted with the compounds placed in platinum crucible in nitrogen atmosphere at flow rate of 40 ml/min to avoid unwanted oxidation. . Kinetic parameters for the thermal degradation were determined from the TGA graphs.

2.3 Differential Scanning Calorimetry (DSC)

TA instrument, Q-1000 was used for DSC analysis with heating rate 20 ^{o}C/min. A heat/cool/heat method was applied using aluminium pan with temperature range 25-250 ^{o}C. Approximately 3 to 4 g of sample was taken for this test. The percentage of crystallinity and melting point of the composite were calculated by using the machine operating software.

2.4 X-ray diffraction (XRD)

X-ray Diffraction (XRD) measurements of solid UF containing carbon nano fibers and without carbon nano fibers were studied. The X-ray diffraction (XRD) was performed in a XRD analyzer. The samples were scanned in 2θ ranges 3-80° at a rate of 1deg/min. The generator was operated at Cu/30 kV/15 mA. The inter layer spacing (d002) of carbon nano fibers was calculated in accordance with Bragg equation: $2d \sin\theta=\lambda$.

3. RESULTS AND DISCUSSION

3.1 Characterization of lamination papers B1 and B2

From the TG curves , it was observed that there is not much effect of the electron radiations on the melamine formaldehyde lamination. All the curves are showing the similar trend of disintegration.
Both of samples TGA curves show the initial transition around temperature of 26^0 C due to start of degradation.

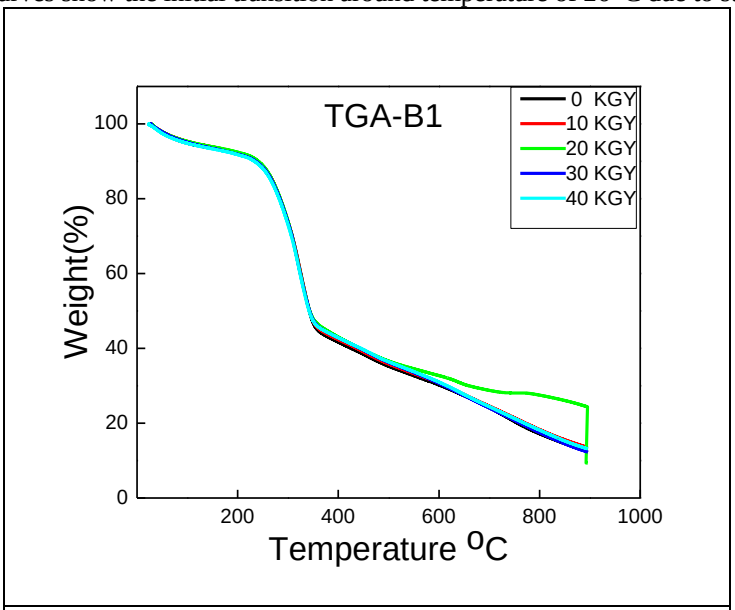

Fig 2. TGA for B1, laminated board with Melamine-formaldehyde paper under different electron radiation dosages

Table:1 TGA properties observed for lamination samples B1

Samples	200^0C	400^0C	900^0C
Standard 0 kgy	7.716 %	50.23	29.52 %
Radiations 10kgy	7.693 %	49.72 %	29.06 %
Radiations 20kgy	6.175 %	55.74 %	13.70 %
Radiations 30kgy	8.027 %	48.40 %	31.17 %
Radiations 40kgy	8.197 %	48.90 %	26.73 %

It is observed from the Figure 2 and Table 1, that there is no significant difference in the disintegration of B1(Melamine formaldehyde samples) with the different amount of electron radiations. The disintegration trend is same in the samples.

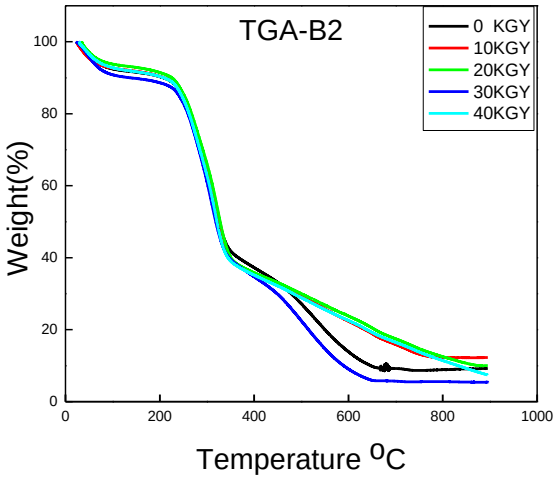

Fig 3. TGA for B2, laminated board with Urea-formaldehyde paper under different electron radiation dosages

Table:2 TGA properties observed for lamination samples B1

Samples	200^{0}C	400^{0}C	900^{0}C
Standard sample 0kgy	9.481 %	51.23 %	29.85 %
Radiations 10kgy	9.557 %	54.15 %	23.99 %
Radiations 20kgy	8.507 %	54.68 %	26.79 %
Radiations 30kgy	11.35 %	52.35 %	30.85 %
Radiations 40kgy	9.319 %	54.41 %	28.54 %

It is observed from the Figure 3 and Table 2, that there is significant difference in the disintegration of B2 (PFC) with the different amount of electron radiations. The samples with the radiation amount of 10 KGY and 20 KGY shows similar trend, where as the samples at 30 & 40 KGY disintegration rate is fast from 400^{o}C till 600 ^{0}C, after the samples becomes thermally stable. It shows the different amount of polymerization due to different amount of radiations.

3.2 DSC TEST

TA instrument, Q-1000 was used for DSC analysis with a heating rate 20^{0}C/min. A Ramp method was applied using Aluminium pan with a temperature range 25-250 ^{0}C. Approximately 3 to 4 of the sample was taken for this test. The percentage of crystallinity and melting point of the composite were calculated by using TA instrument software.

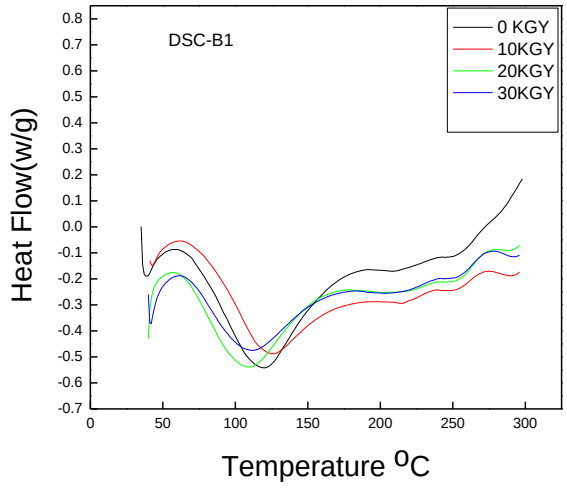

Fig 4: DSC Test for B1, laminated board with Melamine-formaldehyde paper under different electron radiation dosages

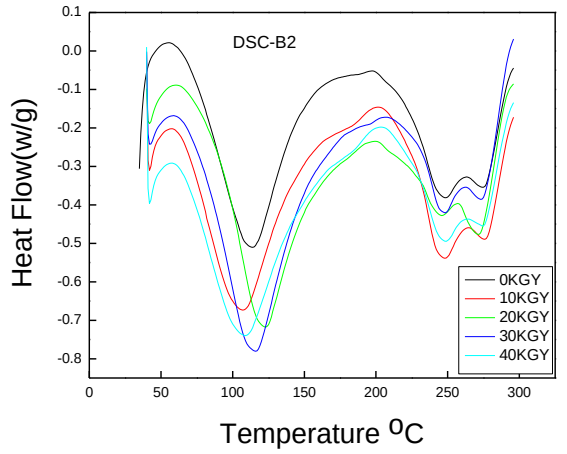

Fig 5: DSC Test for B2,laminated board with PFC paper under different electron radiation dosages

Figure 4 and Figure 5 shows that the total amount heat energy required for the curing of the lamination paper is same for the melamine formaldehyde and PFC lamination papers. The curing energy do not changes with the amount of radiations.

3.3 X-ray diffraction (XRD)

Figure 6 is showing XRD curves of samples radiated using electron radiations. The figure is showing the samples crystalline percentage based on the 2θ angle. All peaks existing within the shape are corresponded to Bragg peaks.

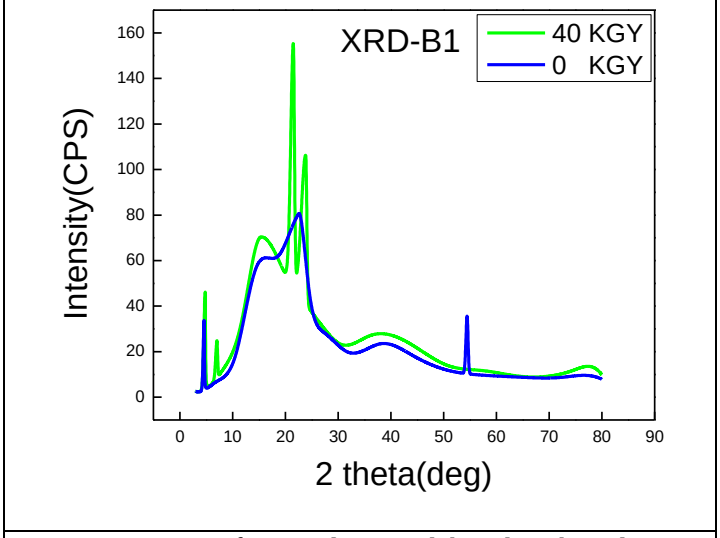

Fig 6: XRD Test for B1, laminated board with melamine-formaldehyde paper under different electron radiation dosages

Table: 3 Showing the 2-theta, d(angle) and phase names

2-theta (deg)	**d (angle)**	**Phase name**	**Irradiation**
4.60(3)	19.20	Unknown,	0 KGY
22.49(4)	3.951	N-Dodecyl-2,4-dichlorophenoxy acetamide, (1,0,1)	0 KGY
54.42(6)	1.6845	Unknown,	0 KGY
4.83(2)	18.29	1-Naphthylammonium octamolybdate, (0,1,0)	40 KGY
7.04(5)	12.55	1-Naphthylammonium octamolybdate, (1,1,0)	40 KGY
15.41(11)	5.75	Neotigogenin acetate, (2,0,0), 1-Naphthylammonium octamolybdate, (0,2,0)	40 KGY
21.51(2)	4.129	Neotigogenin acetate, (2,0,5), 1-Naphthylammonium octamolybdate, (2,-2,-1)	40 KGY
23.85(3)	3.727(5)	Neotigogenin acetate, (1,0,7), 1-Naphthylammonium octamolybdate, (4,1,0)	40 KGY

The radiations have changed the peaks. After the radiations the number of peaks has increased, the XRD also gives information about the material present in the laminations. This indicates that a radiation changes the polymerization of the melamine formaldehyde.

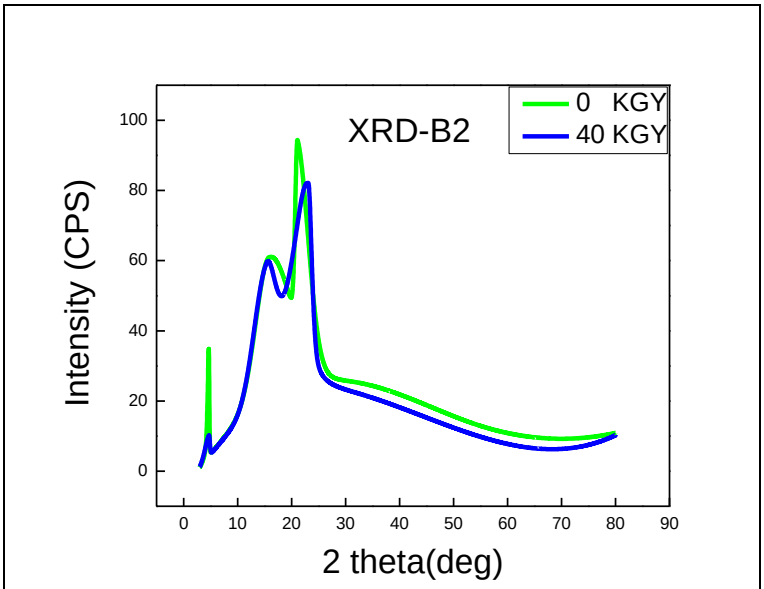

Fig 7: XRD Test for B2, laminated board with Urea-formaldehyde paper under different electron radiation dosages

Table:4 The XRD values after the radiations

2-theta (deg)	**d (angle)**	**Phase name**	**Irradiation**
4.68(3)	18.85	n-Nonacosane, (0,0,4)	0 KGY
15.79(19)	5.61	Unknown,	0 KGY
21.08(7)	4.211	n-Nonacosane, (1,1,1)	0 KGY
4.72(4)	18.72	Unknown,	40 KGY
15.43(13)	5.74	3,6-Diaza-2,6-octadiene, (1,1,0), 1,3,5-Trimethoxybenzene, (1,1,0)	40 KGY
22.4(12)	4.0	3,6-Diaza-2,6-octadiene, (1,-1,-1), 1,3,5-Trimethoxybenzene, (0,0,2)	40 KGY
23.09(4)	3.849	3,6-Diaza-2,6-octadiene, (1,1,-1), 1,3,5-Trimethoxybenzene, (0,2,1)	40 KGY

Figure 7 , shows that the amount of radiations changes the polymerization of the lamination layer, the material after polymerization is depicted in table-4. The software have identified the material at 0 KGY radiations as n-Nanocosane and after the radiations at 40 KGY as 3,6-Diaza-2,6-octadiene, (1,-1,-1), 1,3,5-Trimethoxybenzene, (0,0,2), present in the lamination layers.

4. CONCLUSION

From the present work it was concluded that electron radiations do not have much impact on the thermal degradation of lamination paper using Melamine formaldehyde coatings but the PFC lamination paper becomes more thermally stable after higher dosage of radiations. The peaks in the XRD figure of the lamination paper changes with the radiations; it shows that further polymerization occurs due to electron radiations. There is not significant changes occurs in the DSC curves, the amount of energy required to cure the resin is same. The present works helps in the development of better understanding of the effect of electron radiations on the chemical structure of the lamination papers.

5. ACKNOWLEDGEMENT

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