

# THE EFFECT OF CHEMICAL TREATMENTS ON THE DIMENSIONAL STABILITY OF OIL PALM STEM AND RUBBERWOOD

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**WAN ASMA IBRAHIM & ABDUL RAZAK MOHD. ALI. 1991. The effect of chemical treatments on the dimensional stability of oil palm stem and rubberwood.** Acetylation without the use of any catalyst or organic cosolvent and polymerisation of monomers *in situ* were carried out on oil palm stem and solid rubberwood. The extent of acetylation varied proportionally with curing time. The acetyl content of wood increased with the increase in weight gain after treatment compared to the untreated samples. The dimensional stability of the treated samples was improved in all treatments. Acetylation on both types of wood gave better improvement in dimensional stability per weight gain than polymer treatment.

Key words: Acetylation - rubberwood - oil palm stems - polymethyl methacrylate - polyglycidyl methacrylate - dimensional stability

## Introduction

One of the main disadvantages of wood is that it shrinks and swells with changes in relative humidity. Extensive work has been carried out to reduce this dimensional instability by treating wood with various stabilising agents (Stamm 1964).

Early experiments made use of bulking agents such as water insoluble chemicals or aqueous solutions of several thermosetting resin forming systems (Choong & Barnes 1969). These chemicals replace the water in the cell wall, usually with the water insoluble chemical thus preventing further swelling and shrinking when the relative humidity changes. Then, vinyl type monomers were used for this purpose which resulted in improved dimensional stability of the treated wood. These types of chemicals also bulk the cell walls and lumens keeping the wood in a bulked state so that additional increase in volume is minimized when wood comes into contact with moisture (Stevens & Schalck 1978).

In addition, this treatment also resulted in marked improvements of engineering properties of the wood (Singh 1979). Later, attempts were made to chemically modify the wood. Chemicals that are able to react with the hydroxyl groups in the lignin, cellulose and hemicelluloses in the wood were used. Some of these chemicals are formaldehyde, sulphur dioxide, epoxides, isocyanates and anhydrides (Stevens *et al.* 1979, Rowell & Ellis 1984). The

type of chemical modification is determined by the type of covalent bond formed, for example esterification, etherification, acetal formation, crosslinking *et cetera*. Particleboards made from acetylated *Albizia* wood flakes showed improvement in dimensional properties compared to boards made with untreated flakes as the acetyl content of the flakes increased (Bambang Subiyanto *et al.* 1989).

The present study investigated the effects of acetylation and deposition of polymers and of the weight gain on the dimensional stability of oil palm stems and rubberwood.

## Materials and methods

### *Wood samples*

A 23-year-old oil palm stem was obtained from an oil palm plantation in Damansara and a 28-year-old rubber tree was obtained from Sungai Buluh. Only the outer 5 cm region of the oil palm stem was taken. In the case of rubberwood, samples were cut randomly from the 2 m billet measured 2 m from the ground. Both wood samples were cut into  $2 \times 2 \times 2$  cm (radial by tangential by longitudinal in the case of rubberwood) wood blocks and were oven dried immediately after felling. The wood samples were treated without any prior extraction since this procedure is not practical for application purposes.

### *Chemicals*

Chemicals used for treatments were analytical grade acetic anhydride, methyl methacrylate and glycidyl methacrylate. The chemicals were used without further purification. Azobisisobutyronitrile (AIBN) was used as the initiator for the monomers.

### *Treatment procedure*

The oven dried samples were loaded into a metal vessel. Thirty six replicates were taken for each treatment. The vessel was then evacuated for 1 h at 3 to 6 mm Hg after which treatment solution was introduced into the vessel and left to soak the samples for another hour. Then the treatment solution was drained out of the vessel by flushing nitrogen into the vessel. The vessel was filled with nitrogen gas, sealed and cured in the oven at 120 and 80°C for acetic anhydride and monomers respectively. The curing time were varied hourly in the case of treatment with acetic anhydride. As for methyl methacrylate and glycidyl methacrylate, curing time was 20 h. After curing, the vessel was evacuated to drain out unreacted acetic anhydride and acetic acid produced during curing. In the treatments with monomers, the samples were oven dried overnight in order to evaporate unreacted monomers. This procedure was carried out separately with the three types of treatment solutions.

### Testing

Determinations of wood polymer gain (% WPG) and the antishrink efficiency (% ASE) were carried out according to the procedure of Stamm (1964).

The acetyl content of samples was determined by the procedure of Whistler and Jeanes (Browning 1967).

## Results and discussion

### Reactivities

Figure 1 shows the reactivity of rubberwood and oil palm stem towards acetic anhydride. It is interesting to note that the weight gains were higher for oil palm stem samples than rubberwood samples at each curing time. This may be due to better penetration of acetic anhydride into the oil palm stem samples due to the porous characteristic of its structure. In general, a longer reaction time allowed a higher weight gain. The acetyl contents of the treated samples also increased compared to the untreated samples (Table 1). Evidence of bonding could be seen by comparing the infrared spectra of treated and untreated samples of oil palm stem where there is an increased carbonyl absorption at  $1740\text{ cm}^{-1}$  (Figure 2) in the acetylated samples from the acetate groups bulking the wood structure.

**Table 1.** Average values of acetyl content of treated samples at various weight gains

Weight gain (%)	Acetyl content (%)	Increase in acetyl content (%)
Rubberwood:		
Untreated	1.87	-
2.74	7.86	5.99
4.65	8.87	7.00
5.30	8.99	7.12
6.95	8.90	7.03
8.12	12.4	10.6
Oil Palm Stem:		
Untreated	4.54	-
4.29	8.94	4.40
5.80	9.00	4.46
8.22	10.5	5.98
15.7	10.5	5.99

Preliminary experiments showed that the extent of polymer loading depends on the treatment conditions during monomer impregnation. In this study the reaction conditions were varied in the same manner in order to obtain various wood polymer gains (Wan Asma 1989). Earlier studies reported that

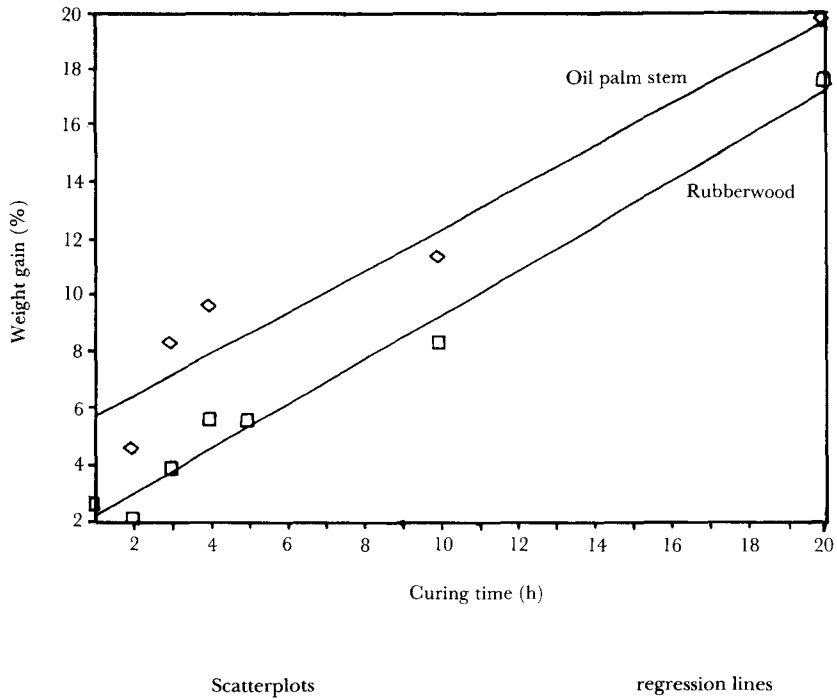


Figure 1. A graph of weight gain against curing time of acetylated oil palm stem and rubberwood

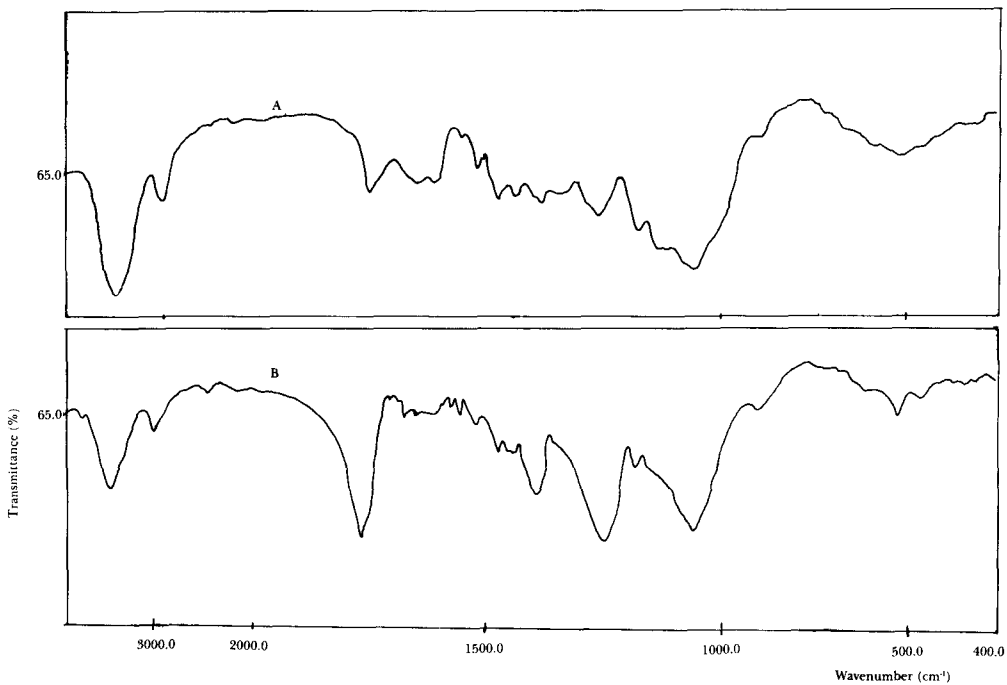


Figure 2. The infrared spectra of untreated (A) and acetylated oil palm stem (B)

the polymers are mainly deposited in the cell walls and lumens of the wood (Meyer 1984). Little chemical reaction takes place between the polymers and the wood. In this study, an attempt to extract the polymers deposited was carried out by soxhlet extractions in order to determine which of the two polymers was able to give better association with the substrate. Results showed that an average values of 36.8% and 1.39% for polymethyl methacrylate (PMMA) and polyglycidyl methacrylate (PGMA) respectively were extracted from treated oil palm stem material. As for the treated rubberwood, average values of 47.6 and 0.41% of PMMA and PGMA, respectively were extracted (Table 2). From these results, some association has occurred between the wood and polymers where this association is better with glycidyl methacrylate than methyl methacrylate. This factor may be explained by the reactivity of the epoxy group in glycidyl methacrylate which may be able to react with the hydroxyl groups in the celluloses and hemicelluloses present in wood (Subramaniam *et al.* 1981).

**Table 2.** Soxhlet extractions on methyl methacrylate and glycidyl methacrylate treated samples

Polymer type	Wood polymer gain (%)	Polymer extracted (%)	Average polymer extracted (%)
Oil palm stem:			
Polymethyl methacrylate	76.8	41.0	
	92.6	37.71	
	42.4	21.8	36.8
Polyglycidyl methacrylate	97.1	1.53	
	85.2	1.37	
	82.7	1.27	1.39
Rubberwood:			
Polymethyl methacrylate	50.2	49.6	
	58.4	46.4	
	63.7	46.9	47.6
Polyglycidyl methacrylate	40.1	0.32	
	47.8	0.41	
	51.0	0.50	0.41

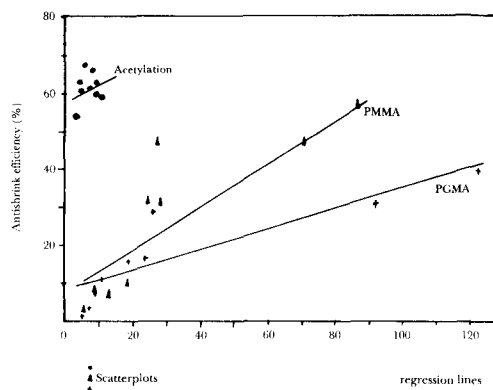
### *Dimensional stabilities*

The data for dimensional stability measured at various weight gains of rubberwood and oil palm stem following acetylation treatment are given in Table 3. A higher value of dimensional stability was achieved by rubberwood compared to oil palm stem despite higher weight gains obtained by oil palm stem samples after treatment. It was also noted that very low weight gains were able to impart a higher dimensional stability in both types of wood as opposed to the findings where these levels of average antishrink efficiencies (ASE) were only obtained from the average weight gains of 20% in acetylated southern pine (Rowell 1982). This may be due to the much higher dimensional stability of tropical hardwoods compared to temperate species softwoods even in the untreated form. This could be seen from the volumetric swelling coefficients

(Sc) for rubberwood (7.43%) and oil palm stem (9.49%) obtained in this experiment compared to that of southern pine (13.3%). Also, the determination of ASE was not carried out by the successive soaking method (Rowell & Ellis 1978). The average antishrink efficiencies (ASE), however, started to decrease at 5.41% weight gain values from 92.7 to 80.0% for rubberwood. In the case of the oil palm samples there were increase and decrease in values for every weight gain. This may be due to the effect of heat which produces slow degradative changes in the wood structure following longer curing times (Browning 1963). The improvements in dimensional stability of the samples after all treatments at various wood polymer gain values are shown graphically in Figures 3 and 4. It can be noted that PMMA & PGMA were not able to give better values of ASE compared to the acetylation treatment. Despite the higher association of PGMA with the substrate, it was not able to contribute towards better ASE values compared to PMMA. This factor may be explained by the higher affinity for water of the hydroxyl groups which result from the polymerisation reactions between the epoxy groups on the glycidyl methacrylate chain and the hydroxyl groups in the woody substrate (Figure 5) (Wan Asma 1989).

**Table 3.** Average values of antishrink efficiencies (ASE) of acetylated rubberwood and oil palm stems at various weight gains

Type of wood	Weight gain (%)	Antishrink efficiency (%)
Rubberwood	1.22	77.2
	3.73	81.6
	4.60	92.7
	5.41	80.0
	6.23	79.6
Oil Palm Stem	3.27	49.8
	4.80	63.9
	5.39	60.4
	6.44	67.8
	7.56	60.2
	8.37	65.9
	9.17	62.4
	10.4	58.3
	11.6	57.4



**Figure 3.** A graph of antishrink efficiency against wood polymer of treated oil palm stem

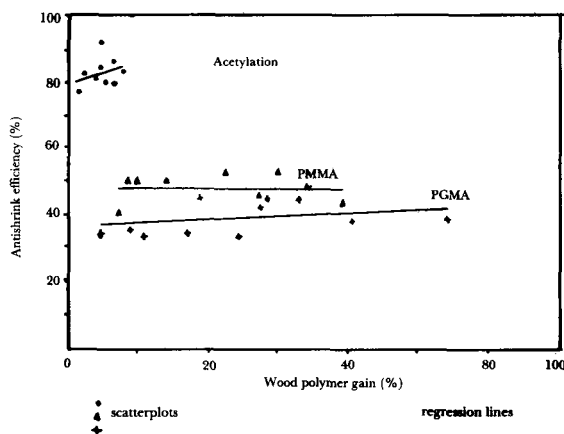
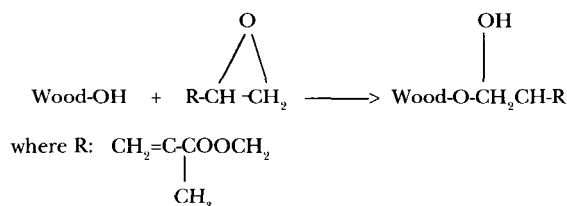


Figure 4. A graph of antishrink efficiency against wood polymer of treated rubberwood



Source: (Subramaniam *et al.* 1981)

Figure 5. Polymerization reaction of the epoxy groups on glycidyl methacrylate with wood hydroxyl groups

## Conclusion

Treatments with acetic anhydride, and *in situ* polymerization of methyl methacrylate and glycidyl methacrylate of oil palm stem and rubberwood gave varying weight gains. The weight gain during treatment with acetic anhydride increased with longer curing time. A better association between the woody substrates and polyglycidyl methacrylate was achieved compared to polymethyl methacrylate. However, a better dimensional stability was imparted by polymethyl methacrylate. However, the acetylation treatment gave the best improvement in dimensional stability compared to the other chemical treatments on the untreated oil palm stem and rubberwood.

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