THE ACIDITY OF FIVE TROPICAL WOODS AND ITS INFLUENCE ON METAL CORROSION

(Keasaman lima jenis kayu tropis dan pengaruhnya terhadap korosi logam)

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ABSTRAK

Keasaman lima jenis kayu tropis telah diteliti dalam kaitannya dengan sifat korosif dua jenis logam yaitu besi dan baja. Contoh kecil logam besi dan baja dipakukan kedalam masing-masing kayu kering udara dan kayu lembab dalam suhu ruangan. Tingkat korosi logam diukur setelah logam kontak dengan kayu selama 1, 2 dan 3 bulan yang dinyatakan dalam persen kehilangan berat. Hasil penelitian menunjukkan bahwa tiap jenis kayu memiliki sifat keasaman yang berbeda dengan bagian kayu teras sedikit lebih asam dibanding kayu gubalnya. Korosi logam besi dan baja dipengaruhi oleh keasaman kayu dan meningkat pada kondisi lembab. Bila kontak dengan kayu, besi lebih mudah korosi dibanding dengan baja. Dari jenis kayu yang diteliti kayu *A. auticuliformis* paling kecil pengaruhnya terhadap korosi sedangkan *M. eminii* paling sensitif terhadap korosi logam besi dan baja.

Keywords : keasaman kayu, korosi, besi dan baja, kayu tropis.

INTRODUCTION

In many purposes, woods are used in association with metals such as nails, screws, hinges, metallic fittings, sawing process, etc. In most case, under certain condition wood is responsible for damage of metals trough corrosion process. The corrosion of metals in association with wood may be considered under two headings, namely (1) corrosion of metals in contact with wood, and (2) corrosion of metals in an atmospheric that is conditioned by the presence of wood (Farmer 1967).

Essentially, corrosion is an oxidation process. However, it may be accelerated by the presence of moisture and some substances, such as acid. Due to the fact that woods generally acidic (Packman 1960), it is not surprising that when wood and metals are in direct contact, serious corrosion of metals may occur. The corrosion properties of wood itself is reflected by its acidity (Krilov and Lasander 1988).

The acidity of wood is caused mainly by free acids and acidic group such as hydrolysable acetyl groups of wood (Fengel and Wegener 1989). Other components, in particular the content of salt, extractives, the amount of uronic acid and other acidic group of the hemicellulose also contribute to the wood acidity.

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The acidity of wood may increase by oxidation of the extractives and hydrolytic degradation of the wood components. Acetic and formic acid in lesser degree, are the main volatile acids found normally in wood (Choon and Roffael 1990; Nawawi *et al.* 2001).

The amount of acetic acid is freely increased by hydrolysis of the acetyl groups of hemicellulose (Krilov and Lasander 1988). Wood treated by temperature, humidity and storage (time) lost of acetyl groups and it is responsible for the increasing of acetic acid release (Packman 1960). Consequently, where sufficient temperature and moisture are available many timbers give rise to a small amount of volatile substances, such as acetic acid. These acids are responsible for wood acidity and reflected by low pH value.

The acidity of wood is an important factor influencing the corrosion of metals by wood, however, this subject has not been intensively investigated for the most of tropical wood in Indonesia. The wood species namely *Acacia mangium, Gmelina arborea, Eucalyptus deglupta, Maesopsis eminii* and *Acacia auriculiformis* are fast growing species being planted widely to serve as a potential wood resources for the future. These woods species are the subject of the present investigation.

The objective of this research is to study the acidity of some woods species and its relation to the corrosion of metals.

MATERIALS AND METHODS

Materials

Five woods species were investigated in this study. These are *Acacia mangium, Acacia auriculiformis, Gmelina arborea, Eucalyptus deglupta,* and *Maesopsis eminii.* The woods samples were taken from stem of about 8 years old. The specimen is then prepared from 1.3 meter above the base of the tree which heartwood and sapwood were separately.

Two kind of metals widely used in many processing and utilization of wood, iron and steel (commercial nail) were tested for corrosion properties.

METHODS

Wood Meal Preparation

Wood meal was prepared by milling and screening of air dried wood flakes of wood species under investigation. The fraction of milled wood passed 40 and retained on 60 mesh were collected.

The pH Value Measurement

The acidity of wood was expressed as pH value and was determined in accordance with the method described by Krilov and Lasander (1988). In this method twenty grams of wood meals were suspended in 200 ml of hot distilled water and shake for one hour in a hot-water bath maintained at 80 °C. The aqueous extract was filtered trough Whatman no. 40 filter paper. The extract was then stored in bottle at room temperature. The pH value was then determined using a callibrated pH meter.

Extractives Contents

The extractives content of wood was determined according to TAPPI T-6m 1991. About 10 grams of wood meal was accurately weighed, and then was extracted with ethanol-benzene 1:2 (v/v) for 6-8 hours. The extract was then evaporated and extractives content was expressed in percentage value based on the oven-dried wood.

Corrosion of Metals

The study of corrosion of metals in association with wood was determined in room temperature. The metals samples were cleaned, dried and accurately weighed as an initial weight. Each metal sample was then nailed in the wood specimen (sapwood and heartwood separately) and then kept at room temperature for 1, 2 and 3 months, respectively.

At each time interval, the samples were washed and cleaned of loose materials. After drying, the samples were weighed and the corrosion of metal was expressed as a weight loss of materials in percentage.

The corrosion of metals, in association with wood, were examined in two condition, i.e. air dried wood condition and moist wood condition. The corrosion of iron and steel in the same air-dried condition left for 3 months was used for control.

RESULTS AND DISCUSSION

The pH Values

The acidity, as pH value, of five woods species examined vary by different of species and between sapwood and heartwood (Table 1). However, all of woods species in the present investigation were acidic in nature. This results confirm the finding of Packman (1960), who found that the aqueous extracts of the great majority of common woods are acidic.

It can be seen from Table 1, that the acidity of heartwood was slightly higher than that of sapwood. The high amount of extractives of heartwood could possibly responsible for wood acidity of heartwood (Fig. 1 and 2). The acidity of wood is conditioned by numerous acidic substances in wood such as organic acid, extractives and polyphenol compounds. The extractives of heartwood may consist of free acids, acidic groups, and polyphenol higher than sapwood (Fengel and Wegener 1989, Krilov and Lasander 1988).

Table 1. The pH values and extractive content of woods species.

No.	Wood Species	Sapwood		Heartwood	
		pH Value	Extractives, %	pH Value	Extractives, %
1.	*A. mangium*	5.56	4.33	5.21	4.84
2.	*G. arborea*	5.67	1.29	4.70	4.43
3.	*E. deglupta*	4.65	2.95	4.58	4.15
4.	*M. eminii*	5.31	1.94	3.92	2.76
5.	*A. auriculiformis*	5.49	4.13	4.68	4.83

Corrosion of Metals

The corrosion of metals which associated with wood in room temperature for 1, 2 and 3 months respectively are given in Table 2 and 3. Each wood species has a different respond to corrosion of metals, which heartwood is more corrosive than that of sapwood.

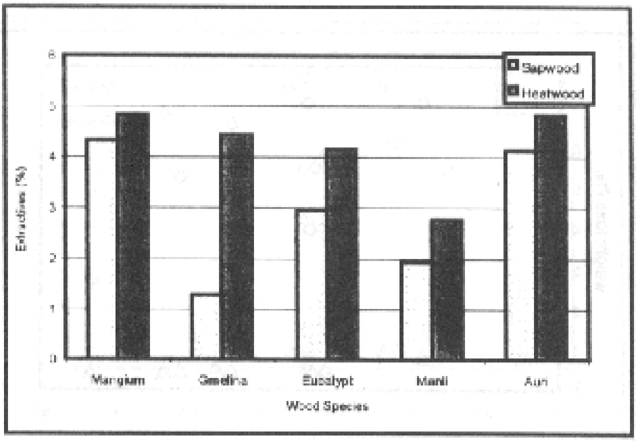

Figure 1. Extractives content of sapwood and heartwood of five woods species

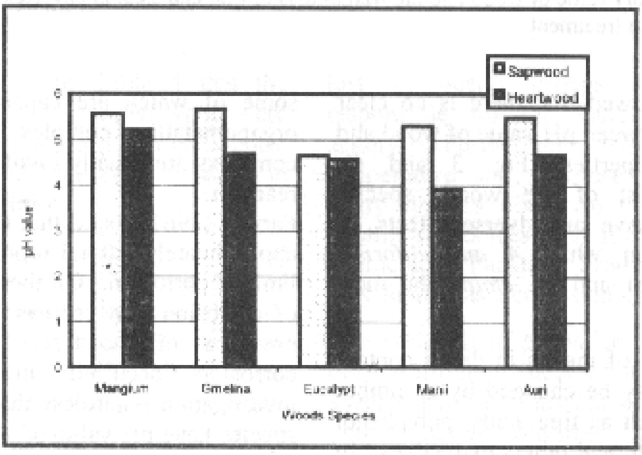

Figure 2. The pH value of sapwood and heartwoods of five woods species

Table 2. The corrosion of metals in association with air-dried wood at room temperature.

Wood Species	Wood Part	Corrosion of Iron (Weight loss, %)			Corrosion of Steel (Weight loss, %)		
		1 month	2 months	3 months	1 month	2 months	3 months
A. mangium	Sapwood	1.83	3.51	5.25	0.19	0.38	0.48
	Heartwood	2.13	3.64	6.55	0.24	0.37	0.48
G. arborea	Sapwood	2.80	5.16	6.81	0.32	0.38	0.45
	Heartwood	3.05	6.13	7.07	0.47	0.56	0.68
E. deglupta	Sapwood	1.94	3.40	5.50	0.21	0.27	0.34
	Heartwood	1.82	4.51	5.83	0.26	0.35	0.50
M. emimi	Sapwood	3.01	5.78	7.57	0.33	0.42	0.59
	Heartwood	3.29	6.17	7.09	0.39	0.50	0.84
A.auriculiformis	Sapwood	0.55	2.18	2.71	0.17	0.28	0.46
	Heartwood	0.59	2.33	3.98	0.27	0.37	0.62
Control				0.47			0.10

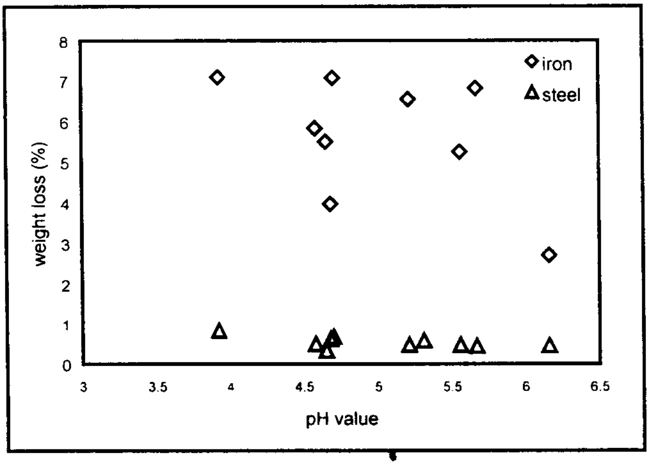

Figure 3. The pH value of wood and the weight loss of iron and steel in air-dried condition after month treatment

The result showed that there is no clear correlation between pH value of wood and corrosion properties (Fig. 3 and 4). However, most of the woods species investigated have an adverse affects on metal corrosion, which *A. auriculiformis* being the least and *M. eminii* the most corrosive.

The corrosion of metals in direct contant with wood may be changed by a number of factors, such as free acids, polyphenol compound, salt, and others extractives. In particular, extractives may contain numerous highly reactive component, some of which are capable of forming organometallic complex, where such complexs are usually involve in corrosion reaction.

Farmer (1967) found that the pH value of approximately 4.0-4.3 represent the lower limit of corrosion. On these limit the rate of corrosion may increase rapidly in the presence of moisture. Nevertheless, corrosion occurred in the present investigation regardless that most woods species have pH value of about 4.61-5.69. The pH value of *M. eminii* is 3.91. Thus, it is not surprising that the wood relatively more corrosive.

Table 3. The corrosion of metals which association with moist wood in room temperature.

Wood Species	Wood Part	Corrosion of Iron (Weight loss, %)			Corrosion of Steel (Weight loss, %)		
		1 month	2 months	3 months	1 month	2 months	3 months
A. mangium	Sapwood	2.17	3.63	5.57	0.22	0.31	0.39
	Heartwood	2.32	4.57	10.69	0.24	0.55	0.63
G. arborea	Sapwood	3.32	5.52	7.45	0.35	0.49	0.71
	Heartwood	3.42	5.62	11.04	0.48	0.77	0.83
E. deglupta	Sapwood	2.14	3.47	5.72	0.22	0.30	0.41
	Heartwood	2.40	4.00	10.63	0.33	0.40	0.63
M. eminii	Sapwood	3.14	5.13	8.61	0.32	0.51	0.72
	Heartwood	3.34	5.70	11.15	0.49	0.80	0.98
A. auriculiformis	Sapwood	0.83	2.25	2.96	0.19	0.32	0.46
	Heartwood	1.04	2.88	7.59	0.35	0.64	1.49

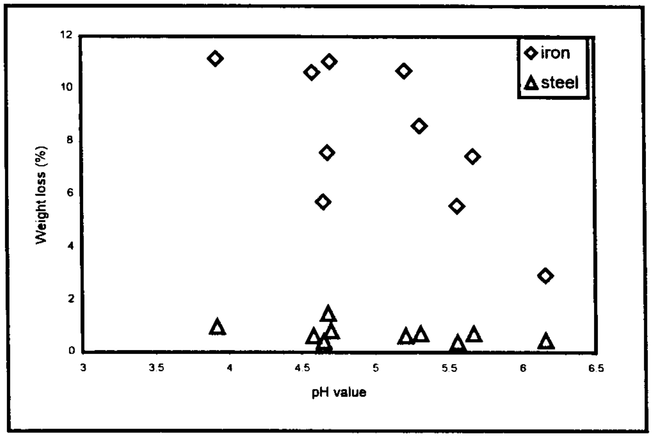

Figure 3. The pH value of wood and the weight loss of iron and steel in moist condition after 3 month treatment

It can be seen from Table 4 that the corrosion of metals in moist wood were higher than that of in air-dried woods. This is due to the presence of water in moist wood condition.

It has been noted that the presence of moisture and oxygen is essential for the most of corrosion to proceed (Farmer (1967). Therefore in a dry condition, serious corrosion will not likely to occur, even when wood and metal are in a direct contact. The rate of corrosion increase rapidly in the presence of moisture with favorable condition.

The resistance of metals to corrosion is also vary considerably. It was found in the present experiment that in comparison to steel, iron is more susceptible to corrosion. Application of a protective coating to the surface of metals in contact with wood may be able to minimize the corrosive effect of wood.

It was also found that the corrosion of metal is dependent of time, in which a prolonge contact of metal with wood increased its corrosion. Temperature, humidity and time (storage) promote the lost of acetyl groups. These are responsible for the increase of wood acidity. Furthermore, where sufficient temperature and moisture are available many timbers give rise the amount of volatile substances such as acetic acid and formic acid (Packman 1960). These acids may fuction as a corrosion agent in wood.

The variation of pH value may exist not only in different species but also within a species, between sapwood and heartwood, young trees and old trees. Therefore, the pH value is only a general indication to the relative corrosion tendencies of different wood species. Special attention is required when wood and metals are used in association, mainly under a favorable condition for corrosion to occur.

CONCLUSSION

The acidity of wood vary by different of wood species and slightly different between sapwood and heartwood.

The corrosion of iron and steel were influenced by the pH of wood and it was accelerated by presence of moisture. Iron is more susceptible to corrosion than steel when it is used in direct contact with wood.

Wood acidity, measured as pH value, may provide useful indication for woods with corrosive properties. Furthermore, special treatment may be required when these woods species are used in association with metals, mainly in favorable condition for corrosion to occur.

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