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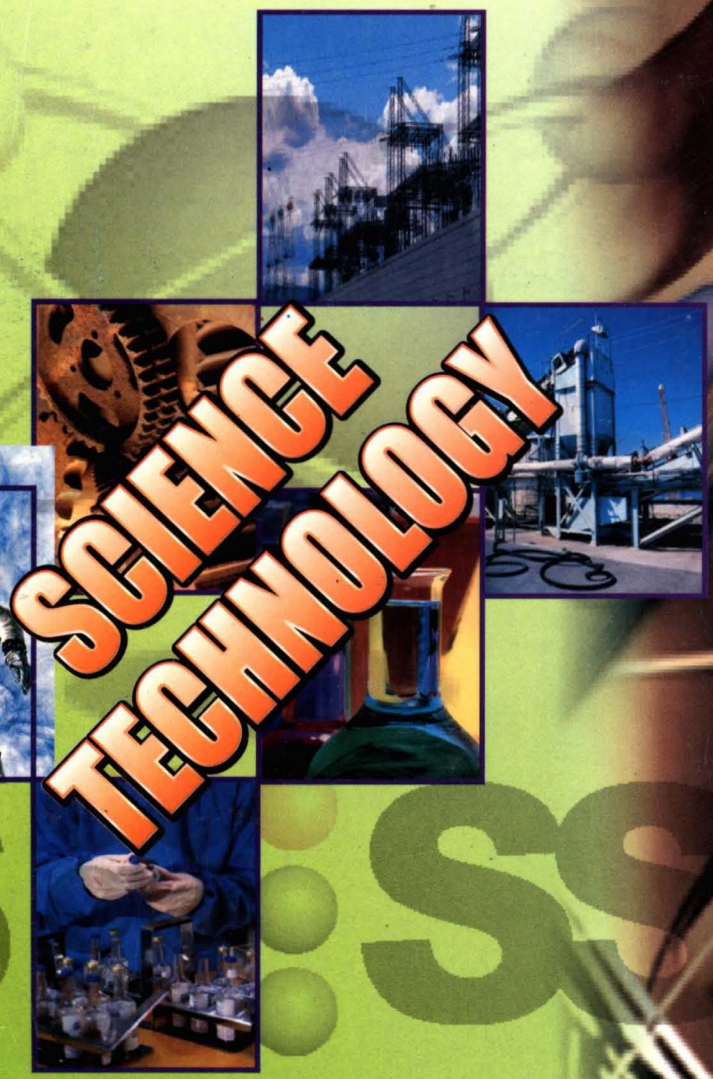

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Hypochlorite Bleaching of Oil Palm Empty Fruit Bunches Soda-AQ Pulp for Blending with Recycled Newspaper

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ABSTRACT

Application of oil palm empty fruit bunch as raw materials for pulp and paper is extremely promising because of its availability and the future demand of paper in Malaysia is expected to be enormous. In this work, the effect of hypochlorite bleaching of EFB soda-anthraquinone pulp was studied. The oil palm empty fruit bunch was pulped by soda-anthraquinone pulping process and bleached by two stages of hypochlorite and alkali extraction. The pulp was treated with different bleaching temperatures, bleaching retention time and hypochlorite concentration of EFB dry weight. After bleaching, the brightness of pulps is in the range of 60 to 76%. Hypochlorite concentration has the highest impact on pulp brightness compared to bleaching temperature and retention time. The pulp brightness can be predicted by varying the temperature, retention time and hypochlorite concentration.

Keywords: *brightness, hypochlorite bleaching, oil palm empty fruit bunch (EFB), soda-AQ process.*

Introduction

As with other rapidly developing nations, Malaysia's demand for paper and paperboard products has grown in tandem with its GDP growth. Malaysia is a net importer of paper. Malaysia imported 1.2 million tones of pulp, paper and paperboard valued at RM3.5 billion in 2000 (Anon 2003).

The imported paper and paper products have caused a lost in Malaysian foreign exchange but can be reduced by utilising local lignocellulosic in pulp and paper industry. One of the abundant lignocellulosic residues is the oil palm empty fruit bunches (EFB). Malaysia's 351 palm oil mills produce 16 million tons of EFB per annum in the year 2000. EFB soda pulp could be used in combination with a softwood thermomechanical pulp or old newspaper to produce newsprints with acceptable properties (Rushdan 2002a, Wan Daud et al. 1998).

Most non-wood pulp is produced by soda pulping process (Atchison 1987; Minor 1996). Anthraquinone (AQ) was discovered to accelerate soda pulping and consequently increased in yield and decreased in amount of lignin left in pulp (Holton 1977). The soda-AQ process of EFB produced a balanced pulp in yield and chemical composition compared to the soda, kraft and kraft-AQ processes (Rushdan 2002b).

After the pulping operation, the pulp is often dark in colour. For newsprint production, the pulp should have a brightness of 60 – 65% (Biermann 1996; Wan Daud *et al.* 1998). Bleaching makes pulp whiter and brighter to the eye. Bleaching is a chemical process applied to pulp to increase its brightness by lignin removal. Pulp brightness is one of the parameter in monitoring bleaching progress. Different types of bleaching chemicals, stages and sequences are used in producing different degree of pulp brightness. An unbleached pulp is coloured due to the absorbance of visible light by the presence of residual lignin, a highly coloured substances. There are more than ten types of bleaching chemicals. Lignin removal is achieved using chlorine, hypochlorite, chlorine dioxide, oxygen or ozone (Reeve 1996). Different types of bleaching chemicals, stages and sequences are used in producing different degree of pulp brightness and will affect the pulp and paper properties. Most non-wood pulps are bleached by using hypochlorite either as a single stage, three-stages or four-stages of bleaching (Kocurek 1987, Kraft 1963). Hypochlorite oxidizes, decolourises and solubilises the lignin (Reeve 1996). Rushdan (2005) found that hypochlorite treatment followed by soda extraction produced pulp brightness suitable for newsprint. The objectives of this study were to determine the effect of hypochlorite bleaching parameters on EFB soda-AQ pulp brightness.

Materials and Methods

Soda –AQ Pulping

Five hundred grams (oven dry) of EFB fibrous strands were pulped by the soda-anthraquinone (soda-AQ) process using a 4-litre rotating digester. The pulping conditions employed were as follows:

1. Maximum cooking temperature: 170°c,
2. Time to maximum temperature: 90 minutes,
3. Time at maximum temperature: 90 minutes,
4. Efb to liquor ratio: 1:8
5. Amount of anthraquinone: 0.1% of efb dry weight

6. Amount of naoh: 20% of efb dry weight.

Hypochlorite Bleaching

At the end of digestion, the softened EFB was disintegrated for five minutes in a hydropulper, washed on a screen and screened by a fractionator (Somerville type) with a screen plate of 0.20 mm slits. The screened pulp was used in bleaching.

In bleaching, the soda-AQ pulps were bleached by Hypochlorite (H) and sodium hydroxide (E) stages. The hypochlorite bleaching (H) and alkali extraction (E) conditions employed were:

	Hypochlorite (H)	Alkali extraction (E)
1.Chemical:	Sodium hypochlorite (NaOCl)	Sodium hydroxide (NaOH)
2.Temperature:	35 & 40°C	30°C
3. Time:	1, 1.5 & 2 hours	1 hour
4. Concentration:	3, 6 & 9% of EFB dry weight	1% of EFB dry weight
5. Consistency:	3%	3%

In each treatment, 24 g of pulp and liquor, at consistency of 1%, were put in 6 bottles, as 6 replications, and placed in a tray in a temperature controlled water bath. The tray was shaken mechanically to mix the pulp and chemical properly at specific time. The pulp was treated with different bleaching temperatures, bleaching retention time and hypochlorite concentration of EFB dry weight. The alkaline extraction stage (E) was constant. The treatments are tabulated in TABLE 1.

The pulps were washed thoroughly between bleaching stages. Pulps brightness was measured according to TAPPI Standard T 452 om-92 "Brightness of pulp, paper, and paperboard (directional reflectance at 457 nm)" (TAPPI 1994). The data were analysed with statistic software Minitab.

Table 1: Hypochlorite bleaching treatments.

ID	Temperature (°C)	Retention Time (h)	Concentration of Hypochlorite (%)
T35R1C3	35	1	3
T35R1C6	35	1	6
T35R1C9	35	1	9
T35R1.5C3	35	1.5	3
T35R1.5C6	35	1.5	6
T35R1.5C9	35	1.5	9
T35R2C3	35	2	3
T35R2C6	35	2	6
T35R2C9	35	2	9
T40R1C3	40	1	3
T40R1C6	40	1	6
T40R1C9	40	1	9
T40R1.5C3	40	1.5	3
T40R1.5C6	40	1.5	6
T40R1.5C9	40	1.5	9
T40R2C3	40	2	3
T40R2C6	40	2	6
T40R2C9	40	2	9

Results and Discussion

The brightness of EFB pulps among treatments is not equal (FIGURES 1 & 2). Their brightness is in the range of 60 to 77%. The differences in brightness is due to the treatments they had undergone. The rate and extent of the hypochlorite bleaching reaction depends on the temperature, bleaching time and concentration of hypochlorite. All parameters affect the pulp brightness (Figures 3, 4 & 5).

The brightening of pulp in hypochlorite bleaching is due to the destruction of lignin derivatives formed from the original lignin in the preceding pulping. The main light–absorbing substances in pulp are derived from the lignin of the original fibrous material. Chemically, bleaching reduces the concentration of light absorbing constituents so that paper reflects more light. These light–absorbing substances are oxidized and reduced to make them soluble in aqueous solution in order to remove them from the pulp (Histed *et al.* 1996).

Hypochlorite oxidizes and fragments the lignin but, because it was carried out under acidic conditions, only part of the degraded lignin dissolves. The role of extraction is to remove the lignin made potentially soluble by the previous acidic oxidizing stage and to reactivate the pulp for further oxidation (Berry 1996). All reactions occurred in extraction are affected by carry over from the previous stage (Berry 1996).

The temperature has an effect on pulp brightness. When the temperature increased from 35°C to 40°C, the brightness has increased from 68% to 74% (Figure 3). Other workers found that when bleached temperate pulps species, the rate of reaction between hypochlorite and pulp doubled for each 7°C (McEwen 1963). In this work, the increased of temperature by 5°C has increased the bleaching rate by 6 points or 9%. This is due to the nature of pulp, temperate wood vs. tropical non-wood.

The bleaching retention time has an effect on pulp brightness. When the retention time increased by 0.5 hour and 1 hour, the brightness has increased from 67 to 70, and 67 to 74 respectively (Figure 4). More lignin and dirt specks are eliminated in a longer time bleached than in a short one.

When the concentration increased by 3 and 6%, the brightness has increased from 65 to 69, and 65 to 74 respectively (Figure 5). Bleaching is expedited due to the increase in the hypochlorite-to-pulp ratio.

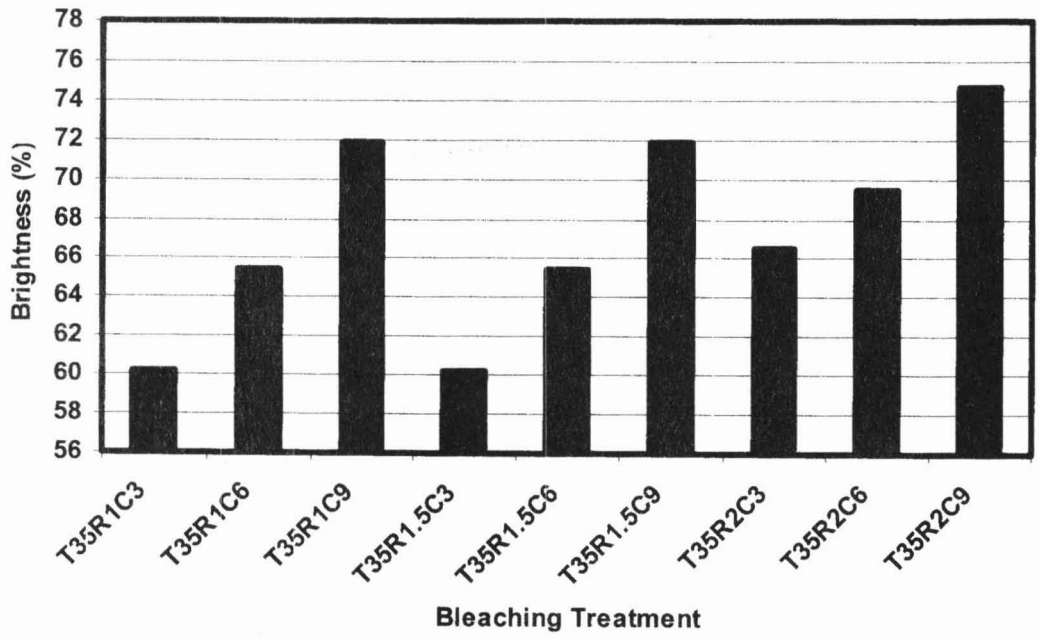

Fig. 1: The effect of retention time and hypochlorite concentration at 35°C on pulps' brightness

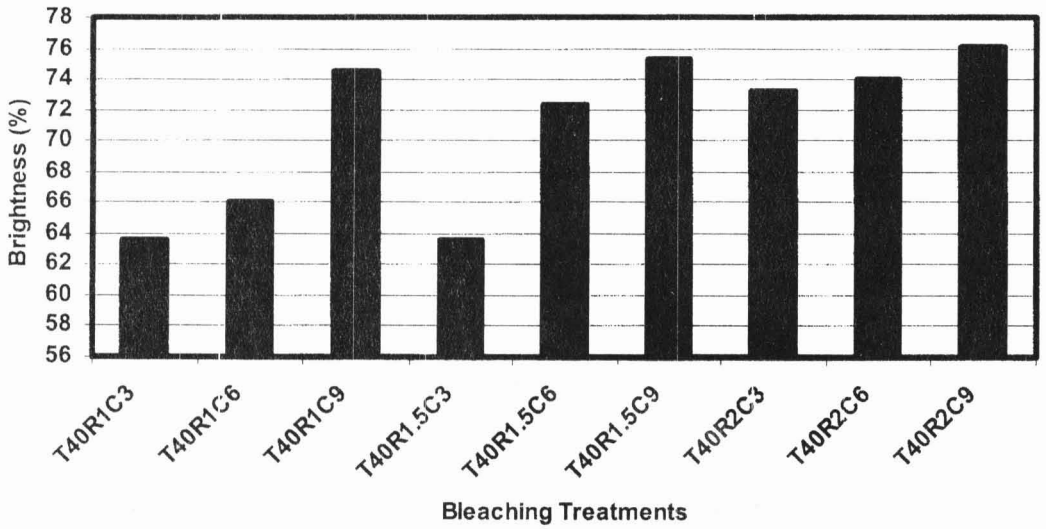

Fig. 2: The effect of retention time and hypochlorite concentration at 40°C on pulps' brightness

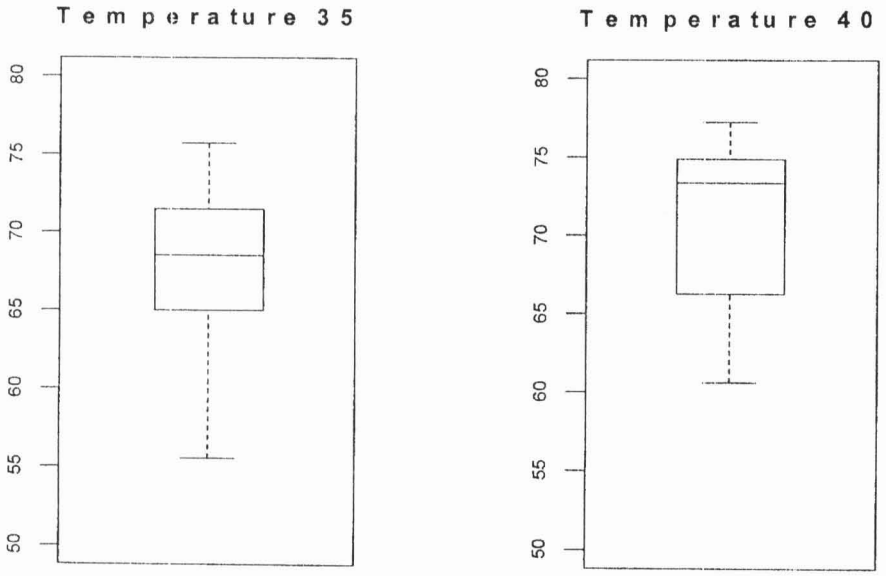

Fig. 3: The box-plots of the effect of bleaching temperature on brightness.

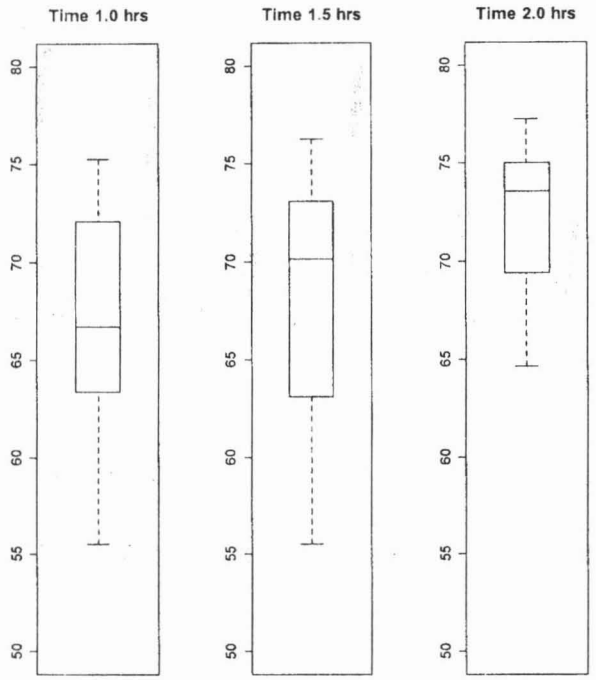

Fig. 4: The box-plots of the effect of bleaching retention time on brightness

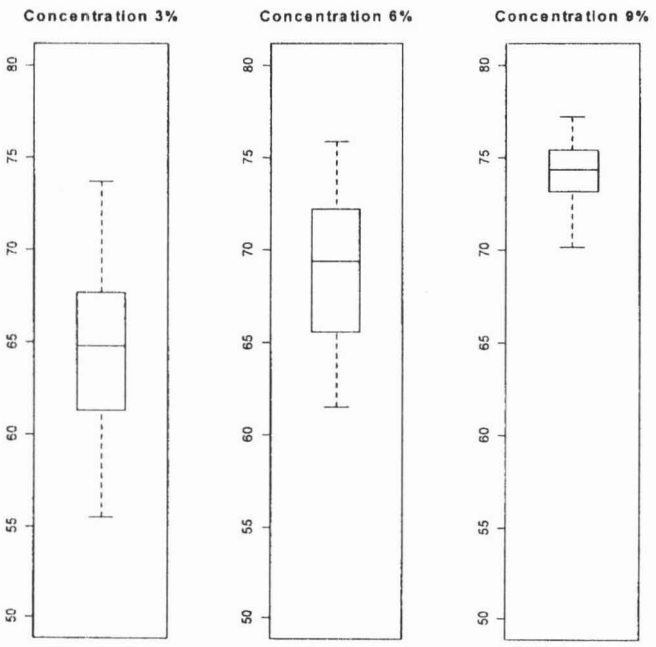

Fig. 5:. The box-plots of the effect of hypochlorite concentration on brightness

Among these parameters, the hypochlorite concentration has the highest impact (see Table 2).

Table 2: The General Linear Model analysis of the effect of temperature, time and concentration on pulp brightness.

Factor	Levels	Values
Temperature (°C)	2	35 40
Time (hour)	3	1 1.5 2.0
Concentration (%)	3	3 6 9

Analysis of Variance for Brightness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Temperature	1	370.74	370.74	370.74	43.82	0.000
Time	2	580.32	580.32	290.16	34.30	0.000
Concentration	2	1624.79	1624.79	812.40	96.03	0.000
Error	102	862.91	862.91	8.46		
Total	107	3438.76				

For newsprint production, the pulp should have a brightness of 60 – 65% (Biermann 1996; Wan Daud et al. 1998). In this study, all treatments produced pulp has brightness more than 60%. In mill operation, cost is a very important factor. High temperature, longer bleaching time and high chemical consistency will increased the production cost. In this study, temperature of 35°C, retention time of 1 hour and chemical consistency of 3% can produce pulp suitable for newsprint production at the lowest cost.

Conclusion

The study showed that the oil palm empty fruit bunch (EFB) could be bleached successfully by hypochlorite for newsprint production. Temperature of 35°C, retention time of 1 hour and chemical consistency of 3% can produce pulp suitable for newsprint production. Hypochlorite concentration has the highest impact on pulp brightness as compared to effect of bleaching temperature and retention time.

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