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Carbon-Polyol Coating Using Carbon Produced From Palm Kernel Cake (PKC)

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Abstract: In our quest to create awareness in using renewable, sustainable natural resources and efficient waste management, palm kernel cake (PKC) which is the waste from the palm industries was used in preparation of Carbon-polyol coating. PKC was subjected to pyrolisis process and the carbon residue obtained was used as a black pigment. In this work modified Polyol was used as the binder for its ideal properties as vehicle to produce good opacity of paint. Various carbon-polyol dispersant with different weight compositions (wt%) of carbon prepared and tested against its respective rheological properties in order to determine ideal paint/ink system. Two different types of paper material (Brown paper B and white paper W) were chosen as a substrate and characterised. Each of the paper was then proofed with Carbon-polyol using palm kernel carbon (PKC) and commercial carbon (PURE_C). Lightfastness test was carried out on the paper specimens and the results on the total colour difference (dE) are obtained. It was found that the total colour change (dE) in specimens using brown paper (B) coated with Carbon polyol coating using carbon derived from palm kernel carbon (PKC_B) and the commercial carbon (PURE_C_B) is within 10%. The other two specimens, using white paper (PKC_W and PURE_C_W), the total colour change (dE) is 17%. It is expected that the coating system has the potential application in paint or ink.

Key words: Carbon-Polyol; Palm Kernal Cake (PKC); Colourant; Lightfast; Coating

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INTRODUCTION

Coating is formed to become a protective layer against exposure to environmental factors causing photodegradation or dissolution of colourant. Colourants are materials that give an paint/ink its colour. Generally, the main two colourants can be classified into dyes and pigments. In this work, black ink/paint using pigment from carbon residues of pyrolysis from waste is viewed by lightfastness evaluation. Many factors influence the lightfastness of polymer ink/paint principally by degradation of structures of the components of the paint/ink. Photodegredation are the physical states of the polymer composition, water, temperature and contaminants [1-4] Photodegradation can take place when solar radiation falls on a dyed polymer where change in shade or depth of shade of the colourant on the coated substrate were influence by the photochemical degradation. Physical polymer-substrate interactions, such as wetting and penetration of

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a liquid ink on paper influence the final attachment of colourant. Colourant also contributed by type of substrate as important physical properties where low porosity and low wettability are inter-related to action of the penetration of light, surrounding air or water into the coating [3,4].

The primary external factors affecting image stability are light, heat, humidity and air quality. The image stability is greatly influenced by the physical environmental elements along with the chemical of the colourant in paper, which are determined by the nature of the coating and the other ink components [5]. Therefore, a proper match of an ink and paper as substrate to a given ink set is critical to achieve good image stability. The properties of the substrates have a strong influence on light fastness. The polymer system of the coating is one of the main factors affecting the fastness properties of an ink jet print, since polymers can stabilize and immobilize the colourant both physically and chemically [6-8].

1. METHODOLOGY

Carbon-Polyol coating is formed into protective layer of paper substrate to be tested. Carbon of PKC were (AC PKC) was obtained from pyrolisis process. The mixture of Carbon-Polyol is mixed using IKA high speed mixer until homogenous. The sample of ink/paint was proofed on the paper substrate using anilox roller print system and cured in a room. Effect on substrates on fading characteristics was to obtain the fastness properties of both print durability and image stability. Image stability stands for the long-term permanence of the printed image, for example light or water fastness. Print durability refers to the physical permanence of the paper, such as tear or scratch resistance. Therefore, it is mainly determined by the properties of the paper, and to a lesser extent by the type of ink.

1.1 Paper Characterization

Paper characterization was performed to investigate the absorption properties and to study the relationship between porosity of the paper to signify the interaction between liquid-solid interface. The summary of the absorption mean values were calculated from repetitive measurements to determine the average properties for paper materials used in the study. The results obtained were explored as the basis for discussion about the efficiency of ink transfer onto the paper substrates. The mean values of thickness, grammage and specific weight for the paper materials used in the study along with the standard specification used for the preliminary evaluation were illustrated. The property standards are thickness, grammage, specific weight and physical aspects of paper material as an evaluation standard.

1.2 Printed Ink Characterization

Samples of proven substrate were cut into chamber fitting for undergoing the light exposure in the lightfast chamber. The exposure was to simulate an accelerated ageing to represent photodegradation or dissolution of colourant process. The accelerated ageing of printed paper was studied using two different substrates (B= brown, W= white) treated at room temperature (27^{o}C) using spectrophotometer from Data Colour (SF600X). The printed paper was exposed to light generated by Mercury-Tungsten light of Halifax, England for several duration of tests. The samples of paper substrates were prepared and exposed to the Tungsten light source chamber and the density of each samples were measured using Datacolour spectrophotometer for recording the optical density (OD) prior and after the aging test. The samples placed into the chamber were exposed for a number of set minutes range from a period of 30 minutes to 150 minutes. The sample's OD were measured instantaneously each time the finished duration period of aging took place until all five sets of samples were completed.

The three basic coordinates represent the lightness of the color ($\boldsymbol{L*}$, $L* = 0$ yields black and $L* = 100$ indicates white), its position between red/magenta and green ($\boldsymbol{a*}$, negative values indicate green while positive values indicate magenta) and its position between yellow and blue ($\boldsymbol{b*}$, negative values indicate blue and positive values indicate yellow).

2. RESULTS

The results of this study indicated that the contribution of the coating composition to light fastness is very complex within many coating's categories where many possible stabilization or destabilization mechanisms of the colourants can be pinpointed. The ageing from Datacolor under its illumination analysis indicated that the significance of the physical paper properties for light fastness was indicated in the carbon-polyol coatings.

2.1 Paper Characterization

Paper characterization measured aspects of physical characteristics of paper substrate summarized in table 1. The mean values of the calculated measurements for various properties for paper materials were explored. The yield of good coating prints are all about the efficient transfer of ink onto the paper substrates. The mean value of thickness, grammage and specific weight of the paper materials is used in the standard evaluation.

Table 1
Summary of Paper Characterization

Property	White	Brown	Standard
Thickness(μm)	258	193	STN ISO 534
Grmmage($g.m^{-2}$)	215	155	STN ISO 536
Specific Weight($g.cm^{-3}$)	0.83	0.80	STN ISO 534
Water Absorbency($g.m^{-2}$)	20.8	19.0	STN ISO 535

2.2 The Effect of Substrates

The test resulted coating lighfastness and observed the aging of carbon polyol ink. The characteristics presented in number of days of ageing quality and viewed in table 2 until table 5 followed by the respected figures of 2 until 5. The ageing results obtained from Spectrophotometer Datacolour presented detail of colour spaces for views of ageing factor in the coating film. The colour space views were determined by colour-scale differential measurement using reflection spectra by Datacolour. The process is known as differential colour wavelength analysis specifically attributed as colour space. The colour space L*, a*, b* was calculated by the spectrophotometer on the coating film investigated. The black ink from PKC and commercial black (PURE_C) ink which printed/proof on brown and white papers were tested for evaluating the respected colour space in the ageing test. The _B is representing brown paper substrate while the _W is for white paper substrate. The colour space were measured and recorded before and after each of the ageing test. The differential or (D) in colour intensity were tabulated in table 2 until 5 accordingly. The respected colour space coordinates of DL*, Da* and Db* values evaluated the changes of colour. The changing of colour densities due to time of light exposure or lightfastness were plotted in figure 4 in accordance of data obtained from table 5.

Table 2
The Change of DL* Measured During Accelerated Aging Test

Time(min)	PKC_B	PKC_W	PURE_C_B	PURE_C_W
30	1.06	3.18	0.43	2.01
60	0.34	0.36	0.67	2.35
90	1.94	6.88	-0.12	2.65
120	2.55	3.65	0.18	0.9
150	3.16	0.42	0.48	-0.85

Table 3
The Change of Da* Measured During Accelerated Aging Test

Time(min)	PKC_B	PKC_W	PURE_C_B	PURE_C_W
30	0.18	0.07	-0.07	0.06
60	0.11	-0.10	-0.09	0.07
90	0.29	0.16	-0.11	0.08
120	0.37	0.05	-0.09	0.01
150	0.45	-0.06	-0.07	-0.06

Table 4
The Change of Db* Measured During Accelerated Aging Test

Time(min)	PKC_B	PKC_W	PURE_C_B	PURE_C_W
30	0.64	0.09	0.05	0.07
60	0.37	0.65	0.18	0.05
90	0.85	0.25	-0.20	0.11
120	1.29	0.43	-0.05	0.17
150	1.73	0.61	0.1	0.23

The total colour difference was calculated according to equation:

$$\Delta E^* = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2}$$

Where $\Delta L^* = L^*(t) - L^*(0)$; $\Delta a^* = a^*(t) - a^*(0)$; $\Delta b^* = b^*(t) - b^*(0)$ are the differences calculated for aged ink film (t) and the original (0) ink layers. [1]

Table 5
The Total Colour Change DE* Calculated Based on Measured Data from Accelerated Aging Test

Time(min)	PKC_B	PKC_W	PURE_C_B	PURE_C_W
30	1.25	3.18	0.44	2.01
60	0.52	0.75	0.69	1.85
90	2.14	6.88	0.25	1.65
120	2.88	3.67	0.21	0.91
150	3.62	0.46	0.17	0.17

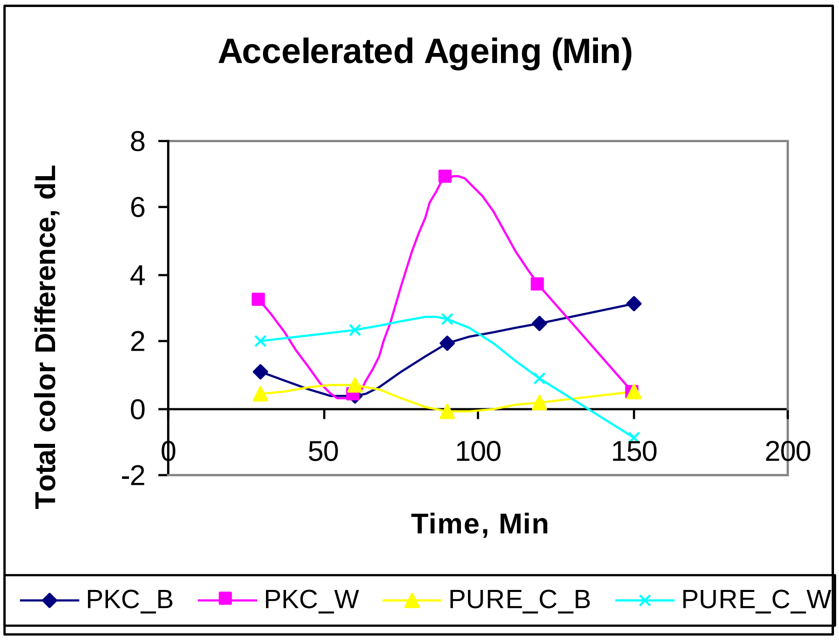

Figure 1
View of Dl Component for Lightfast

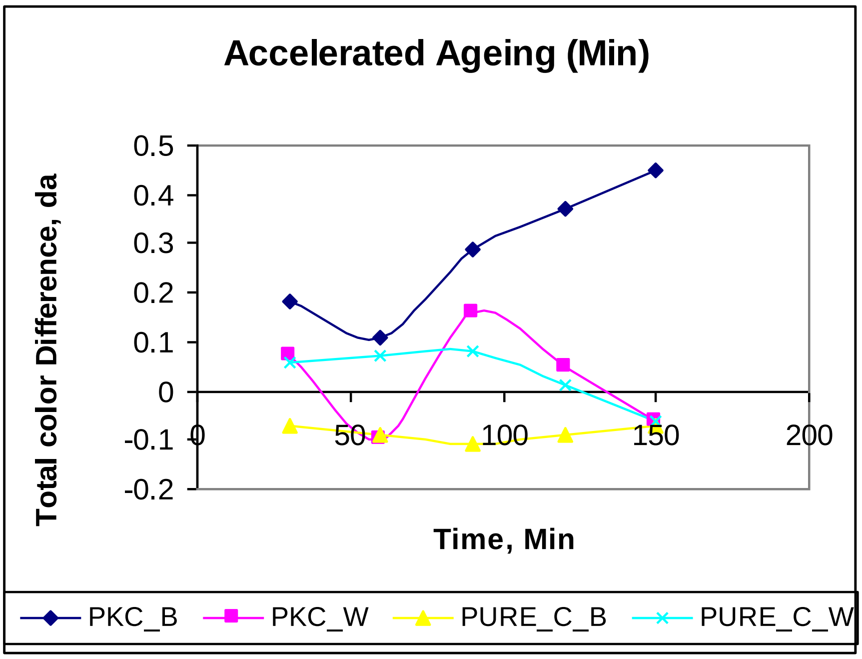

Figure 2
View of Da Component of Lightfast

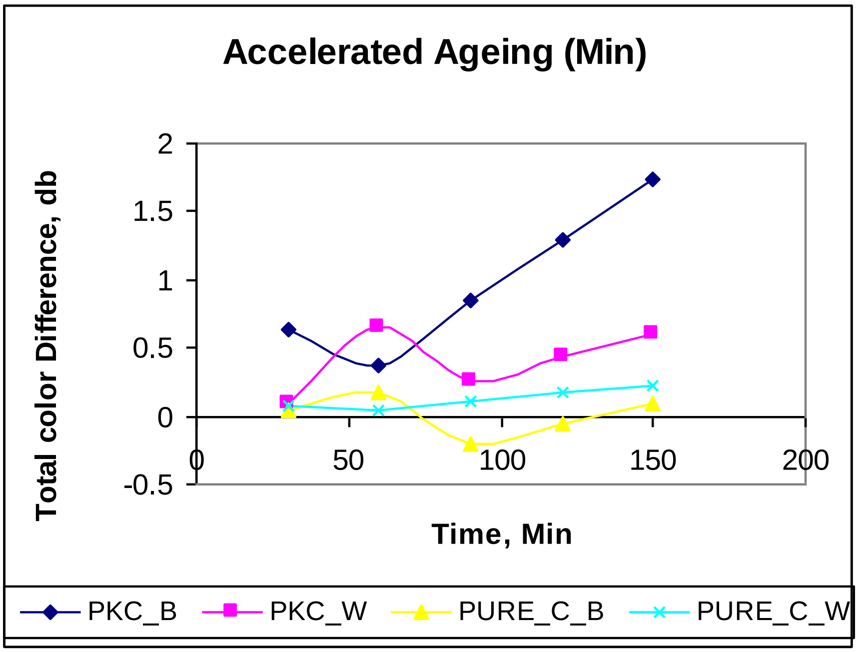

Figure 3
View of Db Component of Lightfast

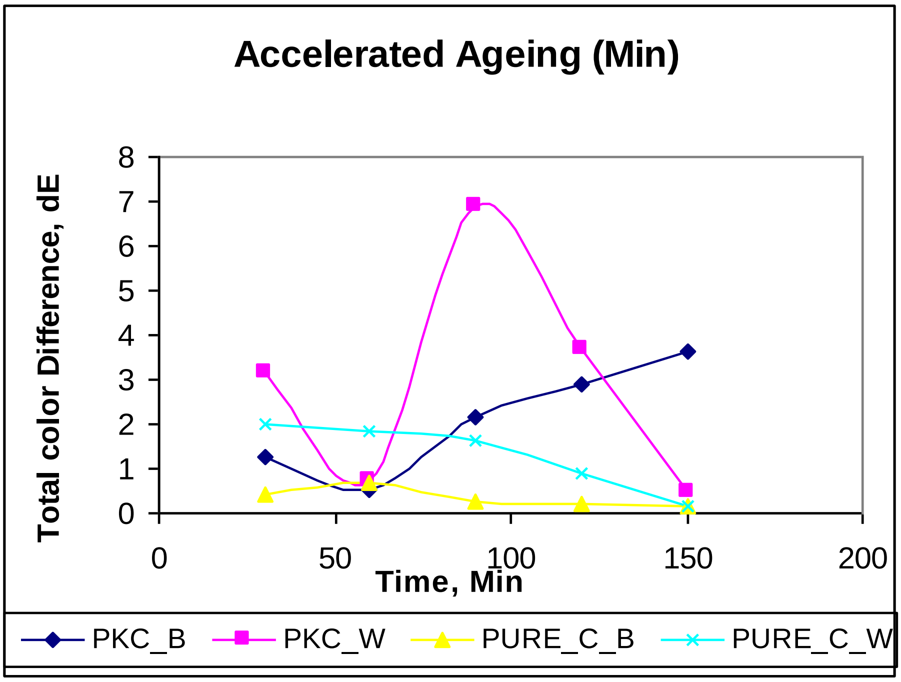

Figure 4
View of DE Component of Lightfast

Figure 1-4 illustrated the accelerated ageing of colour space changes in DL, Da, Db and DE respectively in the ageing test. The total colour difference of black PKC ink on white paper declined twice as much reduction compared to black PKC on brown paper whereas the colour difference for both commercial AC ink also fluctuated towards time with the same trend. However, we cannot obtain the information on the composition of commercial AC inks used in our study. Consequently we were not able to identify the chemical processes initiated by the ageing procedures of the lightfast test.

CONCLUSIONS

The results indicated that the light fastness of ink produced for prints generally depend on both the coating composition and the type of ink. Physical properties played roles in obtaining print permanence into coatings. The goal of this study was to gain a general understanding of the mechanisms contributing to the light fastness of ink produced by Carbon Polyol. The light fastness of dye-based model inks proved to be difficult to find without the contribution of the chemical paper-ink interactions to light fastness examining the effects of chemical degradation of the colourant molecules. The physical properties of the carbon-polyol coating was found in the total colour change (dE) in specimens (PKC_B) and (PURE_C_B) is within 10% while the white paper (PKC_W and PURE_C_W) colour change (dE) is 17% and considered as fair coating.

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