Biobased-Chemical Toner Prepared from Palm oil Derivatives

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Abstract

One of major challenge in bio-toner making was how to increase the amount of bio content. Palm oil based alkyd polyester was synthesized through step growth polymerization, mixed with styrene monomer (Sty) and butyl-acrylate (Ac) as co-monomer to produce the hybrid latex. Different levels of alkyd polyester incorporation were studied. Flocculation process was carried out using the hybrid latex with different alkyd resin percentage mixed with other additives like coagulant, wax, charge control agent, and pigment to produce bio-chemical toner, Palmotone™ CPT. The increasing intensity of OH stretching peak from pure Sty-Ac latex (standard) to highest alkyd polyester containing latex showed alkyd resin was well incorporated into styrene acrylic system. Besides, bio-based content analysis (ASTM D6866) revealed that percentage of renewable carbon to total carbon is increasing when alkyd polyester level increased. In addition, it was proven in this paper that the desirable properties in chemical toners are still achievable with the usage of palm oil based alkyd polyester. Furthermore, incorporation of bio-based materials will create a great versatility and hence serves various requirements in chemical toner applications, covering wide range of printers and copiers in the market. Higher level of incorporation is still under further study.

Introduction

The palm oil industry has been the backbone of Malaysia's commodities market for many years. Being one of the biggest producers and exporters of palm oil and palm oil products(39% of world palm oil production), Malaysia has an important role to play in fulfilling the growing global need for oils and fats sustainably[1]. Generally, palm tree produces palm oil and also palm kernel oil which is extracted from seed of the oil palm. Palm oils are rich in both saturated and unsaturated fats which are useful in various ways. Palm kernel oil was used as a key precursor material in this paper to develop the alkyd polyester resin due to its lower cost, availability and unsaturation for free radical polymerization. Generally, palm kernel oil has very low iodine value and the unsaturation was mainly from the incorporation of fumaric acid during the synthesis of alkyd polyester. Another great advantage of using palm kernel oil would be its environmental friendly properties where it is rich in renewable carbon sources. Since global carbon dioxide gas emission is at alarming rate, this bio-based chemical toner will reduce the CO_2 emission by replacing carbon atoms from petroleum sources with green carbon to promote the carbon neutral cycle. Many research works have been found gearing towards green concept. The introduction of biomass toner by Ricoh [2] mainly discussed on suppressing CO_2 emissions from burning the toner printed on used paper and thus reduce the use of depletable petroleum sources. Another example is the Eco-friendly Prepared Chemical Toner with Mixed polyester resin [3] has been done by Samsung Fine Chemicals which emphasized more on the green process and low volatile organic compound (VOC). However, there is lacking of research on renewable raw material for chemical toner applications. Here, we have used green palm oil derived alkyd polyester into Chemically Prepared Toner (CPT) technology to produce green toners.

JADI's Palmotone™ CPT

Jadi had developed chemically produced bio-chemical toner named Palmotone™ CPT by incorporating alkyd polyester resin which was purely derived from palm kernel oil. Emulsion polymerization technique was applied to polymerize the hybrid system which consist mainly of styrene monomer, butyl acrylate co-monomer and alkyd polyester. Polymerization was carried out in the presence of free radical initiator to produce the hybrid latex emulsion. These hybrid latices were used in flocculation process to yield Jadi's bio-chemical toners, Palmotone™ CPT. This proprietary technology was fully described in a patent filed recently [4].

Experimental

A series of styrene-acrylic latex were synthesized with different level of palm oil derived alkyd polyester incorporation (0%, 5%, 10%, 15% and 25%) through emulsion polymerization method. Combinations of anionic and non-ionic surfactants were used and mercaptan chain transfer agent was added to control the molecular weight distribution and the rheology of the hybrid latex. Hybrid latex with different alkyd % was used in flocculation process to produce Palmotone™ CPT. Hybrid latices and Palmotone™ CPT were characterized by Fourier Transform Infrared Spectroscopy (FTIR), Gel Permeation Chromatography (GPC), Differential Scanning Calorimetry (DSC) and particle size analyzer for particle size distribution and particle shape analysis. The rheology properties were analyzed by capillary flow tester and melt flow indexer. Figure 1 illustrates the process flow of hybrid latex and Palmotone™ CPT making.

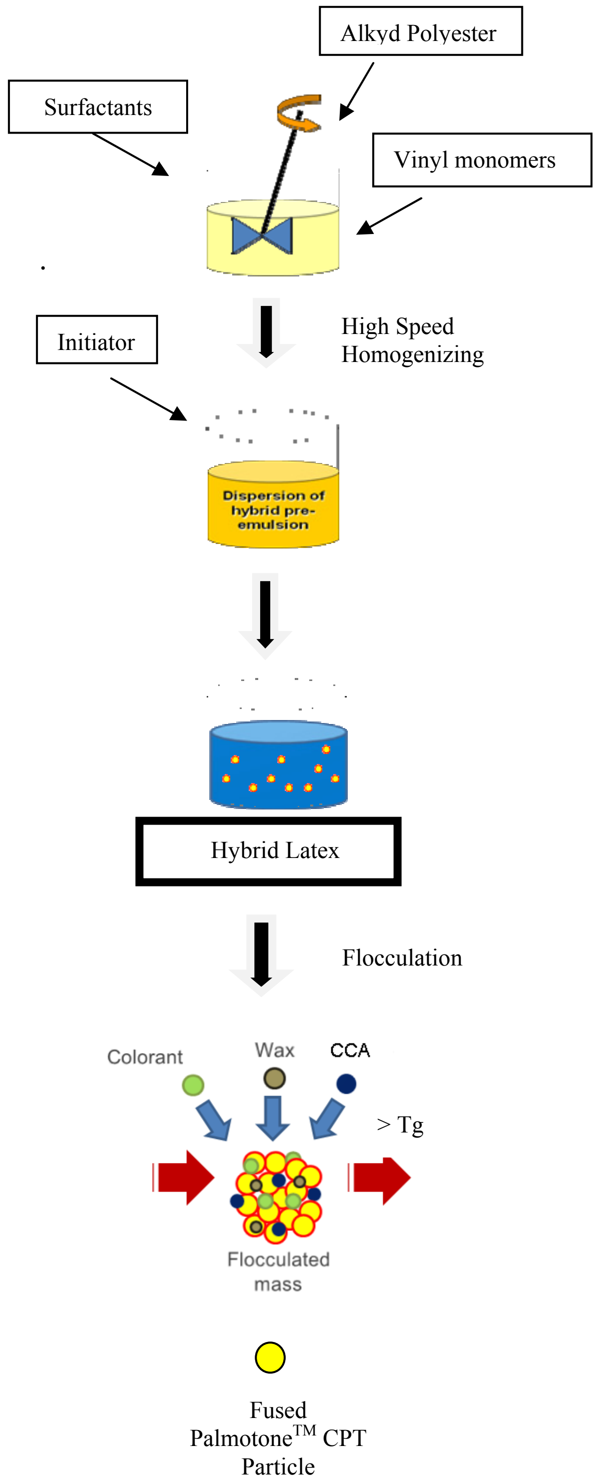

***Figure 1**: Schematic diagram of the preparation of hybrid latex and Palmotone™ CPT.*

Results and Discussion

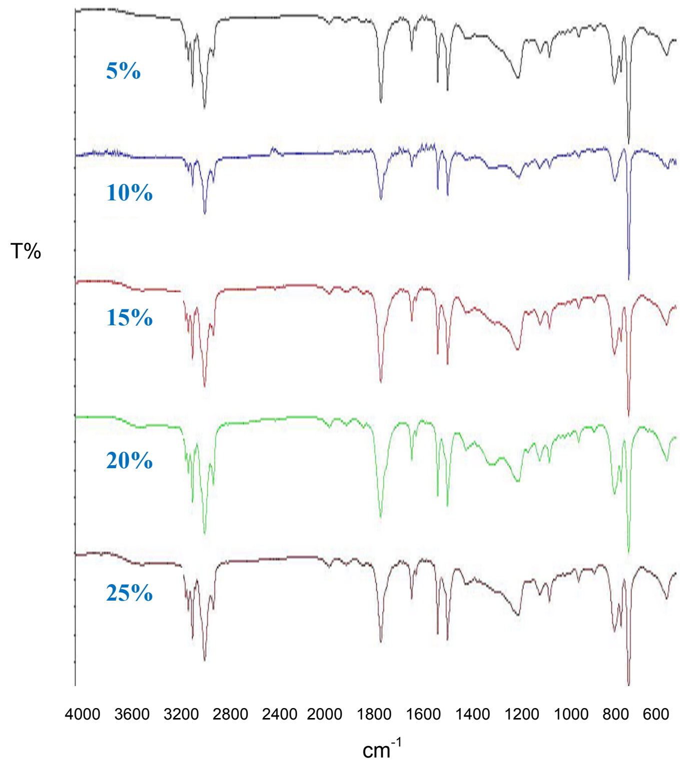

***Figure 2**: FT-IR spectrum for hybrid latex with different % of alkyd polyester*

With reference to the FTIR spectrum in Figures 2, the -OH stretching peak (around 3300cm^{-1}) has increased from pure Sty-Ac latex to 25% alkyd polyester incorporated hybrid latex. The ratio of carbonyl peak (-C=O) to the aromatic peak at 1600 cm^{-1} has also increased from 0% to 25% incorporation of the alkyd. This indicated that alkyd polyester resin was well incorporated into Sty-Ac system to produce hybrid latex. These hybrid latices then underwent flocculation process and were made into Palmotone™ CPT. Bio-content analysis for a number of Palmotone™ CPT samples were carried out according to ASTM D6866 and the results shown in Table 1 are in increasing trend as alkyd polyester incorporation is increased.

Alkyd (%)	Toner Bio-content (%)
0	0
5	2 -3
10	5 -6
15	7 -9
25	12 -14

Table 1: *Bio-content analysis for Palmotone™ CPT by ASTM D6866*

The properties of hybrid latices were compared to standard latex (0% alkyd) as shown in Table 2. The performance of JADI's standard CPT and latex were evaluated based on an OEM CPT property as a guideline. Table 3 shows the properties of JADI's standard CPT are similar and comparable to OEM CPT and thus qualified to be tagged as reference sample in this paper. Thermal property such as glass transition temperature (T_g) was measured by DSC. Gel Permeation Chromatography (GPC) was used to compute the profile of molecular weight distribution. Besides, melt flow index was also measured. Monomer ratio was used as key element to adjust the T_g of hybrid latex to match the standard latex. Chromatography results revealed that M_w for hybrid latices were very much close to standard latex and consistent across all hybrid latices. Reducing M_n values showed the polydispersity indexes (M_w/M_n) were increased as alkyd polyester incorporation increased. Broader molecular weight distribution is highly preferable in toner printing as it could widen the fusing window of the toners. As a result, flexible range of fusing parameters can be tailored to suit the requirement of various printing devices. MFI values also showed insignificant difference between standard latex and hybrid latices as the values fall within the reference range (25-35g/10min @ 130^{0}C).

ALKYD (%)	T_g[1] (^{0}C)	M_N[2]	M_W[3]	M_W/M_N[4]	MFI[5]
Range					**25-35**
0	61.2	13252	39796	3.00	32.41
5	60.6	16696	38548	2.31	32.34
10	59.1	9583	43183	4.51	27.62
15	60.0	8923	39511	4.43	30.76
25	59.7	6316	39856	6.31	30.15

1. Glass transition temperature (^{0}C) 2. Number average molecular weight 3. Weight average molecular weight
4. Polydispersity index 5. Melt Flow Index (g/10min)@130^{0}C

Table 2: *Properties of standard latex and hybrid latices*

ALKYD (%)	T_g (^{0}C)	M_W	MFI	D50(µM)
Range			15-25	5- 6
OEM CPT	56.1	45439	17.65	5.30
0	57.4	39116	22.55	5.60
5	57.8	41348	14.36	5.02
10	57.0	44303	13.09	5.24
15	56.5	41534	13.82	5.67
25	55.8	44764	17.44	5.98

Table 3*: Comparison between cyan CPT of OEM CPT,JADI's CPT and Palmotone™ CPT*

Properties of cyan toners produced from the series of hybrid latex were shown in Table 3. An OEM CPT was used as a standard guideline to evaluate the reliability of JADI standard CPT (0% alkyd polyester incorporation) as a reference sample for Palmotone™ CPT. It is found that the M_w for Palmotone™ CPT again similar yet close to standard toner. Besides, MFI and particle size values could be controlled within a given range. It can be said that the series of Palmotone™ CPT showed little deviation from standard CPT in term of their overall properties and the properties were well kept within the reference range.

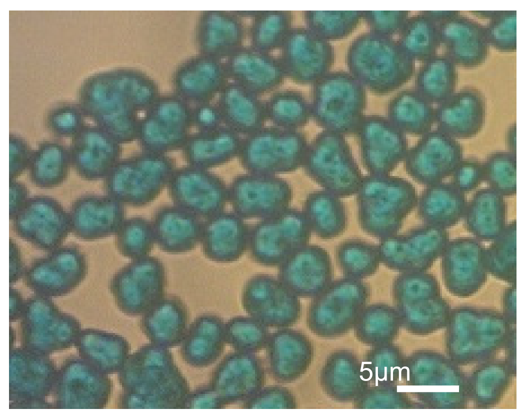

Figure 3*: Optical microscope image of Palmotone™ CPT*

Figure 3 shows the optical microscope image, 40X magnifications for Palmotone™ CPT. The particle shape analysis revealed that circularity ratio is about 0.9 which the value is close to 1 (perfect circle). In the mean time, circularity ratio of these particles can be varied accordingly by adjusting the flocculation processing parameters. This feature of again reflects the flexibility of Palmotone™ CPT in term of the particle shape where it can be directly linked to printing quality.

The change in viscosity of Palmotone^{TM} CPT, standard CPT and OEM CPT relative to temperature is given in figure 4. The ability of Palmotone^{TM} CPT to reach lower viscosity as standard CPT at lower temperature range is an added advantage where fusing temperature can be reduced significantly for Palmotone^{TM} CPT. As a result, power consumption for printing devices can be lowered by using this hybrid toner. [5]

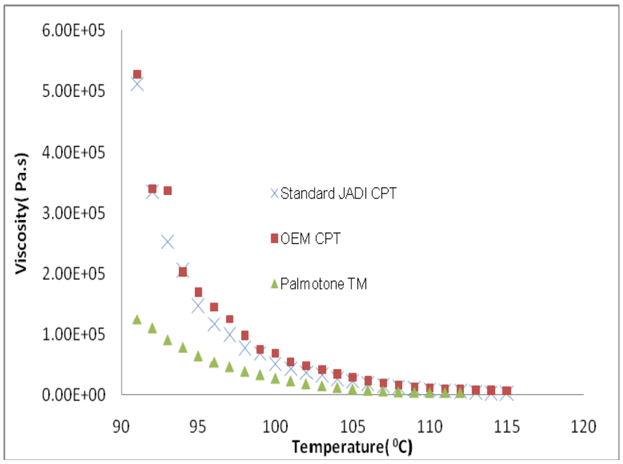

***Figure 4**: Viscosity vs. Temperature profile for Palmotone^{TM} CPT, JADI's standard CPT, and OEM CPT.*

Conclusion

In summary, properties of Jadi's Palmotone^{TM} CPT were well maintained even at high level incorporation of alkyd polyester to match the properties of conventional CPT toners. Besides, adjustable characteristics of Palmotone^{TM} CPT would make it flexible enough to suit different application in printers and copier machines. Bio-content results also revealed the contribution of Palmotone^{TM} CPT towards environment by injecting green carbon to promote carbon neutral cycle.

References

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Author Biography

Jaan Soon Tan is the Senior R&D Manager in Jadi Imaging Technologies Malaysia. He has his Bachelor's degree in Chemical Engineering and received his Master's Degree in Mechanical Engineering in 2001. He has been involved in various toner research activities in the past 6 years.