Dec. 2014. Vol. 5. No. 07 ISSN2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

DEVELOPMENT OF GLASS COATING USING LIQUID EPOXIDISED NATURAL RUBBER

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ABSTRACT

Coatings applied to glass surfaces are an essential part of manufacturing in all parts of the glass industry. We present coating process to enhance the strength and reduce cost of the glass. Our approach is based on the glass coating using Liquid epoxidised natural rubber (LENR). One grades of ENR 25 having 25 mole % epoxidation were respectively used as the polymer coating. Toluene was used as the solvent to prepare the coating into solution for further testing. Coating on glass was carried out using a hand brush coating. For each coating sample, six composition of coating at various ENR with toluene ratio (1:15, 2:47, 2.5:50, 3:54, 4:60, 5:72) were carried out to perform five testing which are viscosity, density, pH, drying time of coating and the strength of the adhesives. The result indicated that the most convenient coating solution compare from the entire sample composition ratio, sample E, ratio 4:60 is the coatings with average viscosity 631cP and pH 8.55 which act as alkaline coating that possibly protect the glass and have less environment impact. The density of sample E coating is 0.895g/cm3. Moreover, the cure time of the coating is 360s at 30 ^{0}C, 240s at 40 ^{0}C and 180s 50 ^{0}C that higher drying temperature result in short dry time.

Keyword: ***Glass, glass coating, liquid epoxidised natural rubber (LENR), natural rubber***

1.0 INTRODUCTION

In glass industry, many challenges were faced due to producing a quality glass. According to the glass container industry, since the 1980s the glass container market has suffered a steady loss of market share to alternate plastic and can packaging. Imports of glass containers in 2001 total 27.9 million gross, compared with 30.6 million gross in 2000; and glass container exports total 11 million gross, compared with 8.8 million gross in 2000 (Mark, 2011). This proves that almost all kind of glass surface without coating actually experience breakage normally that is both a mess and a safety hazard. For instance, glass containers that bang into each other during filling, shipment, or in retail stores have lesser toughness without coatings.

Coatings applied to glass surfaces are an essential part of manufacturing in all parts of the glass industry. Some of these glasses have special coatings deposited on their surfaces (J. Mohelnikova, 2009). There are organic coating, metallic glass coating and ENR glass coating (M. Szocinski et al. 2014). Among the chemical modifications, epoxidation is a simple and efficient method for introducing reactive groups and polarity onto polyisoprene backbone. ENR shows better oil resistance, higher damping and lower gas permeation than those of NR (C.S.L Baker et.al, 1985). Furthermore, the presence of the epoxy or oxiranes making possible for ENR to possess other properties such as heat resistance, air permeability resistance, and stability due to chain re-arrangement as specified (Siti Zaleha et al. 2007). The preparation of the organic coating has effect upon on the chemistry of polymer chain formation and molecular weight. The crucial form of the polymer chain, its length, shape, and configuration determines the properties and physical characteristics of the coating, such as durability, hardness, and adhesion (M. Szocinski & Darowicki, 2014).

Currently Malaysian rubber board produces liquid epoxidized natural rubber (ENR) with the trade name Epoxyprene. There are two grades available, that is ENR-25 and ENR-50, with 25, and 50 mol % epoxidation respectively (T. Johnson & S. Thomas, 2000). However the market and applications for ENR found to be limited knowledge. Different with natural rubber (NR) latex, a renewable polymeric material displaying excellent physical properties, is widely used in the manufacture of thin film products (K. Sanguansap

et al. 2005). Previous studies have shown ENR latex film surface was modified by immersing into methyl methacrylate (MMA) emulsion and then alkaline aqueous solution of ferrous ion/fructose for redox initiated polymerisation. This modification pronounced roughness which, consequently, decreased the friction coefficient of ENR surface (C. Amornchaiyapitak et al. 2008). One of the important products of chemical modification of natural rubber is the epoxidized natural rubber, ENR.

The purpose of this study using ENR for glass coating is to enhance strength improvement of the glass. Thus efforts are being made to broaden the horizons of the usage and application of this rubber, especially in advanced engineering field. Furthermore, these ENRs are chosen as their moderate cost, environmentally friendly, great adhesion properties, and easily gained by means of the production line via a simple and quite rapid route using peroxy acid onto NR (Natural Rubber).

2.0 MATERIAL AND METHOD

2.1 Materials

The following chemicals will be engaged for the preparation of coater (LENR) and painting process, Epoxidized Natural Rubber (ENR-25,25mol% epoxidation), Toluene (C_7H_8) and Isopropyl alcohol, IPA (C_3H_8O). Another materias are glass and hand brush coating.

2.2 Preparation of Liquid Epoxidized Natural Rubber (LENR)

In this study ENR 25 -25 mol% epoxidation were supplied by the *Lembaga Getah Malaysia* at Selangor. The liquid of ENR were produced by diluting with the toluene according to desired ratio and stir using the stirrer. In research, Liquid Epoxidized Natural Rubber (LENR) is the coating solution.

2.3 Preparation of Glass Plate

A plate glass size 10 x 15cm was purchased about 10 pieces at glass workshop Changloon, Kedah. The glass with a chemical composition typical for commercially available are made (SiO_2, CaO and MgO as main components) (C. Noemi et al. 2009)

2.4 LENR Investigation

First, samples of two commercially available LENR-25 glass plate topcoats were prepared with various LENR and toluene ratios; 1:15, 2:47, 2.5:50, 3:54, 4:60, 5:72. Then followed by, cleaning the glass thoroughly using Isopropyl alcohol, IPA before paint LENR on the glass. Isopropyl alcohol, IPA function to wipe out any debris on the glass, so make sure the glass surface completely smooth and clean before start to paint. (Instruction Bulletin, 2014). Next, the glass was lay down so the side to paint glass surface faces upward by using LENR as a coating material. After done with cleaning, touching the paint side/ surface of the glass once it is clean retrieved. Samples were prepared with from 1 to 6 coats of this layer to give a range of final coating thicknesses (Trezona & Hutchings, 2001). Six samples were running on test by determining the pH, viscosity and density of samples using gas pycnometer, pH meter and viscometer respectively. In order to determine the sample can be applied as a coating material several testing was conducted; drying test and adhesion test. This test method relies on a visual assessment of the extent of drying; very light colors and clear varnishes may present difficulties in quantifying the extent of drying. This test method also covers the procedure for determining the drying time of drying painting sample after coating, immediately, start the timer. Few minutes later, test the coating by touch the coating surface with the filter paper. Adhension test was a tape test using the 3M adhesive tape accordance with ASTM specifications.

3.0 RESULT AND DISCUSSION

3.1 Viscosity test

Results in table 3.1 showed the less viscous coating solution is sample A with 373 cP. The highest viscous coating solution is the sample F, with viscosity value 677.25cP. A high viscosity means that the liquid will not flow easily. A low viscosity means that the coating liquid flows very easily once applied on the glass surface.Thickness essential in coating, optimum coating sufficient enough to withstand the environment. Measuring the viscosity of liquid or paste coating and comparing it with a specified value is an inexpensive method and the result are a good

criterion for accepting or rejecting an incoming lot of material

Table 3.1 Result for viscosity, density, pH, drying and tape test in all samples.

Sample	ENR: toluene (Ratio)	Viscosity (cP)	Density (g/cm³)	pH test	Drying test 50 °C, 40 °C, 30°C (second)
A	1:15	372.000	0.8915	8.5	60, 120, 240
B	2:47	519.500	0.8852	8.32	60,120, 300
C	2.5:50	560.875	0.8842	8.29	60, 180, 300
D	3:54	563.825	0.8972	8.31	120, 180, 300
E	4:60	631.000	0.8950	8.55	180, 240, 360
F	5:72	677.250	0.6982	8.29	180, 240, 360

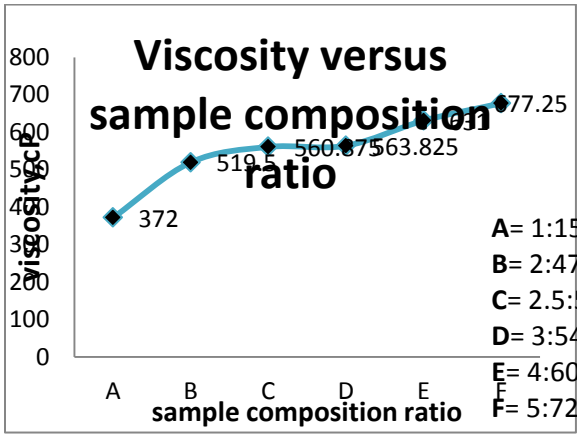


Figure 3.1: Relationship between viscosities of sample at different ratios

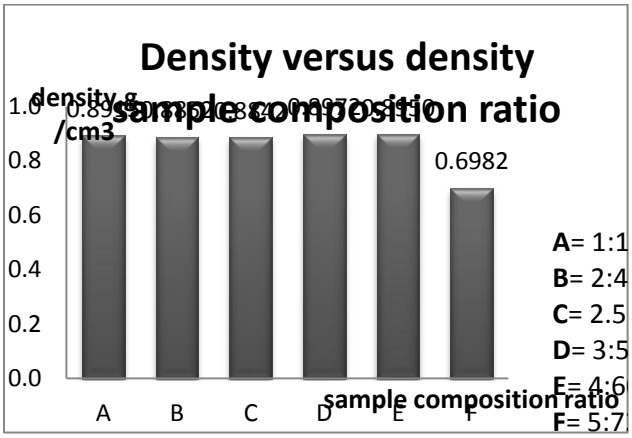


Figure 3.2: Density of sample LENR composition at various ratios

3.2 Density test

According to the result (Table 3.1 and Figure 3.2) the coating solution with highest density is sample E, ratio 4:60. Sample F, ratio 5:72 is the coating solution with lowest density. The density of a liquid is the weight per unit volume at a specified temperature. The density of coating is often used as a quality control test to verify that changes have not been introduced in the coating formulation by the supplier (James, 2003).

3.3 pH test

A solution of this composition is suitable for property characterization of a surface before and after coating application. According to coating expertise, an extremely high or low pH atmosphere can also shorten the life of the coating life also. The ideal pH is 7, (neutral) but a pH of 6– 9 is acceptable for most coatings unless otherwise specified. According to Drisko. 1995 researcher, oil, grease and dirt can be removed by using an alkaline solution in the pH range of 11 to 12, but not greater than 13 as this will

damage the coating. Based on the bar graph below (Figure 3.3), the highest sample coating E (4:60), pH 8.55 and the lowest pH coating sample is sample C (2.5:50) and F (5:72) which is pH 8.29. From result obtained all the samples false in optimum pH range. Thus, the all the sample are eligible for pH of coating which false in the finest coating.

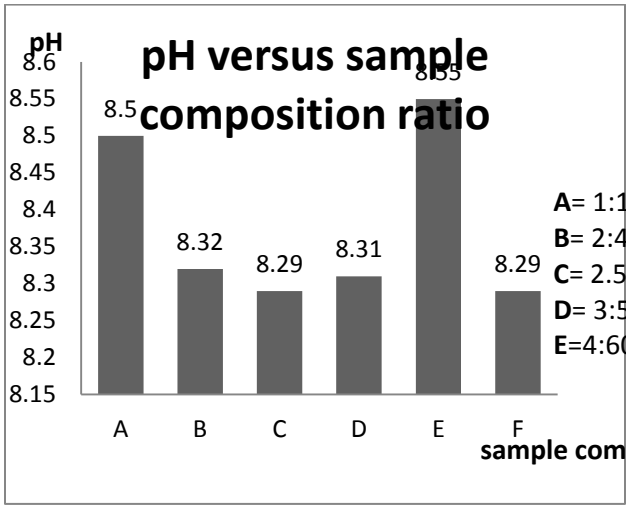


Figure 3.3:pH at various LENR composition ratios

3.4 Drying Time/Cure Time Test

The result indicates that the drying or curing time of a coating on the glass surface influenced by the temperature. At ambient temperature the drying time required from range (180-360)s and at temperature 40^0C the range is (120-240)s and at 50^0C curing time is around (60-180)s. Cure speed can significantly reduce the drying time. Temperature is inversely independent to the curing time. Besides, the viscosity of sample is dependent to the period of drying time. Under cooler temperatures the viscosity or thickness of the coating increases. This reduces the spread rate and dramatically increases drying times sometimes doubling or tripling it. Due to the rate of coating evaporation, area /spread of coating on glass, viscosity, thickness and temperature of coating are the factors affect the curing time. The graph below (Figure 3.4) illustrates the effects of various sample ratios on dry time of the coating. Lower temperatures will increase viscosity and reduce coverage significantly. When high viscosity coat are applied the time taken to cure the coating are longer. Hence, the coating that takes time longer to dry is sample F, ratio 5:72 and the shorter time to dry is sample A, ratio 1:15.

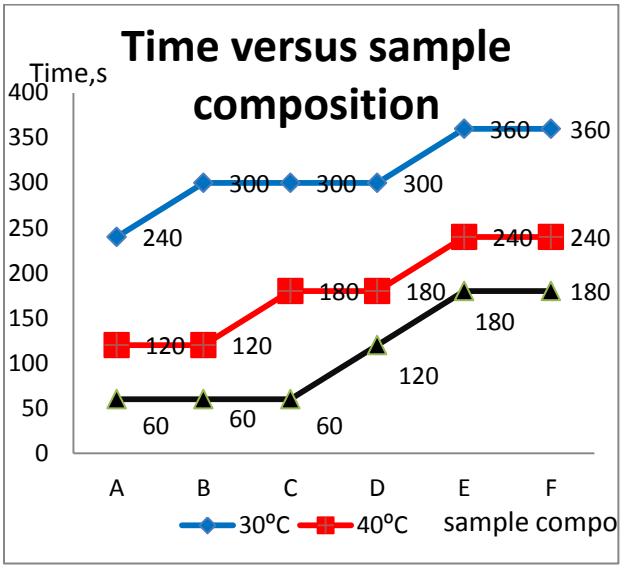
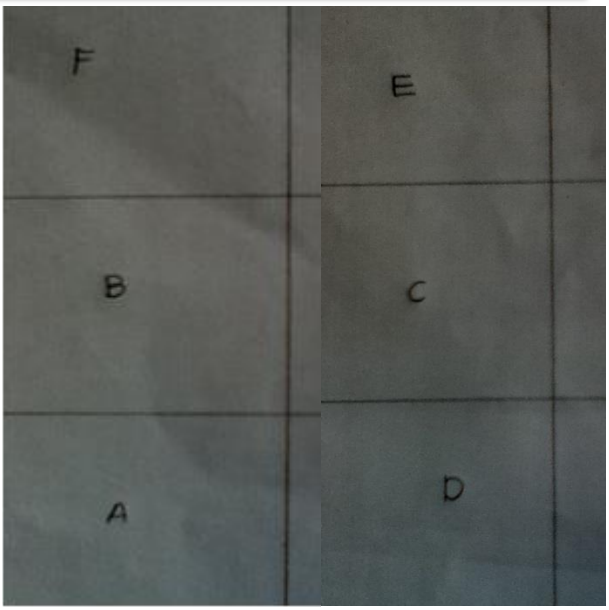


Figure 4.4:Cure time of various sample composition ratios

3.5 Tape Test

Results illustrated below in Figure 4.5 and Figure 4.6 for all LENR-based adhesives, F coated sample showed the highest peel strength whereas the lowest peel strength was exhibited by A coated sample, ratio 1:15. As inspected the coating pattern that stick on the tape sample F has small flakes of the coating are detached along the edges of the tape. The area affected is 5 to 15% of the tape. The sample B ratio 2:47 coating has flaked along the edges and on parts of the squares of the tape. The area affected is 15 to 35% of the tape. However, sample A coating ratio 1:15, the coating has flaked along the edges of the line patterns in long ribbons and whole squares have detached.

Figure 4.5: Tape test of coating sample



5.0 CONCLUSION

In conclusion, the most convenient sample coating compare from the entire composition ratio is sample E. Its act as alkaline coating that possibly protects the glass and has less environment impact. Thus, it is summarize that the harder to peel LENR coating hence small flakes of the coating are detached on the tape due to the high viscosity of the coating hence short time taken to dry. Moreover, the cure time of the coating is 3 higher drying temperature results in short cure time. Also the hydrophobic property is an advantage for coating to protect glass. The thicker the paint coat is the less influence of glass on the paint scale. Mostly natural rubber is used widely and the published literature on epoxidized rubber studies is very limited. Moreover, a study on LENR quality during glass coating is very much needed for developing high quality glass.

6.0 ACKNOWLEDGMENT

The authors acknowledge Lembaga Getah Malaysia and also our special thank also for University Malaysia Pahang for the support for the publication.

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