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THE APPLICATION OF NATURAL DYES FOR NATURAL RUBBER LATEX FOAM PRODUCTS

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ABSTRACT

In this work, we are interested in application of natural dyes in the NR latex foam productions. Three natural dyes from plant including sappan powder, turmeric powder and black galingale powder were applied in the study. They were mixed into rubber latex during foaming process. The obtained products were examined on color distribution and intensity, color sustainability to sunlight and heat, color leaching in water. The results showed that, the products mixing with sappan powder, turmeric powder and black galingale powder gave NR latex foam products in deep red, yellow and brown color, respectively. Increasing the amount of natural dyes resulted in more intensity of color with well pigment distribution. Sunlight showed strong effect on color sustainability of products mixing with sappan and turmeric powder. We suggested that absorption of UV light by chromophore in the chemical structure of pigment resulted in decomposition of pigment. Heat showed slightly effect on the color sustainability. The products mixing with sappan powder and turmeric powder showed significantly color leaching in water. The quantitative analysis by UV-vis spectroscopy showed concentration of pigment at 117, 159 and 166 ppm from product mixing with 5, 7 and 9 gram of sappan powder, respectively. At this point, we can conclude that sappan powder and turmeric powder can be applied in NR latex foam production. Various color shades can be obtained by varying amount of dyes power. However, natural dye was not stable to sunlight. They are suitable for indoor products. Moreover, study of optimal mordant should be carried out in order to increase colorfastness.

Keywords: *sappan powder, turmeric powder, black galingale powder, natural dyes, NR latex foam.*

1. INTRODUCTION

Since scientists have discovered how to make synthetic dyes, they have been used intensively in the industrial production. Synthetic dyes make cheaper to produce, brighter, more color-fast, and easy to apply to fabric. The chemical, aniline, the basis for a popular group of dyes known as Azo dyes (chemical structure shown in Figure 1) which are considered deadly poison and dangerous to work with, also highly inflammable. Dye factories across the world are dumping millions ton of dye effluent into the rivers which cause health and environmental problem. Nowadays, there is an increasing interest in the environmental awareness and public concern about pollution. Therefore, using natural dyes for silk and cotton dyeing are

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alternative choice. To date, the application of natural dye in NR latex foam production have not been reported. Therefore, we are interested in using of natural dyes in the process of NR latex foam products for example latex pillow, yoga mattress, toys and souvenirs.

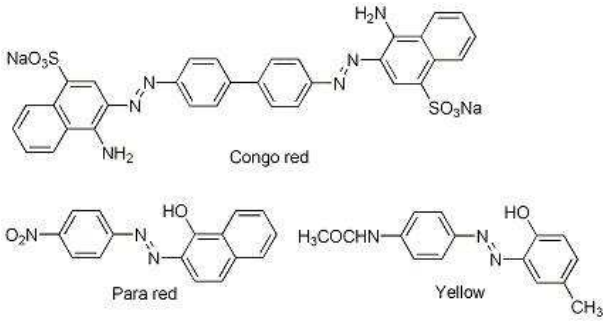

Figure 1: The chemical structure of Azo dyes

Three different dyes were obtained from plant including sappan powder, turmeric powder and black galingale powder. They are available in the market as powder as shown in Figure 2 and used as herb, cooking ingredient, cosmetic dyes and fabric dyes.

Figure 2: Spices in powder form used as natural dyes

The sappan powder was obtained from dried heartwood of *Caesalpinia sappan* L., which is a species flowering tree belonging to the legume or pea family (Nirmal, 2015). The major dyeing component in sappan is Brazilin which gives deep red color. Turmeric power was obtained from dried root of Curcuma longa. The dyeing component is curcumin. Turmeric was traditionally called "Indian saffron" because of its deep yellow-orange color and has been used throughout history as a condiment, healing remedy and textile dye (Borah, 2005).

Black galingale is of the ginger family and grows in Thailand, also known as Krachaidam. Sometimes it is promoted as treatment impotence in a male. The dyeing component is anthocyanins which give purple color. The chemical structures are shown in Figure 3 (Oliveira, 2016).

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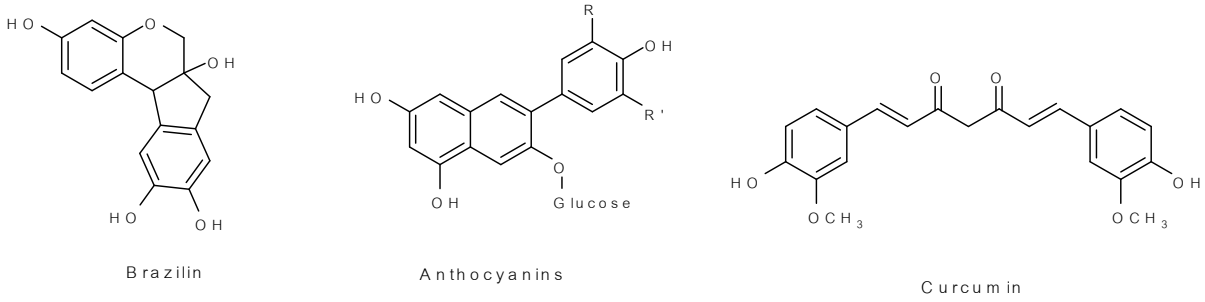

Figure 3: The chemical structure of dyeing components from sappan, turmeric and black galingale

Our studies will be focus on latex foaming process, color distribution and intensity, color sustainability to sunlight and heat, color leaching in water. The results will be discussed below (Jubete, 2007 and Moreno, 2015).

2. EXPERIMENTAL

2.1 Latex Foaming Process

The latex foaming process was carried out after Dunlop production process (Tang, 2006 and Roslim 2012). The ingredients for the NR latex foam mixture used in this study are shown in Table 1. The industry standard 60% NR latex was obtained commercially. solid materials, such as sulphur, zinc diethyldithiocarbamate (ZDEC), zinc 2-mercaptobenzothiazole (ZMBT), zinc oxide (ZnO), diphenyl guanidine (DPG), sodium silicofluoride (SSF) and an antioxidant were prepared in dispersion form by ball-milling for 72 hours. Liquid materials, specifically, ammonium oleate was prepared in emulsion form by continuously stirring in warm water at 60°C to 70°C until completely dissolved. After mixing the natural dyes and latex, a foaming agent; ammonium oleate was added, and the mixture was slowly and continuously stirred at 240 rounds per minute (rpm) for one minute. Then, sulfur, ZDEC and ZMBT were added and kept stirring at 480 rpm and then slow down to 240 rpm for 2 minutes. Afterwards, zinc oxide and DPG were added. A secondary gelling agent was added at last. The foam was stirred slowly at 240 rpm until a fine foam structure was achieved. The NR latex foam was molded and dried in hot air oven for 24 hours. The process flow diagram is illustrated in Figure 4.

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Table 1: Natural latex compounding formulation used in the study

Chemicals	Function	Dispersion %	Ratio phr*
Latex	Rubber	60	100
Ammonium oleate	Foaming agent	10	1.5
sulfur	Vulcanizing agent	50	2.0
Zinc diethyldithiocarbamate	Accelerator	50	2.0
Zinc 2-mercaptobenzothiazole	Accelerator	50	2.0
Wingstay L	Antioxidant	50	2.0
ZnO	Catalyst	50	5.5
Diphenyl guanidine	Accelerator	33	1.4
Sodium silicofluoride	Gelling agent	12.5	0.25
Natural dyes	Dyeing agent	-	5, 7, 9

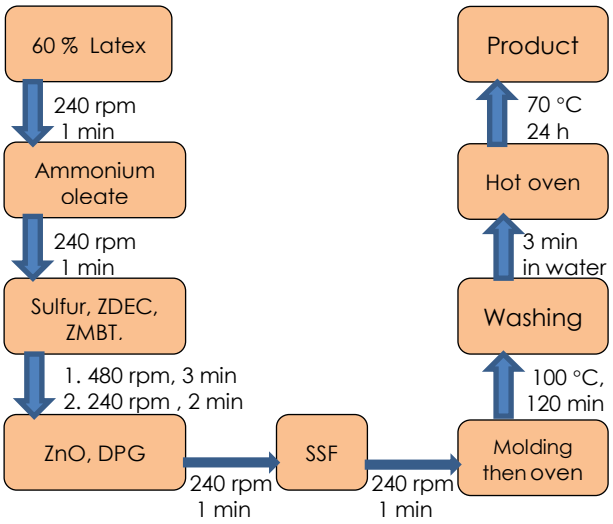

Figure 4: The process flow for preparing foam products

NR latex foam products were prepared by mixing of 3 different natural dyes including sappan powder, turmeric powder and black galingale power in amount of 5, 7 and 9 gram to 100 gram of rubber. The products were prepared in two sets, one set was treated and another set

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will be untreated. We have prepared three batches of product. Batch 1 was investigated on color distribution, color intensity and color sustainability to sunlight. Batch 2 was subjected to study on color sustainability to heat and batch 3 was investigated on color leashing in water.

2.2 Color Distribution and Intensity

The color of the two sets of product mixing with 5, 7 and 9 gram of dye powder was examined (Zahrim, 2011 and Nawamawat, 2011).

2.3 Color Sustainability to Sunlight and Heat

One set of prepared product was treated with sunlight for 7 days. The color was compared with the untreated one by end of each day. The prepared products were investigated of color sustainability to heat by keeping one set at room temperature and another set in the hot air oven at 70 ^{o}C for 7 days after the ASTM D573 standard. The color of the two set of product was examined (Anand, 2015 and Geng, 2016).

2.4 Color Leaching in Water

One set of prepared products using 9 gram of each dye powder was allowed to soak under water for 24 hours. The color of water and color of products were compared with the untreated product.
Moreover, we have studied quantitative analysis of color leaching from NR latex foam product mixing with sappan power 5, 7, and 9 gram by using UV-vis spectroscopy. The color leached from products was measured absorbance at 538 nm in every 6 hours to investigate the concentration of leached pigment.

3. RESULTS AND DISCUSSION

3.1 *Color Distribution and Intensity*

Mixing of the 3 natural dyes was investigated. The results showed that sappan powder could be dissolved well in the latex matrix. The color of the obtained product was pink to deep red as shown in Figure 6. We suggested that the aromatic ring in Brazilin could have pi-pi interaction with isoprene unit in latex matrix. Mixing with turmeric powder showed good dissolution latex matrix and gave products in pale yellow to orange color which is the color of Curcumin. However, mixing of black galingale have not obtained product in purple color. It can be suggested that high polarity of anthocyanin has poor dissolution in the latex matrix. Moreover, the color of anthocyanin is depending on pH of the matrix. Two sets of product gave to same shade of color that indicated the foaming process gave homogeneous foam and good repeatability.

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Figure 5: Color of NR latex foam mixing with sappan powder, turmeric powder and black galingale power in 5, 7 and 9 gram

3.2 Color Sustainability to Sunlight and Heat

The sustainability of color when exposing to the sun light was investigated. We found that after 7 days under sunlight, NR latex foam products dyeing with sappan and turmeric were losing color significantly as can be seen in Figure 6. It can be suggested that Brazilin and Curcumin are unstable with sunlight due to UV light can be absorbed by the chromophore in the chemical structure and cause decomposition of the pigment. Therefore, it can be suggested that NR latex foam product using natural dye is suitable for indoor products. Moreover, we have prepared product batch 2 for investigating the effect of heat on sustainability of color by aging rubber products at 70 ^{o}C for 7 days. We found that heat showed only small effect on the color of product using natural dye which can be seen in Figure 7. These results can be suggested that chemical structure of the pigment such as Anthocyanin, Curcumin and Brazilin are stable under heat. The color distribution of product in batch 2 was not as good as batch 1.

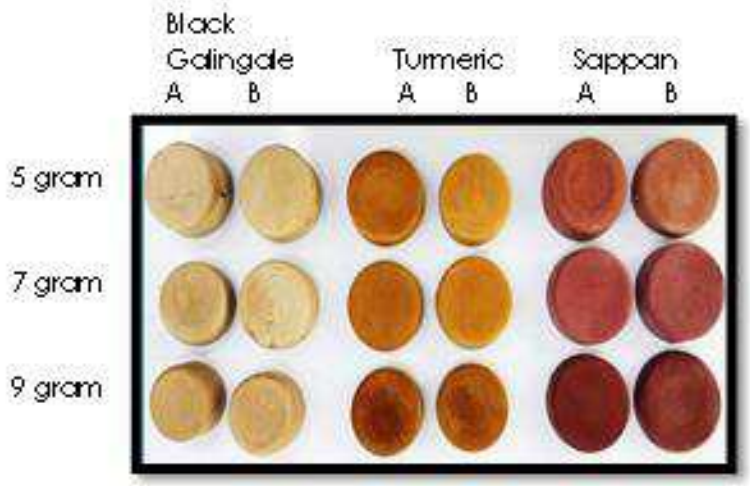

Figure 6: Comparison of color of NR latex foam products, A: treatment with sunlight for 7 days; B: without treatment

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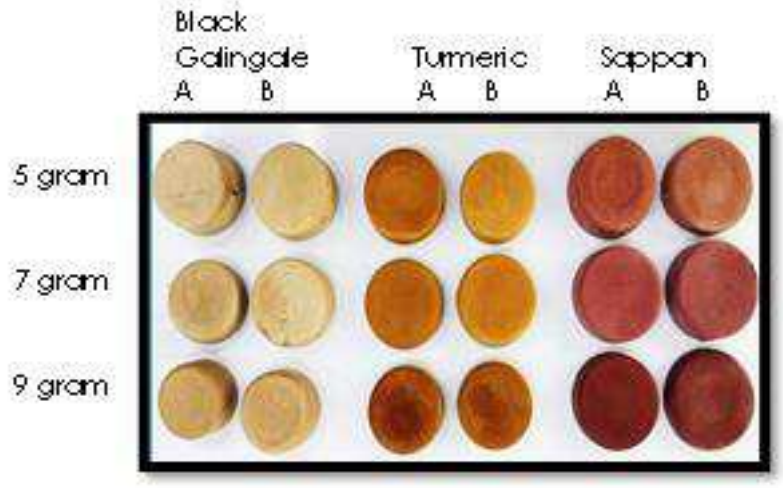

Figure 7**:** Comparison of color of NR latex foam products, A: without treatment; B: treatment with heat for 7 days

3.3 Color Leaching in Water

The color leaching in water was performed by soaking of product using 9 gram of dye powder in water for 24 hours. We have observed color of water and color of NR latex foam products. The products mixing with sappan powder and turmeric powder showed significantly color leaching while black galingale power showed less leaching as can be seen in Figure 8. Color of NR latex foam products after soaking in water at room temperature for 24 hours showed slightly pale color in comparison with the standard set as shown in Figure 9. It can be explained that hydroxyl group in the structure of Brazilin and Curcumin makes the pigment high water solubility. This caused color leaching. The quantitative analysis of color leaching from NR latex foam products mixing with sappan power showed the results in Figure 10. The concentration of pigment was increased after time in water and after amount of dye powder used. After 24 hours, product mixing with 5, 7 and 9 gram of sappan powder showed color leaching in the concentration of 117, 159 and 166 ppm, respectively. Therefore, mordant should be included in the foaming process in order in increase the colorfastness. This is of interest for the future work.

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Figure 8: Comparison of color leaching from foam products A: without treatment; B: treatment with water for 24h

Figure 9: Comparison of color of NR latex foam products A: without treatment; B: treatment with water for 24 h

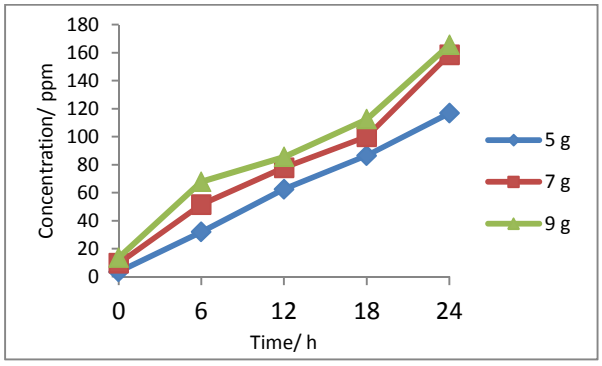

Figure 10: Concentration of leaching pigment from NR latex foam product mixing of sappan powder 5, 7 and 9 gram

4. CONCLUSION

This work is a preliminary study on application of natural dyes with NR latex foam rubber products. We found that sappan powder and turmeric powder can be mixed well with latex matrix. The NR latex foam products were obtained in good color. We found that increasing

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amount of dye powder led to more intensity of color with well pigment distribution. Therefore, various color shades can be obtained by varying amount of dyes power. The study of color sustainability to sunlight and heat showed that sunlight showed strong effect on color sustainability while heat has only slightly effect on the color of rubber products. Therefore, the products using natural dye are suitable for indoor usages. Study of sustainability in water showed that natural dyes could be leached with water due to the polarity of chemical structure of Brazilin and Curcumin. Therefore, some mordant should be added during foaming process. Moreover, study of surface morphology of the obtained product should be carried out to understand the dyeing mechanism. The mixing of herbal plants which give good smell and relaxing effect could be very interesting in the future works.

5. ACKNOWLEDGEMENT

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