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The Characterization of Beetroot Pigment as Surface Coating

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ABSTRACT

The study of beetroot pigment as a surface coating for protection layer on piping plant application was carried out to replace the common chemical coating with organic pigments to enhance the sustainability and environmental impact and to provide potential savings in terms of costs without giving up strength and increases the aesthetic appeal. In this study, natural pigment is commonly found in beetroots or beets and can be extracted using normal filtration process after blending the beetroot into smaller particles. There is also ready-made beetroot powder, which was used in this particular study. The process of using beetroot pigments were found the effects of mechanical and physical properties of the coating. The formulation of beetroot pigment has different concentration of 20%, 40%, 60% and 80%. This different concentration of pigment was synthesized with 250ml solvent and 12.5ml hardener to form superhydrophobic coating. The results of water droplet test (ASTM D5964) showed that superhydrophobic characteristics was achieved the water contact angle measurement. In this case, the ideal coating for self-cleaning characteristic is up to 80% concentration of beetroot pigment with the average contact angles of 141°,140° and 137° for 3, 6 and 9 layers, respectively. Based on the scratch resistance test, the coating showed the best resistance are 60% and 80% concentration for all three varied layers. For adhesion test, the coating with 60% and 80% beetroot pigment concentration showed the best and optimum adhesion between the coating and substrate. It was revealed that the beetroot pigment can be applied on surface coating to reduce the amount of a harmful chemical.

Key words : Optimom, superhydrophobic, coating, concentration

1. INTRODUCTION

Surfaces are painted to protect them from harmful agents in their environment, to decorate them, or to provide some functional purpose[1[. However, the objective of painting is to extent the protective, decorative or functional coating remains bonded to its substrate and retain its essential properties[2]. The subject matter is not limited to conventional paints but also includes pigmented and clear coatings based on a wide variety of cellulosic and resinous film-forming materials that have become available in recent years[2]. The term "paint" is often used in its broadest sense to denote a liquid material that has the property when applied in a thin layer into a continuous film that adheres to substrate. In this sense, any organic coating material may be considered a paint[3]. Pigments are classified as one of surface coating components and can be organic or inorganic[4]. However, organic as known as "betalain" or non-organic as known as "synthetic", they both serve the same purpose in surface coating. The pigment not only adds opacity and a decorative or functional color to the film but also increases its durability and protective character by screening out harmful light rays, controlling the transmission of moisture and gases through the film imparting desirable mechanical properties and contributing various other properties, depending on the nature of the pigment and the concentration in which it is used. In this study, we are focuses on beetroot pigment. The utilization of beetroot are normal water-dissolvable nitrogen-containing shades, with a shading power aggressive to those of engineered colorants give a more prominent degree of usefulness and contains explicit added substances that all assume a job in its presentation including last appearance and strength [5].

2. LITERATURE REVIEW

The beetroot is the taproot segment of a beet plant, typically recognized in North America as a beet. It is one of the many developed assortments of Beta vulgaris developed for their taproots that are eatable and beet greens, which are the leaves. Beetroot is the fundamental wellspring of common red color, known as "beetroot red"[6]. Betanine is the essential piece of the red colorant isolated from Beta vulgaris. Following extraction, betanine is exhibited to degradation. The shading quality is affected by components, for instance, synthetic concoctions, temperature, oxygen, and pH. Betalain hues isolated from red beet roots give a trademark choice rather

than made red hues [7]. Beetroot contains red pigments that are soluble in water. The diffusion of pigment is because of a red pigment that can be found in beetroot. The level of absorbance of beetroot pigment can be measured using visible spectrophotometer, which is a device that measures the absorbance of solutions[7].
Beetroot pigment which is the main contributor to the red color, will absorb wavelengths of different color, yet reflect wavelengths of red color. The expression "betalains" was presented by Mabry and Dreiding; this was bolstered by auxiliary and biogenetic contemplations. In an exacting sense, betalains don't have a place with alkaloids since they are acidic in nature because of the nearness of a few carboxyl gatherings. Initially, betalains were classified "caryophyllinenroth" and progressively renamed "rübenroth" and "chromoalkaloids". Synthetically, betalain definition grasps all mixes with structures dependent on the general recipe appeared in Figure 1 and hence, they are immonium subsidiaries of betalamic acid[8].

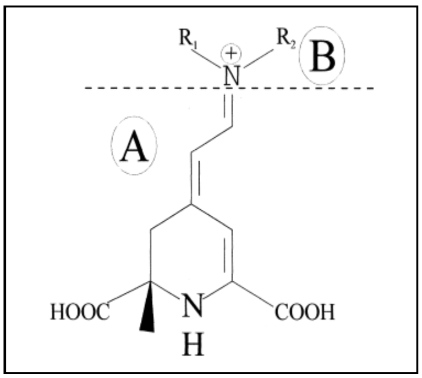


Figure 1: Betalain general formula[8].

The field of application of an organic pigment is not determined by its chemical properties, since the chemical properties of an organic pigments can vary significantly in many of their physical attributions. In particular, the trend towards high-solids coatings requires that the influence of pigments on the viscosity of the coating which is greater in the case of organic pigments because of their smaller particle size than in the case of inorganic pigments must be reduced by optimizing the particle size by providing a surface treatment.

The requirements for pigments used in general industrial coatings are not usually so high. Generally good light stability, weathering and solvent resistance are expected. Air drying coatings, the requirements pertaining to solvent resistance are less stringent. In inexpensive products compromises are often made in respect of the other resistance too. In the case of coil coatings, adequate resistance to high temperatures on the part of the pigments is vital, of course, such as is achieved in only a few high grade organic pigments. This very broad range of requirements means that almost all pigments are used in the area of general industrial coatings. Surface, or harshness, is utilized to improve the characteristic hydrophobic science of the surface, creating very non-wetting surfaces [9].

Superhydrophobic surfaces show extraordinary water-repellency, with water beads laying on them with high contact points. Different applications profit by non-wetting surfaces with some particular items winding up economically accessible, in spite of the fact that the basic standards behind and impacts of superhydrophobicity are still fervently questioned. As of now there are gigantic parallel endeavors to determine both the rule comprehension of wetting and to characterize procedures to manufacture superhydrophobic surfaces on little and huge scales; for research and large scale manufacturing, individually.

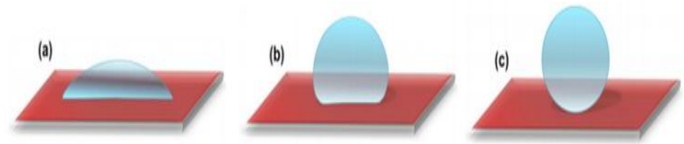


Figure 2: A schematic appearing (a) hydrophilic surface with water contact point under 90°; (b) hydrophobic surface with water contact edge more prominent than 90° and (c) superhydrophobic surface with water contact edge bigger than 150°[9].

There are thusly different courses declared for the age of such surfaces, empowering a colossal extent of materials to be used as substrates, or modified to give superhydrophobic surfaces. To understand the association between's the surface obnoxiousness and wettability, the outstanding Wenzel and Cassie-Baxter models have been proposed. The direct a water dab on a cruel surface in both (Wenzel, 1936) and Cassie's (Baxter, 1944) state are schematically showed up in Figure 2 [9].

3. METHODOLOGY

The beetroots pigment was obtained by extraction process from the beetroots as shown in Figure 3. The concentrations of the beetroot pigment were set into four different concentrations. The concentrations were 20, 40, 60 and 80 %wt/wt respectively. The beetroot pigments were then mixed with distilled water to form water-based coating. The volume of distilled water was remained constant at 240 ml. Then, we proceed to produce superhydrophobic coating by adding with hydrophobic agents in the solutions as self-cleaning properties. The hydrophobic agent was prepared by three phase that was published in the Solid State Phenomenon Journal [10].

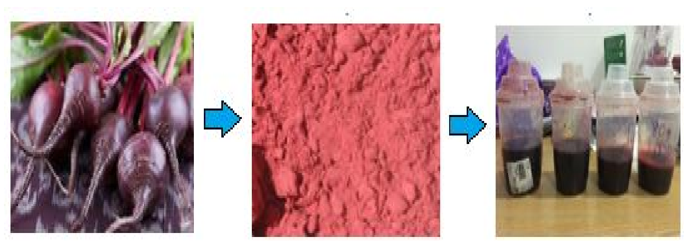


Figure 3: The process of extraction and formulation beetroot pigment from (a) Beetroots into (b) beetroots pigment in powder and (c) beetroots coating.

The preparation of beetroots pigment in superhydrophobic coating is important since it is the major contributor in the self-clean and superhydrophobic trait that increases the sustainability. The coating also was mixtured with solvent and hardener with different concentration in Table 1. The hardener and solvent were stirred using magnetic stirrer for about 8-10 minutes to ensure no coagulation and uniform mix.

Before coating the carbon steel samples with superhydrophobic coating, the samples were cleaned with 60% acetone and 40% methanol to ensure surface of the sample avoid any contamination, oil, grease, oxides and others. The sample surface was coated with beetroot pigment coating in different layers, with gaps between one or two days to make sure that the coating is dry before we applied of the consecutive layer.

The different layers of beetroot pigment coating were prepared which is 3 layer, 6 layer and 9 layers then left to dry for another one or two days. The method of coating is by using spray gun techniques due to the rapid solidification, metastable phases can be present in the deposits the beetroot pigment coating as shown in Figure 4.

Table 1: The concentration ratio of coating

Beetroot pigments (g)	Solvent (ml)	Hardener (ml)
20	250	12.5
40	250	12.5
60	250	12.5
80	250	12.5

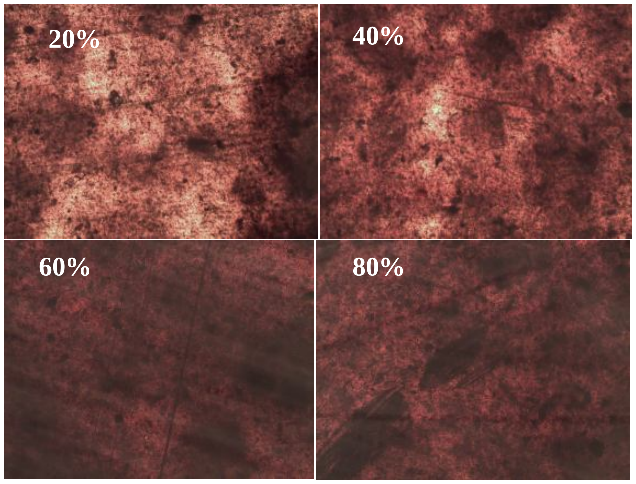


Figure 4:The different percentages of beetroots pigment coating on samples

3. RESULTS AND DISCUSSION

The water contact angle for water droplet test according to ASTM 5946-04 is a measure of water contact angle of water repellency and determining contact angle by direct measurement of angle from the drop profile. Normal hydrophobic leaves can recover their hydrophobic epicuticular wax layer and imitating this capacity to reestablish the surface usefulness can help avert the presentation of hydrophilic mass material on man-made non-wetting surfaces[11].

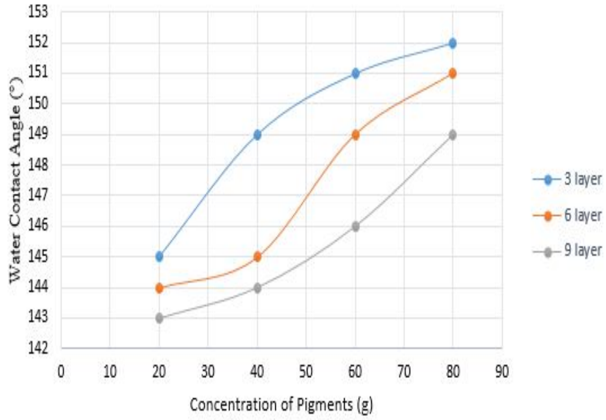


Figure 5: The water contact angles for 20, 40, 60 and 80% concentration of beetroot pigment for 3, 6 and 9 layers of coating

Figure 5 and Table 2 show the results of water contact angle measurements with different concentration of beetroot pigment which is 20%, 40%, 60% and 80% in different layer at 3, 6 and 9 layers, respectively. From the results, the largest water contact angle can be seen at layer 3 while the smallest water contact angle can be seen at layer 9. For the concentration of 20% beetroot pigment, the largest angle is at layer 3 with 145° while the smallest angle is at layer 9 with 143°. For 40% beetroot pigment, the largest water contact angle is 149° at layer 3 and the smallest water contact angle is 144° at layer 9. For 60% beetroot pigment, the largest water contact angle is 151° at layer 3 and the smallest contact angle is 146° at layer 9. Finally, at 80% beetroots pigment has the largest contact angle of 152° at layer 3 and the smallest contact angle of 149° at layer 9.

The result of water contact angles of 80% beetroots pigment for all three layers of coating which is 3, 6 and 9 was revealed the samples possess the most ideal hydrophobic property compare to others concentration. This is due to the combination between beetroot pigment and hydrophobic agent having strong interaction that occurs between the matrix composites. The strong interaction are expected due to the enourmous surface area of carbon steel substrate absorb the beetroot pigment coating directly by spraying method.

Scratch resistance test has been widely used by the coating industry to determine the hardness of clear and pigmented organic coating films according to ASTM D336. The test is typically done by scratching the coated surface area with pencils that are varied in hardness. The pressure and force applied on the specimens for each pencil has to be the same to avoid any inconsistencies that can cause error.

All of them indicates the decrease of scratch resistance as the pencil hardness increases. ‘1’ indicates scratching occurred while ‘0’ indicates that it did not. The data obtained from the scratch test is shown in Figure 6, Figure 7, Figure 8 and Figure 9. From the figures, the sample begin to scratch starting from 2B for the concentration of 20% on 3 layers coating, B on 6 layers and HB on layer. For concentration of 40%, 3 layers begun to scratch when the pencil reached the hardness of B, 6 and 9 layers from the hardness of HB. As for the 60% beetroot pigment, the scratching begun at H on 3 and 6 layers while at 2H on 9 layers.

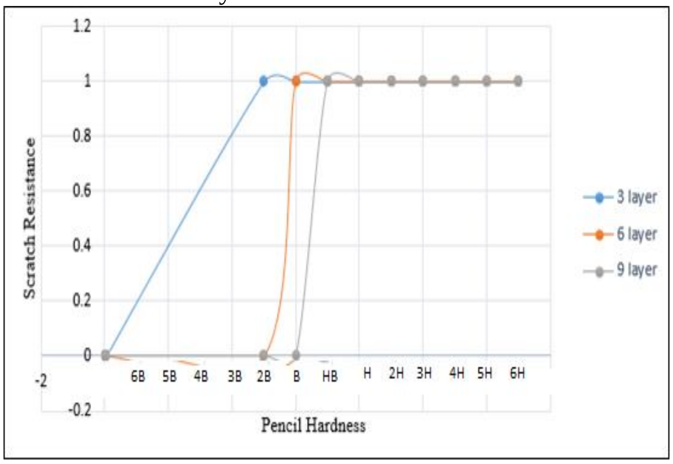


Figure 6: Scratch resistance versus pencil hardness graph of 20% beetroots pigment for 3, 6 and 9 layers.

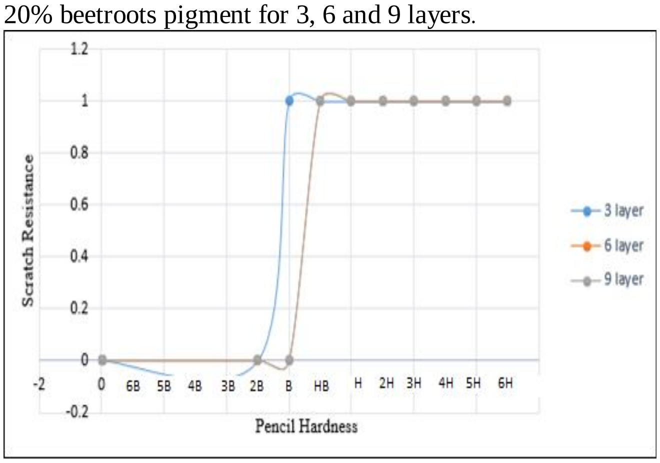


Figure 7 :Scratch resistance versus pencil hardness graph of 40% beetroots pigment for 3, 6 and 9 layers.

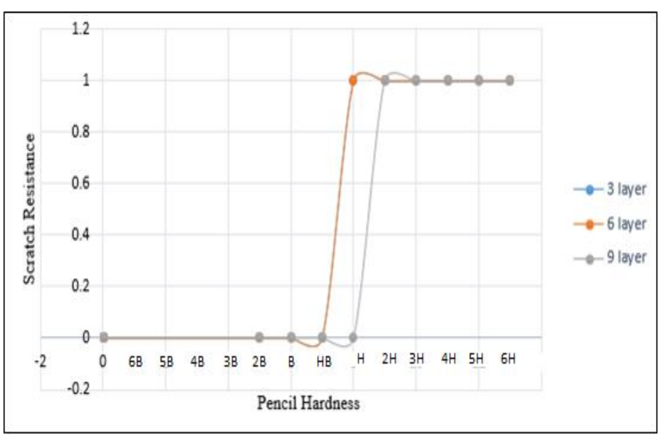


Figure 8: Scratch resistance graph versus pencil hardness of 60% beetroot pigment for 3, 6 and 9 layers

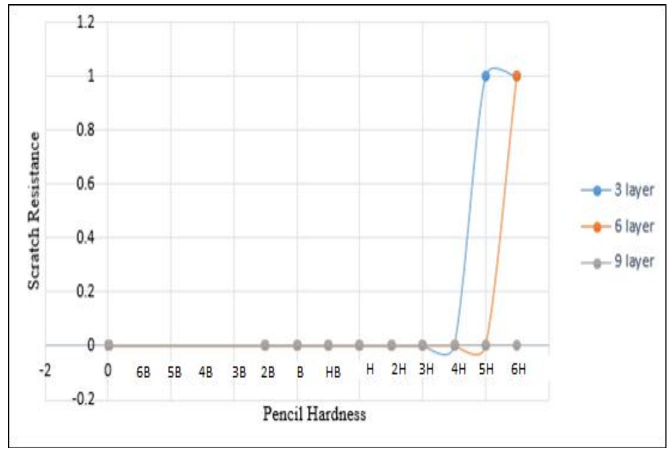
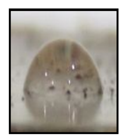
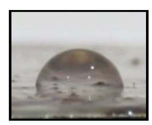
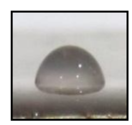
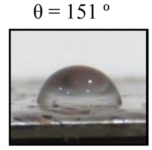
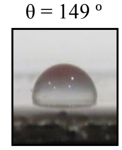
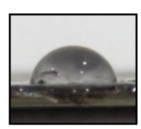
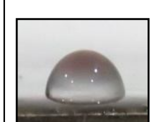


Figure 9 : Scratch resistance graph versus pencil hardness of 80% beetroots pigment for 3, 6 and 9 layers.

Table 3: Water droplet test results of different concentration and layer of coating surfaces in carbon steel surfaces

Beetroot pigment concentration	3 Layers	6 Layers	9 Layers
20%	θ = 145 ° 	θ = 144 ° 	θ = 136 ° 
40%	θ = 149 ° 	θ = 145 ° 	θ = 141 ° 
60%	θ = 151 ° 	θ = 149 ° 	θ = 146 ° 
80%	θ = 152 ° 	θ = 	θ = 139 ° 

For 80% beetroot pigment, the sample scratched when to hardness of pencil reached 5H for 3 layers and 6H for 6 layers. However, at the concentration of 80% with 9 layers, the sample did not scratch at all after being tested with each hardness of the pencil, proving that the scratch resistance is the highest among all with that being said, the sample or coating that had the least resistance towards scratch was the sample with the concentration of 20% beetroot pigment and three layers of coating. The sample that showed the highest scratch resistance was the sample with the concentration of 80% with 9 layers of coating. This proves that as the layer of coating increases, the resistance towards scratch also increases. The relationship between number of coatings and the scratch resistance is parallel[12].

5. CONCLUSION

In conclusion, the water contact angle results shows the best self-cleaning coating is at 80% of beetroot pigment with the water contact angles of 152°, 151° and 149° for 3, 6 and 9 layers, respectively. The concentration of 80% of beetroot pigment with 9 layers was revealed highest scratch resistance test up to 6H without any scratch on the surfaces. It is possible to apply beetroots pigment into superhydrophobic coating as protection layer in carbon steel surfaces. The future research study will be proceed to determine the effect for UV exposure of the beetroot pigments coating.

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REFERENCES

1. Porwal, T. **Paint pollution harmful effects in environment. Social Issue and Environmental Problems**, International Journal – Granthaaalayah 3(9) (2015) 1-4
2. Funke, W. **Problem and progress in organic coatings science and technology. Progress in organic coatings science and technology**, 31(1-2) (1997) 5-9. https://doi.org/10.1016/S0300-9440(97)00013-1
3. Rus, A. Z. M. Mohid, S. R., Nurulsaidatulsyida, S. and Marsi, N. **Biopolymer doped with titanium dioxide superhydrophobic photocatalysis as self-clean coating for lightweight composite**. Advances Materials Science and Engineering (2013) 1-9. https://doi.org/10.1155/2013/486253
4. Marsi, N., Rus, A. Z. M. and Tan, N, A. M. S. **The effects of curcuma longa on the functionality of pigmentation for thin film coating.** IOP Conference Series: Materials Science and Engineering, 226(1) (2017) 1-6. https://doi.org/10.1088/1757-899X/226/1/012160
5. Al-Turaif, H., Unertl W. N. and Lepoutre, P. **Effect of pigmentation on the surface chemistry and surface free energy of paper coating binders**, Journal of Adhesion Science and Technology 9(7) (1995) 801-811. https://doi.org/10.1163/156856195X00707
6. Kujala, T. S., Loponen, J. K., Klika, K. D. and Pihlaja, K. **Phenolics and betacyanins in red beetroot (beta vulgaris) root: distribution and effect of cold storage on the content of total phenolics and three individual compounds**. Journal Agricultural and Food Chemistry. 48(11) (2000) 5338-5342. https://doi.org/10.1021/jf000523q
7. Gonzalez, N. S., Fonseca, M. R. J., Martinez, E. S. M. and Zepeda, G. Extraction, **stability and separation of betalains from opuntia joconostle cv**. Using response surface methodology. Journal Agriculture Food Chemistry 61(49) (2013) 11995-12004. https://doi.org/10.1021/jf401705h
8. Friesen, J. B., McAlpine, J. B., Chen, S. N. and Pauli, G. F. **Counter separation of natural products: an update. Journal of Natural Products**, 78(7) (2015) 1765-1796. https://doi.org/10.1021/np501065h
9. Park, J. Y., Ha, M. Y., Choi, H. J., Hong, S. D. and Yoon, H. S. **A study on the contact angles of a water droplet on smooth and rough solid surfaces**. Journal of Mechanical Sci. and Tech, 25 (2011) 323. https://doi.org/10.1007/s12206-010-1218-2
10. Marsi, N, Rus, A. Z. M., Ibrahim, M. R., Samsuddin, S. A. and Rashid, A. H. A. **The synthesis and surface properties of newly eco-resin based coconut oil for superhydrophobic coating**. Material and Manufacturing Technology VIII (266) (2017) 59-63. https://doi.org/10.4028/www.scientific.net/SSP.266.59
11. Azhar, S. S., Abidin, Z. H. Z. and Khiar, A. S. A. **Color stability and corrosion resistivity of natural dye paint film consisting of curcumin.** Advanced Science Letter, 23 (2017) 4656-4659. https://doi.org/10.1166/asl.2017.8892
12. Horikawa, H., Ogihara, T., Shimomura, A. and Shimomura, J.. **Preparation and characterization of silica film on PBT substrate by sol-gel method using perhydropolysilazane**. Key Engineering Materials 421-422 (2009) 161-164 https://doi.org/10.4028/www.scientific.net/KEM.421-422.161