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The Effects of Curcuma Longa on the Functionality of Pigmentation for Thin Film Coating

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Abstract. This project presents the effects of turmeric (Curcuma Longa) on the functionality of pigmentation was carried out to improve the sustainability, environment impact and reduction of potential cost saving without sacrificing the performance of thin film coating. The Curcuma Longa pigment was extracted by grating the turmeric into small particles at different percentages which is 20%, 40%, 60% and 80% of Curcuma Longa pigment with 3, 6 and 9 layers of coating. The different percentages of Curcuma Longa pigment was formulated and synthesized with polyols by crosslinking agent of glycerol and calcium carbonate into temperature at 140 °C for 2 hours. The results of water droplet test (ASTM D5964) showed the water contact angle was achieved the optimum superhydrophobic characteristic up to 60% of Curcuma Longa at 153°. The formulation of 60% Curcuma Longa was revealed the optimum adhesion resistance test with no flaking and detachment when the coating applied at 9 layers in the classification grading of adhesion test at 5B. It is indicated that the adhesion resistance of thin film coating on metal substrate was obviously increased as the layer of coating as well as the Curcuma Longa pigment percentage up to 60% at 9 layers. This project also highlighted the potential of Curcuma Longa pigment to produce quality in the natural pigmentation as a replacement synthetic pigment which is long-term health hazards.

1. Introduction
Surface coating is used to protect the substrate from the environment. The coating must adhere to the surface that has been coated to decorate or protect any surface and the coating must in remain position. In most cases coatings consist of the following four types of components which is binder, solvent, additives and pigment. Inorganic pigments can be materials like lead oxide, cobalt blue, chromium oxide, cadmium yellow and molybdate orange [1]. New environmental laws are very strict about toxicity a few of these heavy metal pigments are no longer in use. Organic pigments are usually bright, pure, light in weight and rich in tinting strength made up of carbon atoms which form strong, stable chemical bonds and are always present in animal, plant and synthetic organic chemistry [2].

In recent years, the researchers study the use in organic pigments in surface coating or paint. The organic pigment contain carbon and comes with relatively low levels of toxicity. The organic coating are intended to eliminate electrochemical reactions occurring on the coating-substrate interface. The use of non-toxic, non-allergic and eco-friendly organic pigment in car paint has become the matter of significant due to the awareness among world population to avoid some hazardous synthetic dyes [3]. The usage of natural pigment almost vanished with the appearances of synthetic pigment. The wide range of color available with acceptable fastness properties for the substitution of natural pigment. Curcuma Longa has a great importance in the food, textile, cosmetic and pharmaceutical industries [4]. Over the past several years, numerous studies have emerged in the benefits of Curcuma Longa and on its anti-cancerous preventative, antioxidant and powerful anti-inflammatory properties. This advantage plays important role in saving nature and provide an options for nature lovers. In this research, the effects of Curcuma Longa on the functionality of pigmentation for thin film coating was determined to produce self-cleaning characterictic, abundant resources and inexpensive way which is cost saving regarding the formulation of composition that can prevent moisture and contamination on surface as well as extended life expectancy of the coating and substrate.

2. Methodology

2.1 Extraction process of Curcuma Longa into composition thin film coating
The Curcuma Longa pigment was extracted by grating the turmeric into small particles at different percentages which is 20%, 40%, 60% and 80% of Curcuma Longa pigment and was diluted into ethanol. The mixture was gradually stirrer using magnetic stirrer about 2 hours to ensure the mixture of solution in properly dispersed. The extracted Curcuma Longa pigment was filtrated by using whitman No.1 filter paper 6 ± 1 µm. The Curcuma Longa pigment was collected in a glass bottle and labelled for different percentage of Curcuma Longa compositions. The composition of coating was measured weight by weight of Curcuma Longa and ethanol volume with the ratio of 1:1 to obtain 20%, 40%, 60 and 80% of Curcuma Longa. Fig.1 shows the extraction process of Curcuma Longa pigment. The formulation of coating composition were synthesized by an interfacial polymerization method with solvent, hardener and Curcuma Longa pigment. The mixture of 250 ml solvent, 50 ml of hardener and different percentages of Curcuma Longa pigment which is 20%, 40%, 60% and 80% was poured into spray gun for coating process.

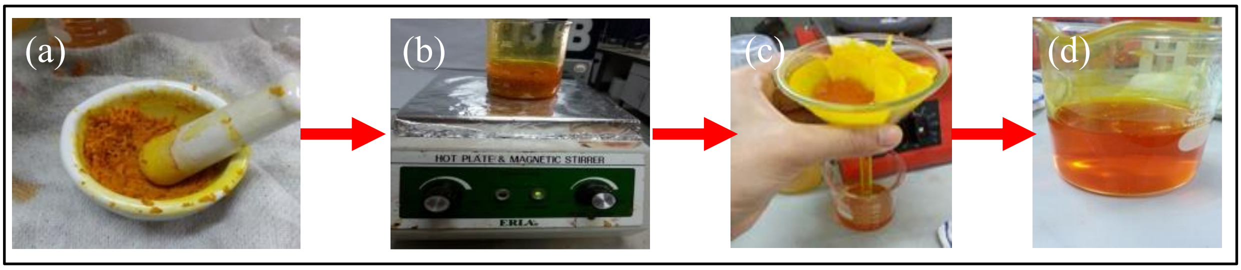


Figure 1 Extraction process of Curcuma Longa: (a) the grated Curcuma Longa was crushed into smaller particle; (b) The mixture was stirred using magnetic stirrer; (c) The Curcuma Longa pigment was filtered using filter paper; (d) Curcuma Longa was extracted with different percentages of composition.

2.2 Method of the coating process for thin film coating
The metal panels were cleaned using medium-fine of 150-grit sandpaper. The method of thin film coating on metal panel was prepared by spray gun technique for coating process. The metal samples were sprayed with three different layers of thin film coating which were 3, 6 and 9 layers for different percentages of 20%, 40%, 60% and 80% of Curcuma Longa pigment. The process coating was involved into three stages which is the 12 metal samples were sprayed thrice at each stage into 3, 6 and 9 layers of thin film coating. The thin film coating were dried for 4 hours before applying another layer. All the

coated samples is continued with the mechanical and physical testing regarding to category of samples as shown Table 1 and Fig. 2. All the samples was tested to determine the effects of curcuma longa on the functionality of pigmentation for thin film coating for adhesion test and water droplet test.

Table 1 Category of samples

No	Samples	Surface coating treatment	Thickness coating (mm)
1	A	Thin film coating with 20% Curcuma Longa pigment	0.20
2	B	Thin film coating with 40% Curcuma Longa pigment	0.20
3	C	Thin film coating with 60% Curcuma Longa pigment	0.20
4	D	Thin film coating with 80% Curcuma Longa pigment	0.20

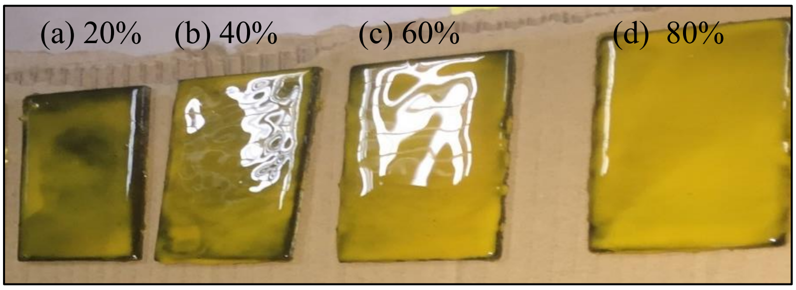


Figure 2 The samples of metal substrate coated with thin film coating with different percentages of Curcuma Longa pigment: (a) Sample A: 20% of Curcuma Longa; (b) Sample B: 40% of Curcuma Longa; (c) Sample C: 60% of Curcuma Longa and (d) Sample D: 80% of Curcuma Longa

3. Results and discussion

3.1 Adhesion test

Adhesion testing enables a quantitative approach producing more replicable evaluations and thus increasing the reliability of the results. The grading of the adhesion test can be referred in ASTM D3359: Standard Test Methods for Measuring Adhesion by Tape Test [5]. Fig.3 shows the results classification of adhesion test thin film coating for 3, 6 and 9 layers. For 3 layers thin film coatings, the coated metal panel shows that the flaking and detachment in excess of 65 % occurs at the steel panel with 20% of Curcuma Longa pigment. The edges of the cuts are completely smooth with none of the squares or the lattices are detached for 40 %, 60% and 80% thin film coating of coated metal panels. It is indicated that there are increasing in the performance of adhesion rate from 40% to 80% Curcuma Longa pigment. The data was obtained for adhesion test conducted on 6 layers thin film coating of coated metal panels. The 20% of Curcuma Longa pigment has flaked along the edges and at parts of the squares. The affected areas are 15% to 35% of the lattice. The coated metal panel surface cross-cut areas are completely detached in excess of 65% after third times test. Meanwhile, the edges of 40% panel sample remain detached. However after third times testing, small flakes of coating are detached at intersection, less than 5% of the area was affected. The cross-cut areas of 60 % and 80 % of steel panels remain smooth.

The adhesion test was conducted for 9 layers thin film coating of coated metal panels shows that the best coating layers for 20 %, 40 %, 60 % and 80 % of Curcuma Longa pigment. The surface of the cross-cut areas are completely smooth and none of the squares of lattice are detached. The classification of adhesion test for 9 layers thin film coating coated metal panels was increase with the increasing of the percentages of the Curcuma Longa pigment from 20% to 80%. The optimum results of adhesion test that there is no flaking and detachment was obtained at 9 layers of thin film coating coated metal panel compare to 3 and 6 layers as shown in Fig. 3. This is due to the formation of covalent bonds between the solvent and hardener molecules into Curcuma Longa pigment of the thin film coating and substrate of metal surfaces to enhance the adhesion resistance [6].

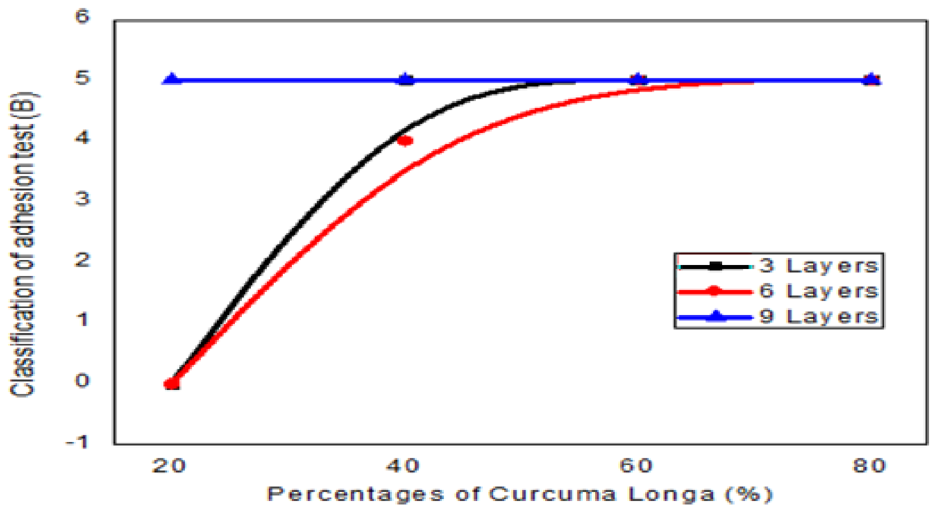


Figure 3 The results of classification of adhesion test (B) at different percentages of Curcuma Longa of 20%, 40%, 60% and 80% for 3, 6 and 9 layers.

3.2 Water droplet test

Fig. 4 show the water droplet test of water contact angle (WCA) of thin film coating at different percentages of Curcuma Longa pigment for 3, 6 and 9 layers. The WCA for 3, 6 and 9 layers of coated thin film coating into metal panel surfaces were tested for three times to determine the superhydrophobic characteristics. The WCA of 20%, 40%, 60% and 80% Curcuma Longa pigment for 3 layers thin film coating is 133º, 137º, 150º and was decreased WCA to 139º, respectively. 20%, 40% and 80% of Curcuma Longa pigment was not attained the superhydrophobic characteristic of the surfaces. However, 60% of Curcuma Longa pigment was achieved the minimum of superhydrophobic characteristic. For 6 layers thin film coating shows the WCA of 131º, 141º, 153º and 140º for 20%, 40%, 60% and 80% of Curcuma Longa pigment, respectively. The 20%, 40% and 80% of Curcuma Longa pigment shows the lowest WCA. The highest WCA was revealed at 60 % of Curcuma Longa pigment for all three time test at 153º in average value. The WCA of the water droplet increases as the percentage of Curcuma Longa pigment increases until 60 % and the water contact angles decreased at 80 %. It has been the similar determination of 9 layers where the 20%, 40%, 60% and 80% of Curcuma Longa pigment of coated metal surfaces developed WCA at 134º, 146º, 155º and 142º, respectively was revealed the development of superhydrophobic characteristics for self-cleaning properties at 60% of Curcuma Longa pigment. From the results, it can be conclude that the higher WCA was developed at 60% of Curcuma Longa pigment which are 150°, 153° and 155° for 3, 6 and 9 layers of water droplet test.

Table 2 shows the image of water droplet test at different percentages of Curcuma Longa pigment and average water contact angles for the coated metal panels. The comparison of water contact angles shows the superhydrophobicity of 3, 6 and 9 layers thin film coating of coated panels. The 3, 6 and 9 layers of thin film coating shows the higher WCA from surface are at 60% Curcuma Longa pigment. Meanwhile the lower WCA are at 20%, 40% and 80% of Curcuma Longa pigment for 3, 6 and 9 layers coated panel where the average WCA about 130° < 150° was not achieved to develop the superhydrophobicity characteristic. The 80% sample showed the decrease of water contact angle may due to the higher composition of Curcuma Longa pigment incompatible with the coating. It is revealed that the 60% composition of Curcuma Longa pigment is the optimal composition give the best quality coating. The development of superhydrophobic characterictic is due to the thin film coating has low surface energy base materials pigment, additives and curing agent. This problem is more severe for metals, typically when water droplets dry on the surface, water mark, or spots are left behind due to the deposit of minerals in contact with water and oxygen can lead to corrosion cell formation [7].

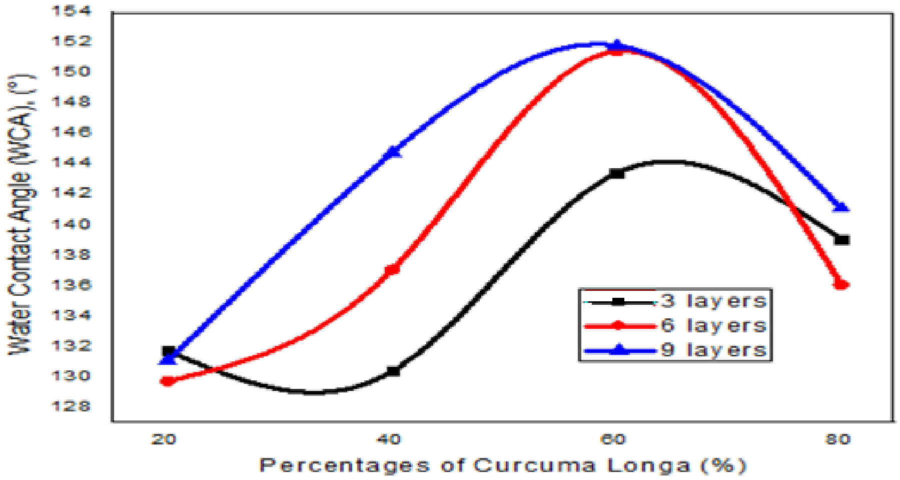
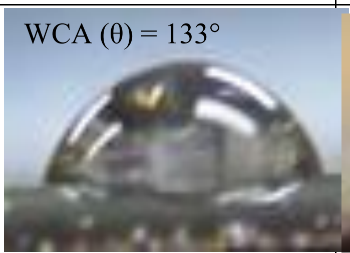
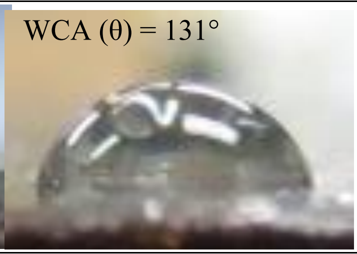
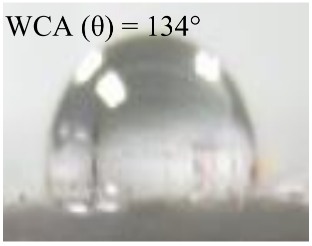
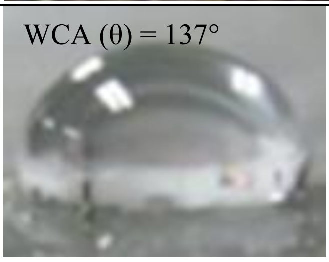
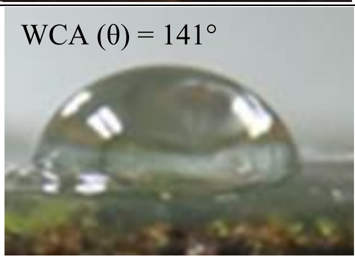
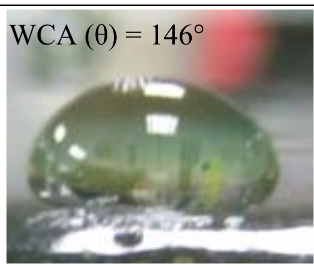
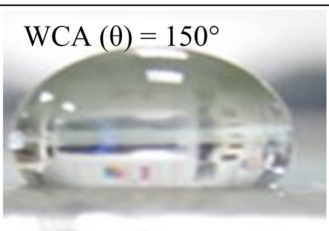
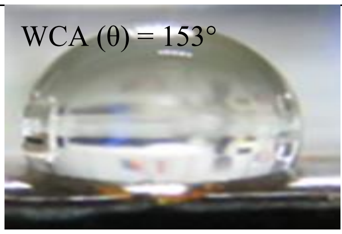
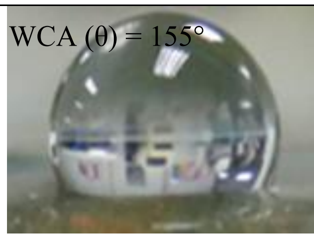


Figure 4 The water droplet test at different percentages of Curcuma Longa of 20%, 40%, 60% and 80% for 3, 6 and 9 layers.

Table 2 The image and water droplet test at different percentages of Curcuma Longa pigment

Curcuma Longa (%)	**3 Layers**	**6 Layers**	**9 Layers**
20% of Curcuma Longa	WCA (θ) = 133° 	WCA (θ) = 131° 	WCA (θ) = 134° 
40% of Curcuma Longa	WCA (θ) = 137° 	WCA (θ) = 141° 	WCA (θ) = 146° 
60% of Curcuma Longa	WCA (θ) = 150° 	WCA (θ) = 153° 	WCA (θ) = 155° 

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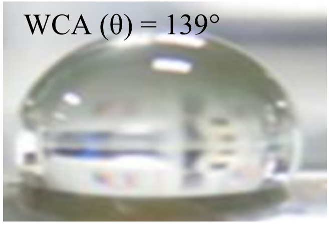
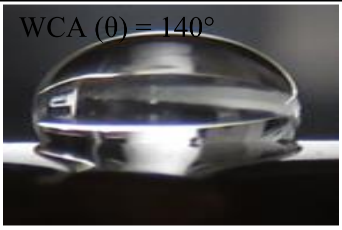
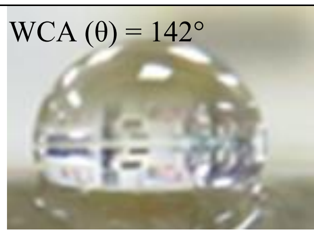
80% of Curcuma Longa			

4. Conclusion

In conclusion, the thin film coating produced successfully with the mix of Curcuma Longa pigment, solvent and hardener with composition percentage of 20%, 40%, 60% and 80%. It is revealed that the optimum thin film coating suitable to applied for self-cleaning properties is 60% of Curcuma Longa pigment with the average contact angles are 143.33°, 151.33° and 151.67° for 3, 6 and 9 layers respectively. The adhesion test, the most durable concentration thin film coating similar for 60% of Curcuma Longa pigment at all three different layers. Meanwhile, the 9 layers of thin film coating shows the great adhesion test between the thin film coating and metal substrate. The use of Curcuma Longa pigment showed the enhancement in the superhydrophobic property, adhesion resistance and anti-corrosion test for the future investigation. The optimum composition of 60% of Curcuma Longa pigment has the potential to produce good performance into superhydrophobic coating.

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References

[1] Mark M R J 2016 High Performance Inroganic Pigments: Complex Inroganic Colored Pigments *SPE ANTEC Indianapoli,* pp. 289-294

[2] Alabi F M and Omojola M O 2013 Potentials of Nigerian Calcined Kaolin as Paint Pigment *African Journal of Pure and Applied Chemistry,* vol. 7(12), pp. 410-417

[3] Rus A Z M, Mohid S R, Nurulsaidatulsyida S and Marsi N 2013 Biopolymer Doped with Titanium Dioxide Superhydrophobic Photocatalysis as Self-Clean Coating for Lightweight Composite *Advanced in Materials Science and Engineering, Hindawi Publishing, pp. 1-9*

[4] Szymanski W, Halama A and Madalinski J 2016 Applying of Non-Toxic Oxide Alloys and Hybrid Polianiline Compounds as Anticorrosive Pigments in Organic Epoxy Coatings, IOP Conf. Series: Materials Science and Engineering 113, *IOP Publishing,* pp 1-4.

[5] ASTM Standard D3359 – Standard Test Methods for Measuring Adhesion by Tape Test,ASTM International, West Conshohocken, PA, www.astm.org, pp. 1-8.

[6] Nguyen T V, Nguyen T A, Dao P H, Mac V P, Nguyen, A H, Do M T and Nguyen T H 2016 Effect of Rutile Titania Dioxide Nanoparticles on the Mechanical Property, Thermal Stability, Weathering Resistance and Antibacterial Property of Styrene Acrylic Polyurethane Coating. *Advances in Natural Sciences: Nanoscience and Nanotechnology,* vol.7, pp 1-9

[7] Chang Y C, Lee C C, Huang S R, Kuo CC and Wei H S 2016 An Easy and Effective Method to Prepare Superhydrophobic Inorganic/Organic Thin Film and Improve Mechanical Property*: Thin Solid Films,*, pp 32-36