International Journal of Chemical Science
www.chemicaljournals.com
Online ISSN: 2523-2843, Print ISSN: 2523-6075
Received: 10-05-2021, Accepted: 25-05-2021, Published: 09-06-2021
Volume 5, Issue 3, 2021, Page No. 22-26

The effect of $BaSo_4$ nanoparticles as coating materials in alkyd paint formulation towards metal surface

Le Huy Hai[1*], Le Mai Xuan Truc[2], Nguyen Quoc Trung[3]
[1] Faculty of Chemical Engineering and Food Technology, Nguyen Tat Thanh University, Vietnam
[2] Faculty of Chemical Engineering and Food Technology, Ho Chi Minh City University of Technology, Vietnam
[3] Faculty of Chemistry, VNUHCM-University of Science, Ho Chi Minh City, Vietnam

Abstract
Alkyd paint is a very popular paint used in industry and life to protect the surface of steel, wood, and equipment against the harmful effects of the environment. The aim of this study is to assess the effect of $BaSO_4$ nanoparticles on alkyd resin paint films to protect metals. The research method is selecting the traditional alkyd paint formula, then replacing this coating powder $CaCO_3$ with $BaSO_4$ nanoparticles to monitor the properties of the paint film over time. Methods of analyzing the properties of the paint film are based on Vietnam standards. The study results showed that $CaCO_3$ coating powder replaced by $BaSO_4$ nanoparticles had increased the properties of the paint film, improved the thickness, gloss, and durability of the paint film. $BaSO_4$ nanoparticles increased from 1% to 6% by weight, the impact increased by about 11.29% (70 to 79 kg.cm), Glossy 60^0 increased by about 10.79%, Glossy 85^0 increased by about 10.92%, especially the durability of paint film over time increased nearly double. However, $BaSO_4$ nanoparticles are more expensive than $CaCO_3$, so they should replace less than 6% by weight to increase the quality of the paint film. This ratio is changed according to the actual equipment requirements.

Keywords: coating powder, durability, glossy, paint film, traditional alkyd

Introduction

Nowadays, alkyd paint is used extensively to protect metals against environmental damage. The main ingredients of alkyd paint are alkyd resins, coatings, and additives such as surface desiccants, anti-deposition agents, defoamer, dispersants, colors, solvents. Alkyd resins come in a variety of fatty resins (long-oil alkyd containing 56-70% fatty oils), lean resins (short-oil alkyd with 30-45% fatty oils), and medium-oil alkyd resins (medium-oil alkyd has 46 - 55% fatty oil), the demand for alkyd resins is huge, about 200,000 tons of alkyd resins are produced per year [1, 2, 3].

The coating is a very important component of paint, it greatly affects the properties of the paint. The commonly used coatings in paint are $CaCO_3$, TiO_2, ZnO, $BaSO_4$... Coating $BaSO_4$ has many outstanding properties in terms of adhesion, UV resistance, keeping color stable, and less changing due to the environment. [4]. $BaSO_4$ nanoparticles are $BaSO_4$ particles with very small particle diameters. $BaSO_4$ nanoparticles are typically 20-80 nanometers (nm) with specific surface area in the 10 - 50 m^2/g. They have the properties of $BaSO_4$ and special properties of nanoparticles in the coating field [5, 6, 7], sterilization [8], synthesized by many different methods in the form of emulsion [9], by precipitation method [10], and many other ways [11, 12]. The purpose of this study is to assess the effect of $BaSO_4$ nanoparticles as coating materials in Alkyd Paint Formulation Towards Metal Surface. This study focuses on the durability of paint films, as a basis for practical application on an industrial scale, helping manufacturers choose suitable $BaSO_4$ nanoparticles ratio for each painting with different requirements for quality and price.

Materials and Methods

Materials

Alkyd- CR 1486-70 DT: Alkyd resin is Oil length 49%, PA content (Phtalic Anhydride) 28%, Solvent type: Xylene, Acid value (mg KOH / g solid): 5 - 12, Solid content: 70 ± 1%, Color temperature (Gardner): Max. 8. Origin: Indonesia

$BaSO_4$ nanoparticles: $BaSO_4$ nanoparticles are in fine powder form, the particle diameter is 40-50nm. It is almost insoluble in water, is slightly soluble in concentrated sulfuric acid. $BaSO_4$ nanoparticles are used in paints to increase adhesion, keep the color bright, clear, not fade, which can improve the product's light fastness, weather resistance, chemical corrosion resistance, and electrochemical resistance, and decorative effect, improve the impact strength of the coating. Packing: 25KG in PE woven bag. Place of origin: Turkey.

$CaCO_3$: $CaCO_3$ content 98%, the density of 2.7, the iron content of 0.05%, fineness of 10 µm, used for painting. Made in Viet Nam.

Oct Co: Cobalt octoate 10% is a drying agent for oil paint systems. Appearance is purple, clear liquid, solid content of 55-65%, the metal content of 9.8 - 10.2, specific gravity 0.93-1.03. Dura origin (India).

Oct Pb: Lead Octoate (32% Pb) is a surface-based drying agent that is often combined with Cobalt and Calcium Octoate. Liquid, clear yellow, solid content of 62-72%, Pb content 32 ± 0.2%. Density 1.2-1.3 g / ml.. Thai origin.

Oct Ca: Calcium octoate 10% is a high purity liquid drying agent with strong activity and compatibility. Calcium Octoate is used when combined with Lead and Cobalt octoate. Origin from Mandeep - India

Bentone 34: Bentone 34 is a special clay mineral, it is a sodium-aluminum hydrosilicate. Bentone 34 is used to refer to natural stone, it is a very fine particle material that mainly consists of clay minerals. Made in China

Airex 900: Airex 900 is a foam breaking agent, it breaks down bubbles formed in the process of grinding, mixing, to make the paint film glossy and smooth. Chinese origin.

Disper 710s: Disper is an effective dispersant that disperses organic and inorganic additives in the paint to create a gloss for paint film. Chinese origin.

Xylene: Xylene is a clear colorless liquid with a pleasant aroma. Auto-ignition temperature 500ºC. Density at 20ºC is 0.865-0.875 kg/l. This mixture is liquid, colorless. Chinese origin.

Research Methods

We create different paint formulas with the replacement rate of $CaCO_3$ coating material with $BaSO_4$ nanoparticles then consider the extent of the effect of nanomaterials on the properties of the paint film. Each formula sample is painted on 12 metal sheets with dimensions of 70x150 mm and a thickness of 0.5 mm with the same film thickness. We compare and draw conclusions, evaluate the advantages of using $BaSO_4$ nanomaterials.

Method of Creating Paint Film

Because creating a uniform thickness paint is relatively difficult, so we create many models to choose from. The common tool for creating laboratory coatings is a manual paint film ruler. We use the manual pull ruler model BGD 201/5 with a 100 µm scale from the Biuged manufacturer. The ruler is based on the method of creating the Doctor Blade technique. It is made of stainless steel with an accuracy of 2%, easy to use, and creates relatively uniform paint film.

Method of Creating Paint Samples

Table 1: Composition of paint formulations

Nº	Raw materials	Uses	F 1 Wt.%	F 2 Wt.%	F 3 Wt.%	F 4 Wt.%	F 5 Wt.%	F 6 Wt.%	F 7 Wt.%
1	Alkyd- CR 1486-70 DT	Resin adhesion for paint	43	43	43	43	43	43	43
2	$BaSO_4$ nanoparticles	Cover substance		1	2	3	4	5	6
3	$CaCO_3$	Cover substance	24	23	22	21	20	19	18
4	Oct Co	Drying substance	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	Oct Pb	Drying substance	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	Oct Ca	Drying substance	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	Bentone 34	Anti-sedimentation	0.3	0.3	0.3	0.3	0.3	0.3	0.3
8	Airex 900	Foam breaking agent	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	Disper 710S	Dispersant substance	0.4	0.4	0.4	0.4	0.4	0.4	0.4
10	Xylen	Solvent	31.6	31.6	31.6	31.6	31.6	31.6	31.6
	Total		100	100	100	100	100	100	100

Methods of Analysis

Coverage of dry paint film is determined according to Vietnam Standard TCVN [13].
Drying time of the paint film is determined according to TCVN [14].
Adhesion is determined according to TCVN [15].
Gloss 60^0 and 85^0 are determined according to TCVN [16]
The impact is determined according to TCVN [17].

Result and Discussion

We create paints based on traditional formulas from formulas 1 to 7 with the same ingredients but different in $CaCO_3$ and $BaSO_4$ nanoparticles coating ratios. The total $CaCO_3$ and $BaSO_4$ nanoparticles coatings in all samples were 24% by weight (Table 1)

Table 2: Properties of paint

No	Properties	F 1	F 2	F 3	F 4	F 5	F 6	F 7
1	Face dry time (minutes)	33	32	31	29	26	25	24
2	Natural drying time (hours)	20	19	18	17	16	15	15
3	Impact level (kg.cm)	70	71	73	75	77	78	79
4	Coverage of dry paint film g / m^2	83	83	83	83	83	83	83
5	Glossy 60^0	89	90	92	94	96	97	98
6	Glossy 85^0	87	88	90	92	93	94	95

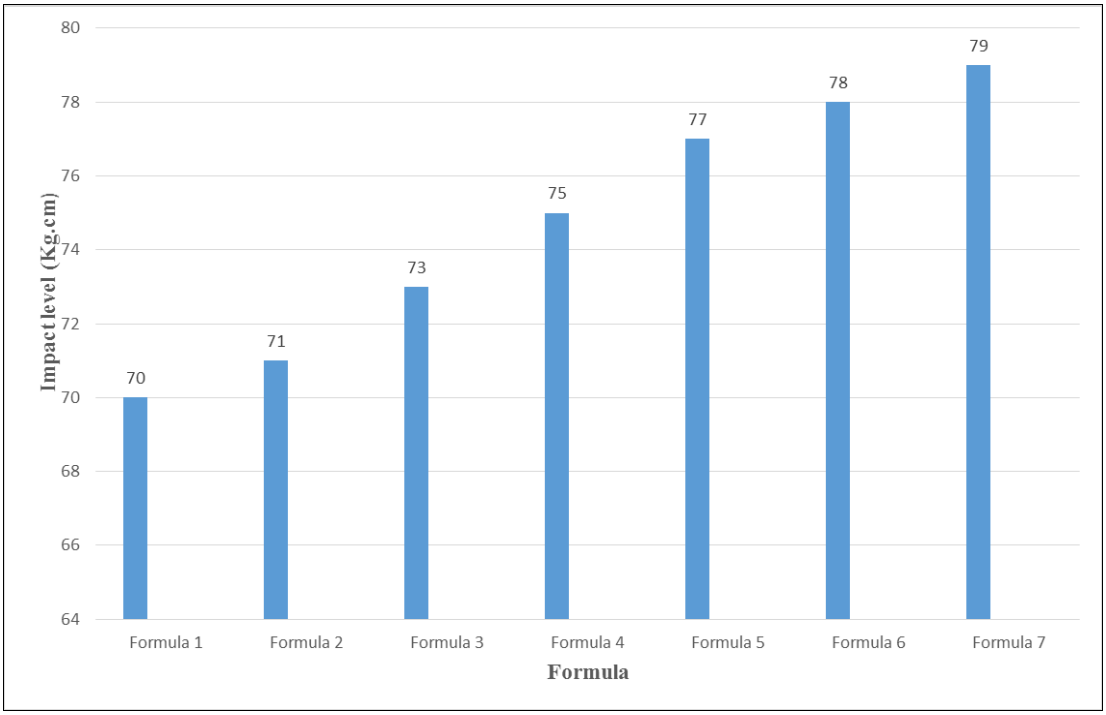

Fig 1: Impact of paint formulations

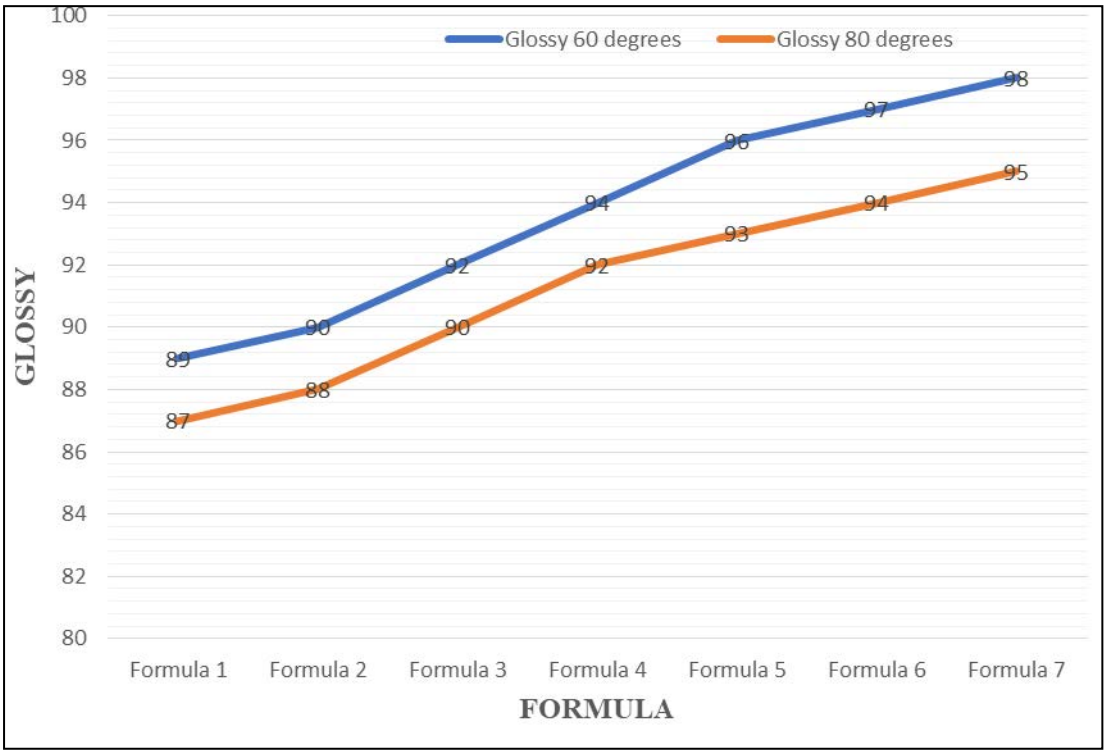

Fig 2: Gloss 60^0 and 85^0 of paint formulations

The data and graphs shown in Fig.1, Fig.2, and Table.2 show that when increasing the concentration of $BaSO_4$ nanoparticles, the level of impact and the gloss of 60^0 and 85^0 also increased. The impact level in formula 1 to formula 7 increased fast from 70 to 79 kg. cm. The gloss of 60^0 and 85^0 increased from 89 to 98 and 87 to 95. This can be explained that the $BaSO_4$ nanoparticles are very small and smooth, so it gives the metal surface a gloss. This issue has also been raised in some previous studies on nanocoatings in paints [18, 19]. $BaSO_4$ nanoparticles are spherical or faceted high surface area oxide nanostructured particles [20]. The outstanding properties of nanoparticles have enhanced the way in which a number of the paint industries around the world. With regards to the paint and coatings industry, researchers believe that nanoparticles can improve the hardening, UV-light absorption, and biocide properties tremendously. Researchers are not only focusing their research on producing better paint formulations with degradable biocides they also consider using nanomaterials as additives for the protection of paints, against microbial degradation, and physical and chemical deterioration. Studies have shown several advantages in every field the nano paints will be used as good chemical resistance, anti-reflection resistance, Shock resistance for many structures [21].

Table 3: Changes in adhesion over time

N⁰	Time (month)						
	Start	6	12	18	24	30	36
F 1	1	2	3	3	4	5	5
F 2	1	2	2	3	4	4	5
F 3	1	2	2	3	4	4	4
F 4	1	1	2	2	3	3	4
F 5	1	1	2	2	2	3	3
F 6	1	1	1	2	2	2	3
F 7	1	1	1	2	2	2	3

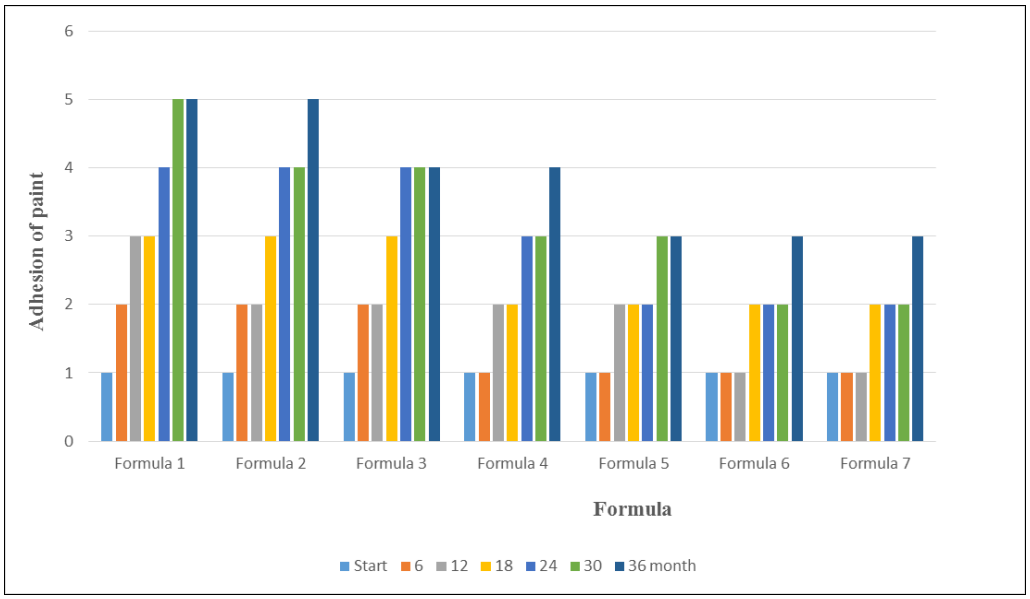

Fig 3: The graph shows the change in the adhesion of the paint formula over time

From the experiment, it shows that the higher the rate of using $BaSO_4$ nanoparticles, the less the adhesion change, the less peeling paint film is. Thus, the added $BaSO_4$ nanoparticles make the coating film better, it is not changed over time. This can be explained by the fact that the metal surface structure is not smooth and ideal, it is rough with very small slots, causing coatings of different sizes to penetrate deeply into the surface. Because the size of $BaSO_4$ nanoparticles is very small from 40 to 50 nm, it easily penetrates the metal surface, the adhesion force between the coating and the metal surface is better than that of the $CaCO_3$ coating, making the paint film more durable.

Replacing the $CaCO_3$ coating with $BaSO_4$ nanoparticles in the metal-protecting alkyd paint has brought better performance on the paint film's properties such as gloss, impact resistance and especially the longevity of the paint film over time. Since $BaSO_4$ nanoparticles are more expensive than the $CaCO_3$ coating, the replacement should be with a ratio of less than 6% by weight of paint. Metal surfaces of inexpensive objects and tools if using alkyd paint coated with $BaSO_4$ nanoparticles need economic consideration. However, in the case of the requirement of good film quality, high gloss, and time durability for valuable equipment, the $CaCO_3$ coating replaced with $BaSO_4$ nanoparticles with a high rate is very suitable.

Conclusion

Replacing $CaCO_3$ with $BaSO_4$ nanoparticles in alkyd paint has increased the adhesion of the coating to the metal surface, making the paint film better resistant to impact, glossier, longer film life under the impact of the environment.

$BaSO_4$ nanoparticles are a good coating in alkyd paint for metal paints, it improves the paint film properties better than $CaCO_3$ material. The higher the rate of replacing $CaCO_3$ coating material with $BaSO_4$ nanoparticles, the better the properties of the coating film. It is advisable to replace the $CaCO_3$ coating material with $BaSO_4$ nanoparticles with a ratio of less than 6% by weight because $BaSO_4$ nanoparticles are more expensive than $CaCO_3$.

Acknowledgement

The authors would like to thank Miss Le Kim Thoa University of Houston (USA).

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

1. Williams RC. Advances in alkyd resins. Applied Polymer Science,2000:21:471-481.
2. Sebastian W, Bernd S, Veronika S. Functionalization of an alkyd resin with (meth) acrylate groups for photoinitiated polymerization. Progress in Organic Coatings,2018:125:316-324. https://doi.org/10.1016/j.porgcoat.2018.08.028
3. Khalid A, Ibrahim KA, Abu-sbeih IA, Laurance B. Preparation and Characterization of Alkyd Resins of Jordan Valley Tomato Oil. Journal of Polymers and the

Environment,2014:22(4):553-558. https://doi.org/10.1007/s10924-014-0664-9
4. Cyrus LB, John BS, Michael CS. Comparison of the reflectance characteristics of polytetrafluoroethylene and barium sulfate paints. Applied Optics, 1984:23(8):1139-1140 https://doi.org/10.1364/AO.23.001139
5. Ramaswamy RM, Vimalathithan, Ponnusamy V. Synthesis and characterization of $BaSO_4$ nano particles using micro emulsion technique. Advances in Applied Science Research,2010:1(3):197-204.
6. Mohamed EIS, Inas MB. Influence of Nano-Barium Sulfate Agglomeration on Microstructure and Properties of the Hardened Cement-Based Materials. Journal of Materials Science and Chemical Engineering, 2015:3:72-81. http://dx.doi.org/10.4236/msce.2015.311009
7. Nagarjun K, Jana K, Lan M, Sibylle G, Robert L, Thomas CD *et al*. Biokinetics and effects of barium sulfate nanoparticles,11,55, 2014. DOI: 10.1186/s12989-014-0055-3
8. George EA, David S, Zifan Y, Thomas JW. Nano-$BaSO_4$: a novel antimicrobial additive to pellethane. International Journal Nanomedicine,2013:8:1197-205. DOI: 10.2147/IJN.S40300
9. Limin Q, Jiming M, Humin C, Zhenguo Z. Preparation of $BaSO_4$ nanoparticles in non-ionic w/o microemulsions. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 1996:108(1):117-126. https://doi.org/10.1016/0927-7757(95)03317-3
10. Mohamed EIS, Inas MB. Synthesis of $Baso_4$ Nanoparticles by Precipitation Method Using Polycarboxylate as a Modifier. Current Research in Nanotechnology,2011:2(1):106-111. DOI: 10.3844/ajnsp.2011.106.111
11. Hari B, Wuyou F, Jingzhe Z, Xuefeng D, Yanqiu J, Kaifeng Y *et al*. Preparation of $BaSO_4$ nanoparticles with self-dispersing properties. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2005:252(2-3):129-134. DOI: 10.1016/j.colsurfa.2004.10.064
12. Du L, Wang YJ, Lu YC, Luo GS. Process intensification of $BaSO_4$ nanoparticle preparation with agitation of microbubbles. Powder Technology, 2013:247:60-68. https://doi.org/10.1016/j.powtec.2013.06.030
13. TCVN 2095-1993: Method of determining the coating coverage. https://vanbanphapluat.co/tcvn-2095-1993-son-phuong-phap-xac-dinh-do-phu (05/12/2020).
14. TCVN-2096-1-2015: Method of determining dry time. https://vanbanphapluat.co/tcvn-2096-1-2015-son-vecni-phuong-phap-xac-dinh-do-thoi-gian-kho-phan-1 (05/12/2020).
15. TCVN 2097- 1993: Method of determining the adhesion of paint. https://vanbanphapluat.co/tcvn-2097-1993-son-phuong-phap-cat-xac-dinh-do-bam-dinh (05/12/2020).
16. TCVN 2101 - 1993: Method of determining the gloss of paint. https://vanbanphapluat.co/tcvn-2101-1993-son-phuong-phap-xac-dinh-do-bong-cua-mang (05/12/2020).
17. TCVN 2100-2- 2007: Method of determining the impact of paint. https://vanbanphapluat.co/tcvn-2100-2-2013-son-va-vecni-phep-thu-bien-dang-nhanh-phan-2 (05/12/2020).
18. Jean-Pierre K, Stefano Z, Peter W. Is nanotechnology revolutionizing the paint and lacquer industry? A critical opinion. Science of The Total Environment, 2013:442:282-289. https://doi.org/10.1016/j.scitotenv.2012.10.009
19. Rotimi S, Rotimi S, Oluranti A, Idowu DI, Peter O. Nanotechnology in Paints and Coatings. Advanced Coating Materials, 2018, 175-233. DOI: 10.1002/9781119407652.ch7
20. Ricardo S, David PO, Adriana H. Preparation of modified paints with nano-structured additives and its potential applications. Nanomaterials and Nanotechnology, 2020:10:1-17. DOI: 10.1177/1847980420909188
21. Nalathambi V, Suresh G. Contribution of Nanotechnology in the Paints and Coatings. SSRG International Journal of Chemical Engineering Research (SSRG – IJCER), 2014:1(1):10-12.