Effect of Sodium Silicate Addition on Flame Retardancy of the Oil Paint Produced by Modern Paint Company

Habaib A. Majeed
Institute of Technology, Foundation of Technical Education/ Baghdad
Email: habaybaltaee@yahoo.com

Received on: 28/5/2012 & Accepted on: 4/4/2013

ABSTRACT

In order to produce a coating with suitable properties, many additives are included in a coating formulation to achieve specific property modifications .

In this work , two kinds of flame retardant materials were used as additives to increase the combustion resistance , and to decrease the flame spread of oil paint , these are : soluble Sodium Silicate and Sodium Silicate powder with oil paint. Different weight percent ratios (2.5 , 5 , 7.5 , 8.5 , 10 , 12.5 ,15) % for the two additives were added to oil paint to obtain different samples. It was found that , good flame retardant , and distinct decreasing in flame spread (flame speed) , of oil paint was obtained , in all weight percent ratios for all the samples of the two additives . Self extinguishing was observed at the ratios (7.5 , 8.5 , 10 , 12.5) % for the two additives , and (no burning) for them , were observed at (15) % .

The mechanical properties tests (adhesion force , impact strength) were carried out to painted samples with oil paint mixed with second additive for all the above ratios, after about month from its preparation , the samples complied with Iraqi standard specifications No. 960 .

Key words: Flame Retardant Paint, Combustion Resistance.

تأثيرأضافة سيليكات الصوديوم على أعاقة لهوبية الطلاء الدهني المنتج من شركة الاصباغ الحديثة

الخلاصة

من أجل أنتاج طلاء بخواص ملائمة ، يجب أن يتضمن عدة مضافات في تشكيلته للوصول الى الخواص المطلوبة .

في هذا العمل تم أستخدام نوعين من المواد المثبطة للهب ، كمضافات لزيادة مقاومة أحتراق وتقليل أنتشار اللهب في الطلاء الدهني ، وهذه المضافات هي : سليكات الصوديوم المذابة و مسحوق سيليكات الصوديوم مع الطلاء الدهني .

أضيفت النسب المئوية الوزنية المختلفة (2.5 , 5 , 7.5 , 8.5 , 10 , 12.5 , 15) % من المضافين ، الى الطلاء الدهني لأعداد النماذج . توضح النتائج بأن هناك أعاقة جيدة للهب ونقصان ملحوظ بسرعة أنتشار اللهب في الطلاء الدهني ، لكل النسب المئوية الوزنية لجميع نماذج المضافين

https://doi.org/10.30684/etj.2013.82178
2412-0758/University of Technology-Iraq, Baghdad, Iraq

المستخدمة. تم ملاحظة الاطفاء الذاتي بالنسب الوزنية (7.5 , 8.5 , 10 , 12.5) % للمضافين ، ولقد تم الحصول على عدم الاشتعال للمضافين عند النسبة الوزنية (15) % .
تم طلاء عينات أختبار الخواص الميكانيكية (قوة الالتصاق ، ومقاومة الصدمة) بالطلاء الدهني مع المضاف الثاني ولجميع النسب المذكورة أعلاه ، بعد حوالي شهر من تحضيره، ولقد أتضح أن هذه القياسلت تتطابق مع المواصفات القياسية العراقية رقم (960) للطلاء الدهني .

INTRODUCTION

Surface coating is a mixture of film forming materials plus pigments , solvents , and other additives , which when applied to a surface and cured or dried , yields a thin film , that is functional and often decorative [1] . Surface coatings include paints, varnishes, enamels, and water emulsion solution [2, 3].

The constituents of paints are [4] : resins (film formers usually called a binder) , solvent , drying oils and fatty acids , pigments , driers , and plasticizers . Alkyd resins are used extensively in industrial coatings. They are widely compatible with oils and other resins , but their durability and resistance to water, sun light, and chemicals is inferior to that of other types. Alkyds are sometimes described as ideal binders for pigments, because they have the ability to wet and disperse them readily [4, 1].

The paint and coating industry has made progress in developing coating products to retard the spread of flames [5]. Flame retardant paints coating on the substrate can prevent fire several ways : intumescent paints form foam produced by nonflammable gases, such as carbon dioxide and ammonia when heated. This results in a thick, highly insulating layer of carbon that serves to protect the coated substrate from fire, modifying the degradation reaction such that water and carbon oxides are formed instead of combustible organic compounds, evolving gases such as nitrogen or chlorine to dilute the concentration of oxygen in the immediate gas phase producing halogen materials which can inhibit the flame propagation process [6,7] . The reduction of the flammability of painted structures is an important consideration in coating development . This is accomplished by the incorporation of pigments and vehicle intermediates with fire – retardant properties [8] .

Combustion includes quick exothermic chemical reaction, especially the quick oxidation of fuel; it's the very quick and complicated chemical and physical conversions, accompanied by the production of heat and light. Combustion occurs in present of fuel, oxidation substance (air oxygen) and fire source [9].

Soluble sodium silicates have many practical uses. They have been used for many years in various inorganic paint formulations and often serve as the basis of incombustible protective coatings for different types of surfaces, ranging from building boards to metal [10] .

Literatures show that there are some studies about adding flame retarding additives , Ahmad [11] studied the synergistic action between the halogens and antimony trioxides on polyethylene low and high density , poly styrene and poly propylene . Al - Bayatee [12] studied the aluminum oxide, chlorinated paraffin and the synergistic action of them , to retard the flammability of polypropylene and polyethelene low and high density . Majeed [13] prepared novolac – ceramic composites used as a flame retarding paint for coating easily burning surfaces like wood to protect its surface from flame for a period of time and to decrease the flame

spread . In this study the flame – retardant ingredients are soluble Sodium Silicate and Sodium Silicate powder, which are added to the oil paints of Modern paints company .

EXPERIMENTAL WORK

Materials

Oil paints

Oil paint was used, it was produced by Modern Paints Company . Its constituents are : alkyd resin , white spirit as a solvent , (Cobalt , Lead , Calcium) as a driers , pigments and anti skin . Its specification comply with Iraqi standard specification number 960 [14] .

Flame retardant additives

Iraqi soluble Sodium Silicate was used . It was supplied by Glass Factory / Al Ramadi with high purity , it was added to oil paint with different percent (2.5 , 5 , 7.5 , 8.5 , 10 , 12.5 ,15) to obtain different samples .

Sodium Silicate powder was supplied by BDH Chemicals Ltd Poole England with (99) % purity. It was added to oil paint with percent (2.5 , 5 , 7.5 , 8.5 , 10 , 12.5 ,15) to obtain different samples.

Samples Preparation

The total samples weights were 100 g , which contented of oil paint and the ratios of the two additives as above .

A bar of hard (carton) was cut in (125 mm) length by (12.5 mm) in width , and of thickness (3 mm) . The bars were painted and left to dry at room temperature .

Metal test panels (used for adhesion and impact tests) were painted with the oil paint and the ratios of the second additive , after about month and more from their preparation , in order to examine the paint homogeny and viscosity in Modern Paint Company before painting . The samples of oil paint with the second additive were succeed , so that the adhesion and impact tests were carried out , but with first additive did not succeed because of the variation in their properties .

MECHANICAL TESTING

Adhesion

Adhesion is the ability of a coating to resist removal from the surface to which it is applied [15]. It was determined according to ASTM D3359 – 87 [16]:

Clean and dry surface of painted sample was selected, parallel cuts were made in the film each about 20 mm long , scrub was used as cutting tool device . A steady motion with a sufficient pressure on the cutting tool was used to have the cutting reach the substrate , additional numbers of cuts were made at 90^{o} to center on the original cuts. The center of the tape (25 mm wide) was placed over the grid of the cuts with the tape running in the same direction. The tape was smoothed into place by finger and pulling it off rapidly .The cut area was inspected for removal of coating from the substrate or previous coating and the adhesion is rated in accordance with scale illustrated in Figure (1).

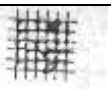
classification	Surface of cross-cut area from which flaking has occurred (example-for six paralleld cuts)
5B	None
4B	
3B	
2B	
1B	
0B	Greater than 65%

Figure (1) Classification of adhesion test result .

Impact Test

This test method consists of a mechanical test in which a tup of fixed weight was dropped through varying heights to produce point impact on the surface . English impact apparatus which is manufactured by Sheen Company conforms to the specifications of ASTM G 14 – 88 [17].

Rate of Burning

Rate of Burning measured according to ASTM D635 – 03 [18]:

A bar of carton cut in (125± 5mm) length by (12.5 ±0.2 mm) in width, and thickness of (3mm ± 0.2 mm). The bars were painted in various ratios of the two additives as in Figure (2). Each test bar marked by scribing two lines , 25 mm , and 100 mm far from one end of the specimen .

The test bar clamped at the end nearest to the 100 mm mark , in a support with its longitudinal axis horizontal and its transverse axis inclined at 45^{o} to the a horizontal. The burner placed so that the flame contacts the end of the test specimen, for 30 second or until the flame front reaches the 25 mm mark. The time recorded in seconds, when the flame front reaches the 25 mm mark, as burning time, (t_o), and when the flame front reaches the 100 mm mark from the free end, as burning time (t) in seconds.

If the burning has not reached the 100 mm mark, the unburned length is measured (X). The length of extent of burning is equal to 100 mm minus the unburned length mm. The procedure was repeated for three specimens of each percent ratio of the additives.

Figure (2) Rate of burning samples.

The calculated variables according to ASTM D-635 are:
1- Average time of burning (ATB), sees as:

$$ATB = \sum (t - t_o) / \text{number of specimens}$$

2- Average extent of burning (AEB), sees as:

$$AEB = \sum (100 - X) / \text{number of specimens.}$$

3- Rate of burning (R. B) = AEB / ATB.
4- Self –Extinguishing (S. E).
5- No – Burning (N. B.).

RESULTS AND DISCUSSION

The results show a significant decreasing in rate of burning (R.B.) of oil paint , when the two additives were used , the rate of burning was measured for oil paint samples without and with additives in weight percent ratios as shown in tables (1and2).

Table (1) Rate of burning (R.B), average extent of burning (AEB) and average time of burning (ATB) tests, for oil paints with different ratios of first additive .

Additives %	Non	2.5	5	7.5	8.5	١٠	12.5	15
AEB cm	10	10	10	4	2.5	٢	١	–
ATB min	2.34	2.55	2.8	1.79	1.78	1.64	1.07	–
R.B cm / min	4.27	3.92	3.57	2.23	1.40	1.22	0.93	–
S.E	–	–	–	Yes	Yes	Yes	Yes	Yes
N.B	–	–	–	–	–	–	–	Yes

Table (2) Rate of burning (R.B), average extent of burning (AEB) and average time of burning (ATB) tests, for oil Paints with different ratios of second additive.

Additives %	Non	2.5	5	7.5	8.5	١٠	12.5	15
AEB cm	10	10	10	3.5	2	1.3	1	–
ATB min	2.34	2.61	3.41	1.64	1.40	1.08	1.13	–
R.B cm / min	4.27	3.83	2.93	2.14	1.42	1.2	0.88	–
S.E	–	–	–	Yes	Yes	Yes	Yes	Yes
N.B	–	–	–	–	–	–	–	Yes

The measurements show that the best active ratio for flame retardant additives to oil paint was (7.5 %) for the first additive "soluble sodium silicate". This ratio caused self extinguishing of oil paint after (1.79) min after the removing of Bunsen burner , as shown in Table (1) . For the second additive " sodium silicate powder " , the best active ratio was (7.5) % after (1.64) min , as given in Table (2) , and the no- burning phenomena (N . B.) of oil paint was obtained in the ratio (15) % weight percent ratio for the two additives as listed in Tables (1 and 2). The time reflects the flame retardancy of the two additives, when their ratios were increased, that is noticed from the rate of burning (R.B) as shown in tables (1and2). The flame spread (R. B.) in oil paint decreased with increasing the weight percent ratios of the flame retardant additives, that is the (R . B.) of oil paint with out additive was (4.27) cm / min , but after adding the first additive , it became (0.93) cm / min at the weight ratio (12.5) % , as given in Table (1) . The addition of the second additive to oil paint decreased the flame spread from (4.27 to 0.88) cm / min at the ratio (12.5) % as illustrated in Table (2) , because an intumescent material has been developed , based on alkali silicates (Sodium silicate) , which can be used in fire protection , the swelling of the material on heating to over 100 °c or on contact with a flame is due to an endothermic process and is associated with emission of water vapor.The solid foam formed is rigid and consists of hydrated silica [10]. The adhesion test results show that the oil paint with the second additive ratioswere acceptable as shown in Table (3) , and the impact test results are within thenormal range as illustrated in Table (4) , that is the oil paint mechanical properties do not change after the addition of the second additive .

Table (3) Adhesion test results.

Composition	Classification as Figure (1)
Oil paint	3B – 5B (acceptable)
Oil paint with the second additive (for all the samples)	4B – 5B

Table (4) Impact test results .

Composition	Normal tup height (cm)
Oil paint	20 and more
Oil paint with the second additive (for all the samples)	50

CONCLUSIONS

A new specification is obtained for oil paint , it is converted from a conventional paint to flame retardant paint , so it can be used for coating the easily burned surfaces such as carton , wood , wood products …etc. , to retard the spread of flame and to increase the combustion resistance . It can also cover the building , and metal surfaces which should not become overheated .

The self extinguishing of oil paint with the first additive " soluble sodium silicate " and with the second additive " sodium silicate powder " is obtained in (7.5) % weight percent , while the no – burning phenomena was observed at weight percent ratio (15) % for the two additives .

The oil paint mechanical properties are within Iraqi standard specification No. 960 , as regards the second additive , but these mechanical properties of the first additive were not examined because the latter converted from paint to paste after few hours .

REFERENCES

[1]. Irene , A. and Michael, A. , " Hand book of Paint and Coating Raw Materials " , Grower Co. , United States of America , (2008) .

[2]. Bhatnagar, M. S., "A Textbook of Polymers, Chemistry and Technology of Polymers, processing and Applications" , Vol.2, S. Chand and Company Ltd., New Delhi , (2004).

[3]. Clauser, H. R ,Vaccani , J.A. , Brady, G.S., " Materials Hand book ",13th ed. , McGraw-Hill , New York, (1997).

[4]. Shreve , R.N. and Austin , G.T. ," Chemical Process Industries" , 5th ed. , Mc Graw – Hill Professional LTD. , New York , (1984) .

[5]. Richardson, L. R and Cornelissen , A. , "Fire- resistant Coatings for Roof / Ceiling Deck timbers", J. Fire and Materials, Vol.11, pp. 191-194 , (1987) .

[6]. Annual Book of ASTM Standards , "Paints, Related Coatings, and Aromatics", Vol. 0601**,** (2006) .

[7**]**. Oneill , L.A , "Flame Retardant Paints", J. Fire and Materials, Vol.8, No.1 , PP. 17- 19 , (1984) .

[8**]**. Board, N.," Modern Technology of Paints, Varnishes and Lacquers " 2nd ed. , Asia Pacific Business Press Inc. (2007) .

[9]. جاسم ، بدري صالح و عبد الرزاق ، اسماعيل وهاب ، " اطفاء الحرائق" ، دار الكتب للطباعة والنشر ، جامعة الموصل ، العراق ، (١٩٩٥) .

[10]. Bulewicz, E. M. and pelc, A. , "Intumescent Silicate-based Materials: Mechanism of Swelling in Contact with Fire", J. Fire and Materials, Vol.9, No.4 pp.171-175, (1985).

[11]. أحمد ، عباس فاضل ،" أستخدام بعض مركبات الانتيمون العضوية الهالوجينيه في تثبيط لهوبية ومقاومة احتراق بعض البوليميرات "، رسالة دكتوراه ، كلية العلوم ، الجامعة المستنصرية ، بغداد ، (١٩٩٩) .

[12]. Al-Bayatee , H.B. , "The Synergistic Action of Aluminum Oxide and Chlorinated Paraffin as Flame Retardants for Polypropylene and Polyethylene", M.Sc. Thesis, College of Science, University of Baghdad , Baghdad , Iraq , (2001)

[13]. Majeed , H. A. , "Studying and Preparation of Flame Retardant Novolac – Ceramic Composites ", M . Sc .Thesis, Technical College / Baghdad , Foundation of Technical Education , Baghdad , Iraq , (2007) .

[14]. الجهاز المركزي للتقييس والسيطرة النوعية ،" المواصفة القياسية رقم (٩٦٠) الطلاء والوارنيش طلاء ألكيدي لماع للسطوح الداخلية والخارجية "، بغداد ، العراق ، (٢٠٠٠) .

[15]. Nelson ,G.L. , " Adhesion in Paint and Coating Testing Manual " , 14th ed. , Philadelphia , PA , (1995).

[16]. Annual Book of ASTM Standards, "Standard Test Methods for Measuring Adhesion by Tape Test", D3359-87, Vol. 06.01, (2002) .

[17]. Annual Book of ASTM Standards, "Standard Test Method for Impact Resistance of Pipe Line Coatings (falling weight test) ", G14-88, Vol. 06.01, (2004).

[18]. Annual Book of ASTM Standards, "Standard Test Method for Rate of Burning and / or Extent and Time of Burning of Self – Supporting Plastics in a Horizontal Position ", D635-03, Vol. 08.01, (2003).