

## **The combined action of polyammoniumphosphate and chlorinated rubber as flame- retardants for unsaturated polyester resin**

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الفعل الاتحادي لبولي فوسفات الأمونيوم والمطاط الكلور كمنثبات لهب لراتنج البولي  
استر غير المشبع

الخلاصة :

في هذا البحث تم استخدام بولي فوسفات الأمونيوم (PAP) المضاف I والمطاط  
الكلور (CR.) المضاف II ، استخدمت كمنثبات لهب لراتنج البولي استر غير المشبع  
وبنسبة مئوية وزنية (٢ و٤ و٦ و٨%) من خلال تحضير شرائح ذات ابعاد  
(3×130×130) ملم كذلك تم تحضير شرائح بنفس القياسات لخليط مكون من  
[ CR . %50 + PAP %50 ] المضاف III وبنسب مئوية وزنية (٢ و٤ و٦ و٨%) وتم  
استخدام هذا الخليط لدراسة تأثير التآزر بين المادتين اعلاه في تثبيط اللهبية للراتنج.  
تم استخدام ثلاثة طرق قياسية لقياس تثبيط اللهبية وهي :

١- الطريقة القياسية ASTM : D-2863

٢- الطريقة القياسية ASTM : D-635

٣- الطريقة القياسية ASTM : D-3014

ان النتائج المستحصل عليها من هذه القياسات تشير الى ان (CR.) , (PAP)  
وخليطهما اعطت تأثير جيد على تثبيط اللهبية لراتنج البولي استر غير المشبع ، لكن  
تأثير التآزر لهاتين المادتين كان اكثر فعالية في تثبيط اللهبية مما لو كانت كل مادة  
لوحدها .

**Abstract :**

In this investigation, polyammoniumphosphate (PAP) (I) and chlorinated Rubber (CR.) (II) ,were used as flame retardant for Unsaturated polyester resin in the weight ratios of 2,4,6 & 8%, by preparing films of (130×130×3) mm in diameter, Also film of Unsaturated polyester resin with mixture of [50%(PAP)+50%(CR.)] (III) in percentage of 2,4,6 & 8% by weight prepared to test the combined action .

Three standard tests used to measure the flame retardation which are :

1-ASTM : D-2863

2-ASTM : D-635

3-ASTM : D-3014

The results obtained from these tests indicating that , the (CR.), (PAP) and their mixture, have a good effect as flame retardants for Unsaturated polyester resin, but their combined action of them was more effective than each of them alone .

Finally , the compatibility between the additives and polymer which have a clear effect on retardation .

**Introduction :**

The history of all polymer materials were traced by the success of their applications in replacing tradition materials like wood , leather and metals . The rapidly expansion of combustion in courage many researches to used many additives to retard flammability of the polymers <sup>[1]</sup> .

The chlorinated paraffin (CP) are group of chemicals manufactured by chlorination of liquid –paraffin or paraffin wax, containing from 30-70% chlorine , they are largely inert , almost in soluble in water and have extremely low vapor pressure , most

commercial chlorinated paraffin product are liquids and range from related low to extremely high viscosity . There are also solid types, (Chlorinated Rubber) which have longer carbon chains and usually contain 70-72% chlorine <sup>[2]</sup>.

The phosphorus is one of the elements , the flame retardant action of which is most difficult to understand . phosphorus compounds is association with different polymer substrates , may exert modes of action ranging from condensed – phase to gas–phase and from physical to chemical mechanism <sup>[3]</sup> .

The phosphorus compounds have been shown to promote chare formation , there by reducing the production of combustible gases during polymer decomposition , as well as , may reduce the exothermic heat of burning by limiting oxidation of carbon chare to the formation of carbon monoxide <sup>[4]</sup> .

flame – retardation is essentially an interruption of the burning process<sup>[5]</sup>. There are two distinct types of flame-retardant must be recognized:

- a. Reactive flame retardants are compounds usually containing heteroelements which can also be chemically incorporated in smaller proportions , usually during the polymerization process .
- b. Additives of flame – retardants are incorporated in to polymers by physically mixing with the polymer , normally after the polymerization complete <sup>[6,7]</sup> .

### **Experimental :**

#### **1- Materials :**

- a. polymer: unsaturated polyester resin , hardener type (MEKP), imported from United Arab Emirate (U.A.E)
- b. flame-retardants : Polyammoniumphosphate (PAP) in powder form, with purity of 98% , imported from MERCK CO. and a solid

chlorinated Rubber (CR.) containing 72% chlorine , imported from MERCK CO .

## **2- Equipments :**

a. ASTM : D-2863 : The measurement of limiting oxygen Index (LOI), is widely used for studies for measuring flammability of polymers, The (LOI) is the minimum concentration of oxygen and nitrogen, that supports a candle-like combustion of specimen<sup>[8,9]</sup>.

b. ASTM: D-635: The measurement of rate of burning (R.B), Extent of burning (E.B) and time of burning (T.B) for self-supporting plastic in horizontal position<sup>[10,11]</sup> .

c. ASTM D-3014 : The measurement of maximum flame height (H)<sup>[12]</sup>.

## **3- Preparation of samples :**

The samples were prepared in the dimensions of (130×130×3)mm, Three Unsaturated polyester resin sheets were prepared for each percentage weight 2,4,6 & 8% with the additives I,II and III .

## **Result and Discussion:**

### **1-ASTM : D-2863 :**

(Table – 1) and (Fig-1) indicated that. Limiting oxygen Index (LOI) for Unsaturated polyester resin with out additives is (20.4)<sup>[13]</sup>

The oxygen concentration required to support a candle-like of epoxy resin samples was increased with increasing of weight percentages of additives . The efficiency of I,II and III additives were in the following order: III > I > II

### **2-ASTM : D-635 :**

The result obtained from these tests showed that , the (R.B) of Unsaturated polyester resin with additives compounds has continues reduction with increasing the percentage weight of additives , as in (Table-2,3 & 4) respectively . (Fig-2) shows the flame speed curves of flame-retardation for Unsaturated polyester resin .

**3- ASTM : D-3014 :**

(Fig.-3) shows the maximum flame height (H) with increasing of percentage weight of additives , (Tables-5,6 & 7) .

**Conclusion :**

- 1- The flame-retardance efficiency of I,II and III additives appeared to follow the order :  $III > I > II$
- 2- The polyammoniumphosphate (PAP) and chlorinated Rubber (CR.) together have a good efficiency to retard the flammability and combustion of Unsaturated polyester resin which means that their combined action is better .
- 3- The (LOI) increased with increasing the percentage of additives.
- 4- The (R.B) decreased with increasing the percentage of additives.
- 5- The flame height (H) decreased with increasing the percentage of additives .
- 6- The good results of limiting oxygen Index, Rate of burning and flame height mean, the compatibility has a significant effect on the burning of polymers that means a good compatibility had taken place during the preparation of the sheets .

**Table-1 : LOI of unsaturated polyester resin with additives.**

Additives	(LOI)				
	Non	2%	4%	6%	8%
1- I	20.4	24.37	26.21	28.89	31.65
2- II	20.4	23.35	25.07	26.64	28.18
3- III	20.4	25.61	28.60	31.60	33.45

**Table-2 : Rate of burning of resin with PAP.**

Additives%	Non	2%	4%	6%	8%
AEB cm	10	4.6	-----	-----	-----
ATB min	6.92	9.34	-----	-----	-----

R.B cm/min	1.44	0.49	-----	-----	-----
S.E	-----	yes	yes	yes	yes
N.B	-----	-----	yes	yes	Yes

**Table-3 ; Rate of burning of resin with CR.**

Additives%	Non	2%	4%	6%	8%
AEB cm	10	9.6	4.2	-----	-----
ATB min	6.92	11.32	7.10	-----	-----
R.B cm/min	1.44	0.84	0.59	-----	-----
S.E	-----	yes	yes	yes	yes
N.B	-----	-----	-----	yes	yes

**Table-4 : Rate of burning of resin with mixture.**

Additives%	Non	2%	4%	6%	8%
AEB cm	10	3.1	-----	-----	-----
ATB min	6.92	8.37	-----	-----	-----
R.B cm/min	1.44	0.37	-----	-----	-----
S.E	-----	yes	yes	yes	yes
N.B	-----	-----	yes	yes	yes

**Table-5 : Flame height (H) of resin with PAP.**

Additives%	W1	W2	PWR	H
Non	5.63	2.57	54.35	14.0
2	6.44	2.35	63.50	3.0
4	6.52	-----	-----	-----
6	6.61	-----	-----	-----
8	6.69	-----	-----	-----

**Table-6 : Flame height (H) of resin with CR.**

Additives%	W1	W2	PWR	H
Non	5.63	2.57	54.35	14.0
2	6.17	2.26	63.37	7.0
4	6.25	2.37	62.08	3.5
6	6.33	-----	-----	-----
8	6.41	-----	-----	-----

**Table-7 : Flame height (H) of resin with mixture.**

Additives%	W1	W2	PWR	H
Non	5.63	2.57	54.35	14.0
2	6.37	2.25	64.67	2.0
4	6.45	-----	-----	-----
6	6.53	-----	-----	-----
8	6.62	-----	-----	-----

Fig. (1)  
LOI of the  
resin with  
additive.

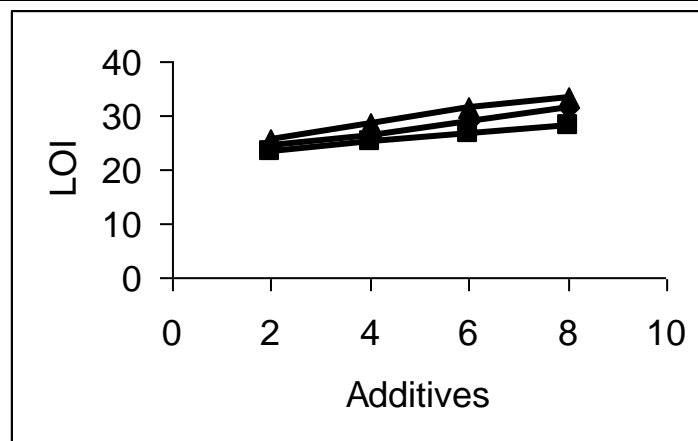


Fig. (2)  
Rate of  
burning (R.B)  
for the resin  
with additive.

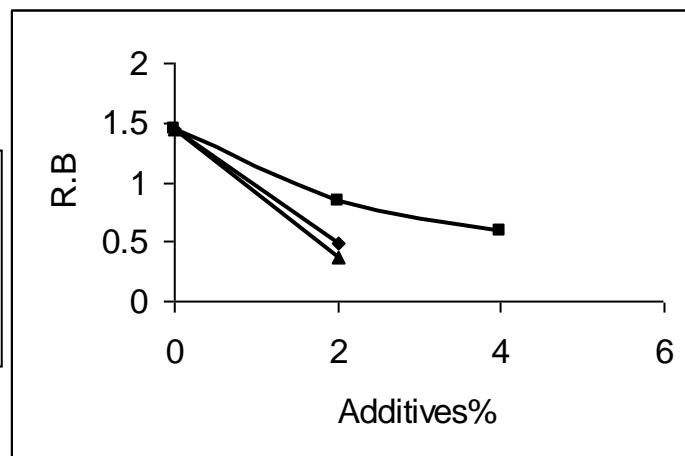
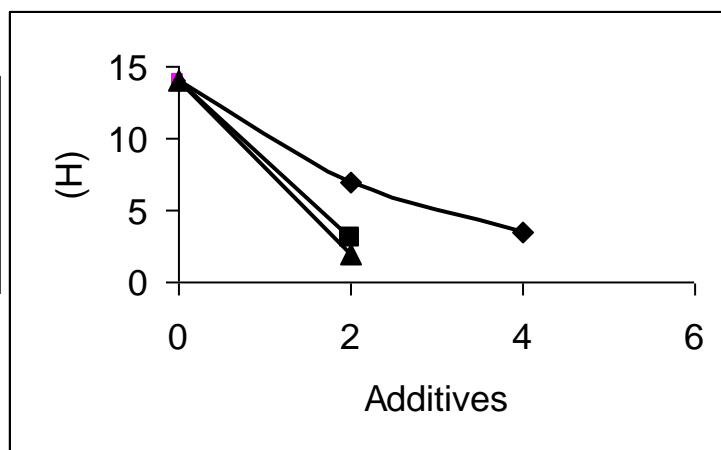


Fig. (3)  
Flame height  
(H) for the  
resin with  
additive.



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