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FLAME RETARDANT EFFECTS OF POTASSIUM ALUMINIUM SULPHATE (ALUM) ON KRAFT SHEET

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ABSTRACT

Fire is a world wide problem which claims lives and causes significant loss of properties. The effectiveness of potassium aluminium sulphate (alum) as flame retardant on kraft sheet was studied by incorporating varying concentrations of it: 0.1M, 0.2M, 0.3M, 0.4M, 0.5M and 0.6M on the kraft sheet. Fire characteristics of the treated kraft sheet were investigated and results compared with the control. Results show that flame propagation rate, flame duration and after glow time decreased with increase in alum concentration while char formation and ignition time increased with increase in alum concentration. The work showed that potassium aluminium sulphate is a very effective flame retardant on polymeric material.

Key Words: *Flame Retardant, Kraft Sheet, Alum, Polymer*

INTRODUCTION

Loss of life and possessions caused by the fire hazards due to the use of polymeric materials has aroused much concern among government regulatory bodies, consumers and manufacturers Zyon (1994), Irvine, Mc Cluskey and Robinson (2000) and Beyler (2001). Therefore, to meet multifarious applications, flame-retardants are used to reduce combustibility and suppress the smoke or toxic fume production from the polymers.

Flame retardants denote that material which when added to or chemically incorporated in the formulation of flammable materials (mainly polymers), substantially suppresses/quenches the ease of ignition or flame propagation of the material Kroshwitz, (1987). Flame-retardant can be classified as: durable-finishes, semi-durable finishes and non-durable finishes.

For a material to burn, the surface receives heat from an external source as well as from the burning mass. Heat losses occur in two ways, viz, that needed for the gasification of the polymer and by other usual methods of convection, conduction, radiation, dripping, etc. The function of a flame retardant is to interrupt pyrolysis or combustion.

Flame retardancy can be achieved through the following agents Eboatu (1992) additives which evolve non-flammable gases, such as carbon dioxide, water, hydrogen chloride, sulphur dioxide, ammonia, etc and sometimes also raise the flash points of the gaseous pyrolysis. Again, there are materials capable of forming glassy coatings on the pyrolysis/burning mass. Finally, there are materials forming low flammable char. The aim of this study is to produce cheap and harmless flame-retardant that can rise the ignition time of kraft sheet.

MATERIALS AND METHODS

The raw materials used in this work, potassium aluminium sulphate (alum) were obtained from Oghe market Emene, Enugu and distilled water got from the Caritas University laboratory.

Preparation of raw materials

The molar mass of crushed alum which is $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ was first calculated as $948(g)mol^{-1}$ and was times by different concentrations of moles which are 0.1M, 0.2M, 0.3M, 0.4M, 0.5M and 0.6M. An empty beaker was weighed on an electronic weighing balance for each concentration of mole and the value was added to the sum got from multiplying the molar mass of alum by different

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concentrations in order to get accurate result. The alum was weighed for the six (6) different concentrations by pouring the alum in the empty beaker on an electronic weighing balance and weighing at the limit value of each concentration. The measuring cylinder was used to measure distilled water at 1000cm³ and the water was poured inside the volumetric flask. The alum was then poured inside the volumetric flask containing the distilled water and was left to dissolve. Six (6) different volumetric flasks but of equal size were used.

The kraft sheet was measured with meter rule and then cut with scissors into six (6) equal sizes. Each kraft sheet was treated in each concentration of alum for complete one hour after which it was brought out from the solution to dry.

Charaterisation of treated samples

The following parameters were analyzed: flame propagation rate, after-grow time, ignition time, char formation and flame durability Eboatu et al., (1993).

Determination of flame propagation rate

The method described by Eboatu et al [Eboatu (1992)] in number of articles was adopted. Each splinted kraft sheet was clamped vertically by the use of a retort stand in a drought free room. The kraft sheet was ignited at the base with the lighter. The distance traveled by the flame and the time taken for the flame to traverse that distance was measured. The flame propagation rate which is the ratio of distance traveled by the flame to the time taken for the travel was obtained.

$$\text{Flame propagation rate} = \frac{\text{Distance traveled by the flame (cm)}}{\text{Time (Sec)}}$$

$$\text{Average distance traveled (cm)} = \frac{\text{length sample}}{2}$$

$$\text{FPR (cm/sec)} = \frac{\text{Average length (cm)}}{\text{Average time (Sec)}}$$

Flame propagation Rate as in (cm/sec⁻¹)

Determination of after – glow time

After-glow time was obtained by the time between flame extinction and the last visually perceptible glow. It was taken as the time between flame out and the last glow.

Determination of ignition time

This was obtained by bringing light source in contact with the base of the splinted kraft sheet ignition time is taken, when the ignition source came in contact with the kraft sheet and it was got for each kraft sheet.

Determination of char formation

The sample was burnt and at the end of combustion, the burnt part of the sample was scraped off and weighed the left in the crucible was used regarded as char.

$$\text{Char formation} = \frac{\text{Weight of sample after burning}}{\text{Weight of sample before burning}} \times \frac{100}{1}$$

Determination of flame durability

Sample was clamped vertically in a room with no air current and ignited at the base. The flaming time i.e. the duration between the onset of the combustion or ignition and self-extinguishments was recorded.

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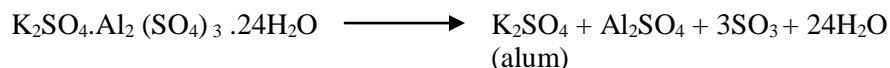
RESULTS AND DISCUSSION

The results of the experiment are shown in Tables 1-5.

Table1: Effect of alum concentration on flame propagation rate.

Concentration	Sample Length (cm)	Average Distance Traveled (cm)	Average Time (sec)	FPR cm/sec
0.00	24	12	40	0.3
0.1M	24	10	40	0.25
0.2M	24	8.4	40	0.21
0.3M	24	6.2	40	0.15
0.4M	24	5.5	40	0.14
0.5M	24	4.0	40	0.1
0.6M	24	3.5	40	0.09

Table 1 shows that as the concentration of alum increases, flame spread rate decreases. The flame propagation rate is suppressed at a minimum range by the presence of the flame suppressant.



On decomposition, K_2SO_4 and Al_2SO_4 being solid form coating on the surface of burning material. SO_3 which is non combustible gas reduce the rate of burning, H_2O helps to cool the surrounding environment. Thus, the reduction in flame propagation rate must be due to two principal factors; evolution of water and non combustible gases which cool the flame as well as dilute the concentration of flammable pyrolysis product. Alum is a very active flame retardant in retarding some polymeric materials such as Kraft sheet, wood, cloth, thermosetting, thermoplastic and elastomeric applications. It was observed that 0.5M and 0.6M of alum concentration are more effective as flame retardant in splinted kraft sheet than lower concentrations used in the experiment. It was observed that kraft sheet without flame retardant burns easily than the Kraft sheet incorporated with flame retardants knowing fully well that fire is a terrible menace to the industry and society at large there is an urgent need to make flammable materials flame retardant. Flame retardant used in the kraft sheet was not sprayed or coated kraft sheet but was incorporated into the kraft sheet and as such the kraft sheet are very much protected from flame as it does not wash away after some time.

Table 2: Effect of alum concentration on after- glow time

Concentration	Sample Length (Cm)	After-Glow Time (Sec)
0.00	24	45
0.1 M	24	37
0.2 M	24	34
0.3 M	24	31
0.4M	24	25
0.5M	24	23
0.6M	24	18

From the results shown in Table 2, it is observed that as the concentration of alum increases, the after-glow time decreases. This is similar to the work reported earlier[Eboatu (1992)], where by addition of appropriate potassium aluminium sulphate on some cellulosic textile materials resulted in decrease in

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after-glow time. After-glow depends on such factors as availability of oxygen as well as on the nature of the burnt material.

Table 3: Effect of alum concentration on ignition time

Concentration	Sample Length (Cm)	Ignition Time (Sec)
0.00	24	2
0.1M	24	5
0.2M	24	6
0.3M	24	8
0.4M	24	9
0.5M	24	10
0.6M	24	11

The results in Table 3 show that as the concentration of alum increases, the ignition time of the kraft sheet increases. This shows that alum concentration is active to reduce the ignition time or rate.

Table 4: Effect of alum concentration on char formation

Concentration	Sample Length (Cm)	Weight Of Sample (G)	Char After Burning	Char Formation (%)
0.00	24	0.06	0.42	20
0.1M	24	0.63	0.40	53
0.2M	24	0.60	0.7	54
0.3M	24	0.58	0.35	58
0.4M	24	0.53	0.31	60
0.5M	24	0.48	0.26	61
0.6M	24	0.43	0.23	63

In Table 4 it can be seen that there is some perceptible decrease in char formation as the concentration increases. Under static air, thermal decomposition of kraft sheet proceeded through different stages. Decomposition of primary cellulose when the splinted Kraft sheet was burnt resulted in the formation of combustible volatile. Dehydration leads to formation of carbonaceous char that could lead to glowing combustion.

Table 5: Effect of alum concentration on flame duration rate

Concentration	Sample Length (cm)	Flame Duration Rate (sec)
0.00	24	50
0.1M	24	37
0.2M	24	34
0.3M	24	39
0.4M	24	35
0.5M	24	34
0.6M	24	39

The results in Table 5 show that as concentration of alum increases, the flame duration decreases.

Conclusions

In conclusion, the incorporation of alum concentration into splinted kraft sheet decreased the flame duration, after-glow time and flame propagation while char formation and ignition time increase.

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