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Studies on the Effectiveness of Flame Retardant Paint Treatment of Timbers

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Abstract: Timbers used for building are often susceptible to burning in the case of fire outbreak. Hence, the need to treat them with flame retardant paints. The effectiveness of this technique was studied by coating two common place timbers, *Gmelina arborea* and *Cholophora excels* with emulsion and gloss paints mixed with different concentrations of antimony trichloride. The effectiveness of $SbCl_3$ as a flame retardant was ascertained by assaying the ignition time (IT), flame propagation rate (FPR) and after-glow time (AGT) of the coated dried wood splints. The results indicated reduction in FPR and AGT while IT increased, with increases in concentration. It was also seen that flame retardant emulsion paint performed better than its gloss counterpart. Reasons are adduced from these observations. It is our view that reducing fire risks is a contribution to sustainable development, generally.

Key words: Antimony Trichloride · AGT · FPR · IT · Flame Retardant and Timber

INTRODUCTION

Wood is highly combustible and easily disintegrates in the presence of heat. It is an essential component in building and other manufacturing products. Since it is prone to fire, there is always the need to develop skills that will reduce its burning tendency. This can be achieved by coating with a flame retardant paint. Flame retardancy is a technique of treating materials so that their combustibility will reduced or totally stopped. Therefore, a fire retardant chemical when incorporated into a material substantially suppresses the ease of ignition and/ or flame propagation [1-3].

The modern day flame retardants are efficient for use in reducing fire hazards. They operate by a number of mechanisms, e.g. by inhibiting the free radicals (OH°, H°) that propagate flame reactions. The retardant chemical upon decomposition forms a new catalytically active surface which is effective at destroying the free radicals required for flame propagation. They provide cooling effect and blanketing property. They also have the property of minimizing the formation of volatile, flammable products and increasing the amount of water and solid char formed as well as induce less exothermic combustion incapable of maintaining itself. For example, formation of carbon monoxide instead of carbon dioxide [4, 5].

a. $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = - 4.76KJ/mol$
b. $C(s) + ½\ O_2(g) \rightarrow CO(g)$ $\Delta H = - 1.31KJ/mol$

MATERIALS AND METHODS

Materials: The timbers *Gmelina arborea* or simply Gmelina and iroko *(Chlorophora excels)* were obtained from the Timber Market at Awka, Anambra State. The white emulsion and white gloss paints were procured from Jacbon Paint Industry Ltd, Obosi, while antimony trichloride ($SbCl_3$) was procured from BDH limited, England.

Procedure:

- The Gmelina and Iroko wood samples were cut into splints of uniform sizes of length 60cm, width 0.25cm and thickness 0.5cm. Six splints of each wood were prepared for each concentration of $SbCl_3$ for both emulsion and gloss paints. They were labeled accordingly and oven dried at 105°C for 6 hrs.

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- The flame retardant paints were made by mixing 150cm^3 of paint with various concentrations (0.01, 0.05, 0.10, 0.20, 0.50, 1.00, 3.00 and 5.00g) of $SbCl_3$. Each mixture was stirred thoroughly to uniformity.
- Six splints were coated evenly with a particular retardant paint concentration by means of a brush. They were allowed to dry at room temperature for 14 days.
- Determination of ignition time (IT)

Each splint was clamped vertically using a retort stand in a draught free room. It was ignited at the base using a cigarette lighter. The ignition time was taken as the time between which the ignition source came in contact with the base of the sample and the time a tiny spark was observed on the splint. It was carried out twice for each sample.

Determination of Flame Propagation Rate (FPR): The method adopted was according to [6]. As earlier mentioned, the vertically clamped coated sample was ignited at the base with the lighter. The distance travelled by the char front and time taken were recorded. The same method was repeated for other splints and each concentration was performed twice.

FPR (cm/sec) = Distance travelled by the char front / time taken

Determination of After- Glow Time (AGT): This represents the time between flame extinction (Flame out) and the last visibly perceptible glow (Last glow). Again for each concentration two readings were taken and average calculated.

RESULTS AND DISCUSSION

At the surface of a burning polymer, heat is gained from the external source causing combustion. Consequently, heat is lost from the gasification of the polymer and other processes like radiation etc. Flame retardants do not seek to promote combustion and therefore, act by interrupting pyrolysis or combustion at any stage, resulting in total heat loss being greater than total heat gained and thus, flame extinguishment.

It is evident in Fig. 1 that ignition time increases as the concentrations of $SbCl_3$ incorporated into emulsion and gloss paint increase. The control i.e. has the lowest value indicating the efficiency of $SbCl_3$ in suppressing fire. It does this by inhibiting the attainment of the optimum pyrolsate-oxygen concentration necessary for ignition [8] by the free radical trap mechanism.

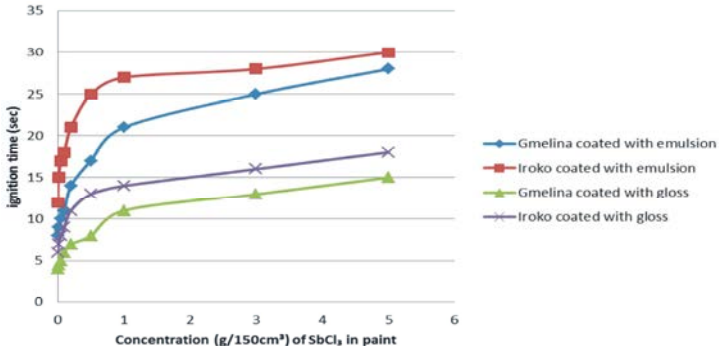

Fig. 1: Effect of antimony trichloride flame retardant on the ignition time of coated wood splints.

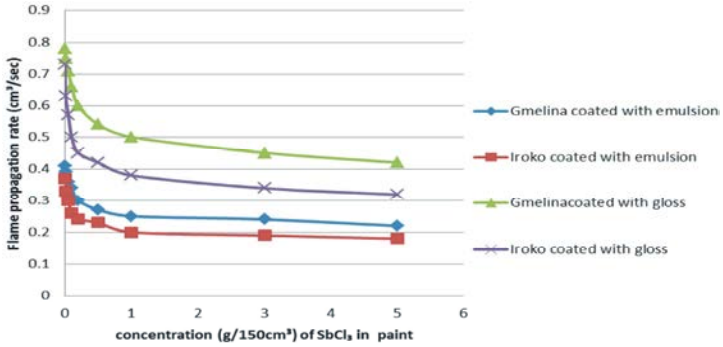

Fig. 2: Effect of antimony trichloride on flame propagation rate of coated wood splints.

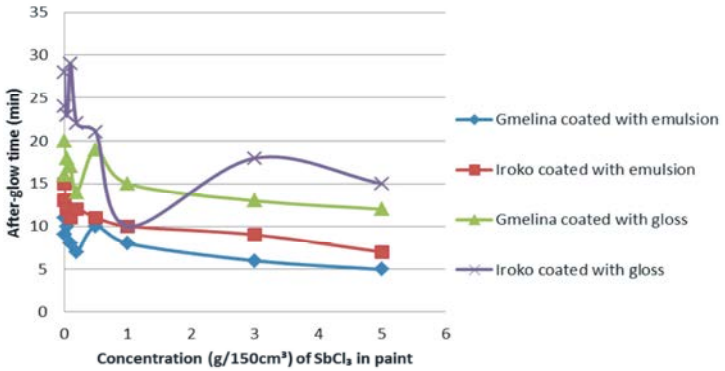

Fig. 3: Effect of antimony trichloride flame retardant on the after-glow time of coated wood splints.

Further, wood coated with gloss paint ignites faster than that with emulsion paint, perhaps due to higher levels of moisture in the latter.

The result in Fig. 2 shows that as the concentration of $SbCl_3$ increases the flame propagation rate decreases. Also, the splints coated with treated emulsion paint gave lesser flammability value for FPR than those of gloss. On comparison of FPR of both timbers coated with the same treated paint Gmelina recorded higher propagation time than Iroko. Perhaps a plausible reason could be that Iroko contains greater amount of lignin than Gmelina. Moreover Gmelina is more porous and hence, admits air more readily. The control exhibits the largest FPR when compared to the treated splints. The overall view indicates that $SbCl_3$ retards FPR.

Evidently Fig. 3, the untreated splint glows longer than the treated ones. Glow is a heterogeneous surface oxidative reaction and depends on the char formation. The after-glow time reduced with increase in$SbCl_3$ concentration showing that this FR reduces char formation.

CONCLUSION

The incorporation of antimony trichloride into emulsion and gloss paints adds the character of flame retardancy to the paints i.e., FPR and AGT were noticeably reduced while ignitability was drastically inhibited. The burning of timbers in our homes can be minimized by coating the material with retardant paints. The results also depict gloss paint to be more flame propagating than emulsion paint.

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