THERMAL EVOLUTION ANALYSIS OF SOME ORGANIC MATERIALS

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There has long been considerable interest in the search for effective chemicals which make organic building materials resistant to fire, to investigate the basic mechanism of ignition of these materials, and to develop the relevant technique or equipment for fire prevention and protection.

A flame-retardant additive operates by interfering with at least one of the stages of the burning process. Hiladol has presented a concise picture of the burning process involving a series of time resolved stages from the initial transfer of heat to the surface of a flammable material to the final step of a self-sustained fire. These stages include: a) the heating of the flammable substrate, b) its subsequent degradation and decomposition, c) the ignition of the flammable gases involved, and d) their continued combustion with sufficient net heat from the combustion sustaining the flame propagation. Normally, an efficient flame-retardant additive will affect more than one of these steps, either in a physical or chemical way. The end result of the presence of the flame-retardant additive is the retardation and final elimination of the burning process mechanism.

In this paper the results of studies of fire retardants in wood and self-extinguishing agents in polystyrene, polyethylene, and latices are reported.
Experimental Procedures

The instrument used in evaluating the flame-retardant additives was the model 916 TEA plug-in module for the DuPont 900 Thermal Analysis System. The system measures the evolution of organic carbon caused by temperature induced increases in volatility and thermal decomposition of the sample. The heart of the instrument consists of a temperature-programmable quartz furnace, directly coupled to a high temperature flame ionization detector whose response is specific to organic carbon and directly proportional to the gram atoms of carbon evolved from the sample. Samples placed in the furnace are rapidly swept into the detector by nitrogen purge gas as they are volatilized or thermally decomposed during the sample analysis, giving a measure of the rate of organic carbon evolution as a function of temperature as well as total organic carbon content of the sample. The total fuel value of any organic system can thus be correlated to the response of the instrument.

All of the organic systems used in this study were either commercially prepared products currently on the market (being sold as fire-retardant or self-extinguishing preparations) or in the case of wood, proposed fire-retardant chemicals still in the development stage. The compositions of the various fire-retardant chemicals were not known, and, in many cases, this data was not available from the manufacturer.

The thermograms were all obtained at a heating rate of 20°C per minute, and the areas under the curves were measured by planimetry. The peak area is then related to the fuel value of the sample by the equation

\[ F.V. = \frac{A}{Wc} \]

where \( c \) is the area per milligram of untreated sample, \( A \) is the area under the curve for the sample, and \( W \) is the weight of the sample in milligrams. Duplicate runs were made for each system and reported values were within 3% relative in all cases.

Fire-Retardant Wood Systems

Typical thermograms for treated and untreated woods are shown in Figure 1. The results of a series of experiments using commercially available preparations and fire-retardant systems still in the development stages are listed in Table I. The standard used in the evaluation of these systems was ponderosa pine treated with mono-ammonium phosphate. This has long been used by industry as a standard to evaluate the effectiveness of fire retardants.