CHAPTER I

INTRODUCTION

The Flammability Problem

Fire is one of the main problems affecting modern life, its destructive potential manifesting itself principally in terms of human suffering and in loss of property. As a result, considerable attention is being paid throughout the world to reduce the risks associated with fire. There can be little doubt that the introduction of plastics has been a major factor in the increased incidence and severity of modern fires. As the use of these synthetic polymers has grown, taking the place of traditional construction materials, fire brigades have reported significant changes in the nature of fires, particularly with regard to the evolution of greatly increased quantities of smoke and toxic gases. Recent statistics clearly indicate that smoke inhalation, and not fire itself, is the killer that accounts for over 80% of fire fatalities. Although the actual cause of death is likely to be asphyxiation by toxicants such as carbon monoxide and hydrogen cyanide, particulate smoke impedes escape by obscuring vision, due to its opacity and its irritating effects on the eyes and respiratory system. Hence, current research in fire safety places great emphasis on the design of products that have low flame spread properties and are low smoke producing.

Because plastics are synthetic organic materials with high carbon, and often high hydrogen contents, they are combustible. For various applications in the building, electrical, transportation, mining, and other industries, plastics have to fulfill flame retardancy requirements laid down in mandatory regulations and voluntary specifications.

Compliance with the flame retardancy requirements for plastics is substantiated and controlled with the aid of a plethora of different flammability tests. A multitude of fire retardant formulations have evolved because plastics have to be treated with fire retardants to meet flammability requirements.

Flame-Retardant PVC

Although polyvinyl chloride is inherently fire-retardant, plastic compositions based on this polymer represent one of the largest markets for fire-retardant additives. In unplasticized form, PVC is fire-retardant due to its high chlorine content (approximately 57%). When PVC is compounded with diester plasticizers and other modifiers, the resultant compositions will usually be combustible. Flame-retardancy is readily restored by adding various solid or liquid additives, chiefly those containing chlorine, phosphorus, or antimony. The market for fire-retardant PVC compounds is growing as these plastics compete for increasing applications in such industries as residential building, industrial building, public building, automobiles, aircraft, upholstery, and clothing. Other significant markets include electrical insulation and military equipment. The requirements for fire-retardance are becoming more rigorous as these markets are penetrated, as test methods become more realistic and sophisticated , and as awareness of the inherent danger in using flammable materials increases. This awareness has been accentuated by the total destruction, by fire, of buildings that were supposedly fireproof, due to combustible contents, furnishings, and decorations.

Novel Flame Retardants

The most common fire-retardant additives for PVC are antimony oxide, organicphosphates and chlorinated hydrocarbons, the latter two groups possibly also functioning as plasticizers, depending on specific structure. In addition, there is minor use of a variety of other materials.

Antimony oxide (antimony trioxide) has very little fire-retardant activity when used by itself but performs synergistically with halogens. One theory holds that antimony oxychloride is formed during burning, and that this is the active fire-retardant. With PVC, the chlorine in the polymer itself supplies this function.

When the total chlorine content of a PVC compound falls below about 30%, because of dilution with plasticizers or other additives, it can be restored to an effective level by the use of chlorinated hydrocarbons as a portion of the plasticizer blend. Representative types include chlorinated paraffins, ranging from 40% to 70% chlorine.

Transparent fire-retardant PVC compounds can be made by partial replacement of primary plasticizer with an organic phosphate. Those most commonly used are tricresyl phosphate, cresyl phosphate, 2-ethylhexyl diphenyl phosphate, decyl diphenyl phosphate, and tris(beta-chloroethyl) phosphate. Others that are useful are triphenyl phosphate, tributyl phosphate, tris(2-ethylhexyl) phosphate, tris(dichloropropyl) phosphate, and tris(2,3-dibromopropyl) phosphate. When transparency is not required, antimony oxide can be added to phosphate-plasticized PVC compounds for maximum fire-retardance. Useful levels of most phosphates range from 5 to 15 phr , depending on the degree of flameproofing required , and on the side effects of the phosphate. (The latter will be discussed separately) Tris (dibromopropyl) phosphate is effective at about 1 phr.

All fire-retardant additives have undesirable side effects on PVC, making their use a compromise between the degree of fire protection needed and one or more other properties. Antimony oxide produces varying degrees of opacity and color, depending on particle size and concentration; it cannot be used for clear products.

The chlorinated hydrocarbons, which are low in cost and are generally considered as secondary plasticizers with limited compatibility, may adversely affect heat stability. Improved grades recently introduced, however, are lighter in color and have less effect on stability than the older types.

The phosphate plasticizers in general have marked adverse effects on heat stability and possibly also on light stability, although the latter point is controversial. Most of them also adversely affect low-temperature flexibility.