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Additives of Many Types

11.1. INTRODUCTION

Resorcinol-based functional additives provide enhanced performance not only for all kinds of organic materials, but they are used in aqueous systems as well (i.e., corrosion inhibitors, electrolytes). This chapter highlights the wide variety of applications. Indeed, it is inevitable that there is an overlap of categories. Where that has occurred, where materials that fit here have been mentioned in other categories, appropriate reference will be made; and the index can be used to locate them all.

11.2. COMMERCIAL PRODUCTS

11.2.1. Ultraviolet Light Absorbers

All polymers undergo a deterioration under the influence of ultraviolet (UV) light and air, modulated by temperature and other environmental conditions. This degradation can be a discoloration or the actual loss of physical properties, e.g., the material may become brittle. In most cases, stabilizers can be added not only to extend the useful life of the polymer, but also, nowadays, to reduce the amount of material to be disposed of in dumps or to reduce the amount of plastics for recycle. Recycling can be costly and the recycled material is usually not quite as good as the virgin material.

The need for stabilizers arose first as light-sensitive plastics, from polystyrene to polyethylene, polypropylene, and many others, achieved acceptance for many uses. Even seemingly inert materials contained impurities such as catalyst residues, processing aids, and pigments which could initiate the formation of radicals, hydroperoxides, ketones, and other causes of eventual deterioration. Indeed, as higher plastics processing temperatures began to be used in this industry, the potential for degradation was accelerated.

The 4-benzoylresorcinols (2,4-dihydroxybenzophenones) were among the first commercial UV stabilizers for plastics, emerging in the 1950s. Their success was based on their high absorption coefficient in the 290–360 nm wavelength range, which is the high-energy part of the sunlight reaching the earth. The UV absorption of the benzoylresorcinols is low at and above 400 nm, so that, at least at the low concentrations at
which they are used (usually in the 0.25–1.0% range), they add little color to the polymer. These additives are thermally stable in the use range, they are of little health risk, and they are (designed to be) compatible with the particular polymer. These facets, together with cost/performance considerations, account for continued use as well as the development of a wide variety of compounds based on or related to the 2,4-dihydroxybenzophenones.

The effectiveness of the 2-hydroxybenzophenones has been ascribed mostly to preferential UV-light absorption and a keto–enol equilibrium, the ground state being in the hydrogen-bonded phenol form, with formation of a cyclohexadienone form in the (singlet) excited state which rapidly reverts to the phenol form with dissipation of energy in the form of heat, as sketched in Eq. (11.1) for 4-benzoylresorcinol. The rotation of the hydroxyphenyl group and/or the possibility of energy transfer from the excited state (of oxidized) polymer to the UV stabilizer have also been proposed to account for the effectiveness of these additives.

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The 4-benzoylresorcinols have been found also to have modest antioxidant activity. All these features have been well discussed in short\(^1\) as well as lengthy\(^2\) reviews. Much academic work has been devoted to this topic. The commercial products of the hydroxybenzophenone type are shown below.

Resorcinol monobenzoate, 11-1, is a latent stabilizer, active because it undergoes a photo-Fries rearrangement to 4-benzoylresorcinol, 11-2, on UV-light exposure. The resorcinol monobenzoate is recommended for the stabilization of cellulosics such as nitrocellulose and cellulose acetate, for polystyrene, flexible PVC, and poly(vinylidene chloride).

2,4-Dihydroxybenzophenone (4-benzoylresorcinol), 11-2, is sold for use in cellulosics, epoxies, polystyrene, and unsaturated polyesters. It minimizes crazing in poly(methyl methacrylate) aircraft windows, it is used in pressure-sensitive adhesives to prevent loss of tack, and it is used to protect alkyd and phenolic varnishes and color photographs.

The sodium sulfonate of benzoylresorcinol, 11-3, is used to inhibit the yellowing of wool.