INTRODUCTION TO POLYMER ADDITIVES AND STABILIZATION

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Introduction

Polymer additives are used in all aspects of our lives, including pharmaceutical packaging and medical device preparation. They are compounds that perform specific functions in polymers or during their processing or service life. These compounds are added to a polymer matrix to provide specific functionality that cannot be achieved using the polymer alone. Additives are used in small quantities, typically less than 1%, to impart properties to a polymer or to improve its performance. They can be divided into two broad categories: stabilizers and functional additives. Stabilizers are used to protect the polymer from degradation caused by heat, light, oxygen, or other conditions, while functional additives are used to impart specific properties to the polymer.

Polymer Auto-oxidation Cycle

Auto-oxidation: Most labile hydrogens

Polymer: -CH=CH-CH2-
Polyacetal: -O-CH2-O-
Polypropylene: -CH2-CH-CH2-

Some additives are designed to react and transform during use.

- An organophosphite, for example, will be oxidized, leading to the formation of the phosphate.
- A phenolic antioxidant may then be used for long-term antioxidant protection.
- A polymeric material may undergo degradation reactions, leading to the formation of color bodies.

Stabilizers

Stabilizers are used to protect the polymer from degradation caused by heat, light, oxygen, or other conditions. They can be divided into two broad categories: primary and secondary antioxidants. Primary antioxidants are used to prevent the polymer from being oxidized, while secondary antioxidants are used to retard the rate of oxidation once it has started. Some common stabilizers include phenolic antioxidants, organophosphites, and UV absorbers.

Phenolic AO Oxidation Chemistry

BHT and Irganox 1010 undergo similar chemical transformations leading to chromophore changes.

BHT Oxidation Chemistry

Phenolic Antioxidants

Phenolic Antioxidants

Stabilizers (cont’d)

- Most polypropylenes contain one or more antioxidants at levels of 0.2% - 0.4%
- Primary antioxidants are generally radical scavengers or H donors.
- Secondary antioxidants are typically hydroperoxide decomposers.

Relative Discoloration

Polymers stabilized with phenolic AO’s can be susceptible to discoloration if the system - antioxidant to protect the polymer during the high temperature and shear conditions of processing.

Degradation of Polyolefins

Technical preparation of “pure” polymer is simply not possible. Trace amounts of impurities are always mixed with the neat material. Some stabilizers, which can terminate alkyl radicals, are especially effective. Good stabilization will reduce formation of aldehydes, ketones, and color bodies.

Oxidative Decarboxylation

Oxidative Coupling

Oxidative

Decarboxylation

Diphenoquinone

Oxidative Coupling

O O-4 H ·

Degradation products

Colorants

- dyes or pigments used to impart a particular color

Chemistry of Phosphate Stabilizers

- hydroperoxide decomposers

Stabilizers

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Slip Agents

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