CHAPTER I

INTRODUCTION

Polymers have become commercially attractive material as they are relatively cheap, strong and light. They tend to exhibit superior properties per unit cost than other materials for which they may have substituted. For these reasons, the production of polymers has been increasing rapidly even if all polymers are virtually vulnerable to deterioration in their practical properties towards the action of various external effects such as heat, light, atmospheric oxygen and other environmental factors. Increasing the stability of polymers has always been a very important issue to polymer manufacturers, processors and users. This is because the instability of most polymers limits them to only certain applications, some are degraded rapidly over periods ranging from months to a few years.

Virtually all polymeric materials, both of synthetic or natural origin, undergo oxidation reactions with oxygen. Technically it is important to distinguish whether such oxidation reactions are taking place as purely thermal processes at usually elevated temperatures, or with the assistance of light (mainly ultraviolet). Oxidation can manifest itself in every stage of the life cycle of a polymer, i.e. during manufacturing and storage of the material, or during processing and end use.

The typical manifestations of oxidation are summarized by the term *aging phenomena*. They are very dependent on the polymer; for example how it is processed and fabricated, and its end use. The polymer appearance may be changed. Discoloration, especially yellowing, is a frequently experienced phenomenon. Also important are changes in the surface appearance, such as hardening, chalking, cracking, loss of gloss or loss of transparency. Often more important is the loss of mechanical properties, such as impact strength, flexural strength, tensile strength and elongation since the loss of the physical properties of a polymer impairs the usefulness of the articles manufactured therefrom.

Retardation of polymer degradation, which in turn means increasing the polymer service life or lifetime, can be achieved by several ways. One possible method generally practised is by adding certain stabilizers to counteract the degradation of polymer systems by various agents. Without stabilization of polymers, it would be inconceivable to employ polymers in everyday use. Antioxidants, one of the most important stabilizers, have been used voluminously for improving thermo-oxidative stability. Antioxidants are absolutely essential to maintaining the desirable properties of polymers during their processing, storage and service life-time. Even though some antioxidants exhibit multifunctional stabilization possibilities, none can be satisfactorily used alone. Therefore, carefully selected combinations with other additives are required to provide optimum protection of the polymer.

White color is regarded as a symbol of purity in many cultural groups. "Clean" and "pure" are terms associated with high quality. In virtually all fields in which plastics are used, there is a demand for very white finished articles for everyday use; for example handbags, raincoats, refrigerators, cables, and so on. These requirements are not met by using white pigments such as titanium dioxide, chalk, barium sulfate or zinc sulfide alone. Optical brighteners have to be used. They result in first-class effects that are technically and commercially entirely satisfactory. Optical brighteners have a coloristic effect not only in white or colorless plastics, other interesting effects can also be achieved by adding them to pastel colorations. The resulting color shades are clearer and more brilliant, very often they are shifted toward blue.

Among polyolefins, both polyethylene and polypropylene have achieved the greatest commercial importance. Their possible uses are manifold. Domestic articles, packaging material, tool components, pipes, toys, fibers, carpet backing fabric and needle felt are a few examples. Transparent and white articles are frequently called for, and optical brighteners are often employed in these articles.

1.1 Objectives of the Present Study

The current research work aims to investigate the effects of primary, secondary antioxidants, optical brightener and their interactions on commodity plastics. Specifically, high density polyethylene (HDPE) was selected to represent the commodity plastics due to its vast commercial availability, extensive applications and worldwide high consumption. As HDPE is going through processing, degradation is going to take place and cause discoloration in HDPE. Also focused in the present study is how to improve the problem of yellowness in compounded HDPE.

The present research involves a variation of several variables such as the concentration of antioxidants and the amount of the optical brightening agent to be applied. To minimize the number of experiments, an experimental design has been applied so that the results, obtained from a minimal number of experiments, would still be statistically conclusive. The present study has chosen the technique of Central Composite Rotatable (CCR) for the experimental design. Empirical models depicting relationships between the studied variables such as the concentration of the antioxidants and their corresponding response will be analyzed by the technique of Response Surface Methodology (RSM). The results of the experimentation is further analyzed in the form of response surface equations. Response surface graphs and contour plots will be conducted in order to find out the relationship between the quantity of additives and major physical properties. It is anticipated that these empirical models can be utilized as a guideline to find out the appropriate formulation for compounded HDPE.

1.2 Scope of the Present Study

The current research work utilizes unstabilized high density polyethylene (HDPE). The HDPE is compounded with antioxidants in combination with other additives. Five commercially available antioxidants, an optical brightener and an hindered amine light stabilizer (HALS) will be utilized in the present study. Design of the experimentation by adjusting the quantity of the chosen additives will be performed by the application of CCR technique. After each compounding formula is designed, and the selected additives of the designed amount will be dispersed thoroughly within the unstabilized high density polyethylene. The mixing will be conducted by using a single screw extruder. Extrusion will be repeatedly performed up to five passes. Physical properties and the thermal stability of the compounded HDPE will be investigated. Analysis of the aforementioned properties will be conducted by using RSM. Empirical models in the form of response surface equations will be proposed and plotted as response surface graphs and contour graphs.