CHAPTER II
LITERATURE SURVEY

2.1. Optical Properties

Various investigators have considered the optical clarity and haze of blowing film from LDPE resins.

In a classic study, Hugg and Clegg (1961) recognized that the light scattering originates from both surface irregularities and bulk scattering and that the former is predominant. They interpreted their results in terms of two mechanisms for generating rough film surfaces. These mechanisms give rise to "extrusion haze" and "crystallization haze'. In the extrusion haze mechanism, surface bumps are assumed to form on the molten film surface upon exit of the polymer fluid from the film die. The surface bumps are thought to smoothen upon moving downstream from the die until solidification of the film prevents further smoothening. Crystallization haze was postulated to occur from surface roughening caused by the formation of crystalline aggregates on or close to the film surface.

Based on these hypotheses, a number of workers have studied the effects of film fabrication as well as polymer chain structure on optical clarity of film. The melt elasticity of polymer is believed to closely relate to blown film haze. According to Hugg and Clegg, the haze in LDPE film increases as extrudate die swell increases.

Stehling *et al.* (1981) confirmed two mechanisms causing surface roughening and surface haze: (1) extrusion haze, which results from flow disturbances at the die exit caused by the elastic nature of the polymer melt, and

(2) crystallization haze, which results from stress-induced crystallization close to the film surface. They also proposed that the haze arising from melt flow disturbances can be reduced by selecting resins that contain relatively low concentrations of large molecules and by intense mechanical deformation of the melt before extrusion. Haze arising from crystallization may possibly be reduced by introducing more irregularity into polymer chain by copolymerization or by increasing short chain branching.

The effect of polymer chain structure on LDPE film haze has also been investigated. Perron and Lederman (1972) concluded from GPC examination of a few LDPE resins that broadening molecular weight distribution causes an increase in haze. However, no allowance was made for long chain branching of LDPE in the analysis of the GPC chromatograms, so this conclusion was not firmly established.

Han and Kwack (1983) concluded that the observed differences in the haze and gloss of the tubular blown films may be attributable to the difference in the degree of long chain branching of the resin with the haze increasing as the degree of LCB increases. Foster et al (1980) reported a similar observation.

Ashizawa *et al.* (1984) investigated the surface and interior contributions to the scattering in terms of film processing variables. Slower cooling rate increases the scattering of both surface and bulk. As draw-down ratio and blow up ratio increase, the scattering from the film interior decreases but the contribution from the surface increases slightly. These effects were discussed in terms of changes in crystalline morphology and surface roughness produced by flow defects generated during extrusion.

2.2. Mechanical Properties

Mechanical properties of blown film have been found to depend on morphology and molecular orientation of film, which in turn, correlate well with processing conditions.

Han and Kwack (1983) studied the relationship between tubular film blowability and the molecular parameters of three different grades of LDPE and also between processing conditions and the mechanical properties of the tubular blown film produced. They found that the tubular film blowability increases as the MWD of the resin becomes narrower and the degree of LCB is less. It has been found further that a resin having lower elongational viscosity tends to give a greater draw-down ratio, indicating a better film blowability. However they could not comment on the effect of the molecular parameters on film strength.

An investigation of processing-structure-properties relationships in polyethylene blown film was investigated by Rajen *et al.* (1994). The molecular orientation imparted during film fabrication is known to have a major effect on mechanical and thermal properties. Measured key film properties were correlated to processing conditions and to measured molecular orientation. Birefringence gives a measure of total orientation in the sample while shrinkage can be taken primarily as a measure of amorphous segment orientation and amorphous chain extension. Broad MWD resin with a significant amount of low molecular weight chains, would be expected to crystallize with C axis oriented away from MD resulting in negative crystalline birefringence. It was noted that in broad MWD resin, shrinkage may be determined by higher molecular weight fraction.

Kim and Park (1996) reported the effect of short chain branching on the blown film properties of LLDPE. The mechanical properties seem to be highly associated with the length and distribution of short chain branches and

consequently, the lamellar thickness distribution of the resins. The author suggested that the smaller lamellae and more homogeneous lamellar thickness distribution resulting from the narrower short chain branching distribution may be responsible for the higher impact strength and tear strength.

Calabro *et al.* (1992) synthesized a low density polyethylene having a broad MWD with a melt flow ratio of about 50 to 250, and a substantially constant melt index-corrected density,i.e. the number of short chain branches is substantially constant throughout the polymer. The polymer produced by blending a first polymer component of high molecular weight with a second polymer component of low molecular weight, with both polymer components having substantially the same frequency of branches. The resulting film was found to have improved mechanical properties and low hexane extractables, as compared to film made from comparable individual components. However, the results appear to contradict the previous findings which suggest that it is not possible to produce useful low density high molecular weight polymer because theoretically such a polymer would have such a high extractable level that it would render the polymer unsuitable for extrusion. The author also synthesized a low density polymer, having essentially no low molecular weight fractions and short branches. The polymer was prepared by blending a first polymer component of low density and high molecular weight with a second polymer component of relatively high density and low molecular weight. The melt index-corrected densities of the two polymer components are dissimilar. The new polymer also gives film having excellent mechanical properties and low level of extractables. It is believed that concentrating the branches on the relatively high molecular weight component helps to skew the branching distribution toward the high molecular weight of the blend and reduce the extractable contents of the final polymer product.