RELATIONSHIP BETWEEN PROCESSING INDUCED MORPHOLOGY, MOLECULAR ORIENTATIONS AND MECHANICAL BEHAVIOUR OF AMORPHOUS POLYMERS

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INTRODUCTION

Although HOUWINK [1] suggested already in 1936 the existence of colloidal superstructures in amorphous polymers newly developed methods of electron microscopic preparation techniques allow in the recent years for the first time to obtain direct evidence of well defined morphologies in many high polymers. So for example it was possible to show in the case of atactic polystyrene [2], styrene/acrylonitrile copolymer [3], polyethylene terephthalate [4], polycarbonate [4] and polymethyl methacrylate [5] that the isotropic and slightly oriented states are characterized by globular network structures; the highly oriented materials possess a line by line structure. Geometrical shape and regularity of the morphology only depend on the degree of molecular orientations, but not on the way producing themselves by varying the hotstretching parameters. Therefore similar relationships can be assumed between morphological changes and processing induced molecular orientations in injection moulded polymers.

EXPERIMENTAL

The material used for the experiments was commercial bulk polystyrene with a molecular weight of $M = 111 \times 10^3$. In order to mould specimens with significant different molecular orientations in the cross section a low injection temperature of only 180°C and a mould cavity wall temperature of 40°C have been chosen. The dimensions of the longitudinally moulded prismatic specimen were 120 x 15 x 4 mm³.
To get informations about the processing induced internal structure due to the wanted distance to the sample surface thin layers have been cut by a microtome knife. Now the morphology of the remained uncovered internal surface could be identified by means of electron microscopy and one-step-replica method after oxygen ion etching. The selective etching process is based on different degradation rates of regions with locally differing densities and/or differing packing types of the chain molecules.

Fig. 1 shows the scheme of the used etching apparatus type GEA 004- S. The bulk specimen is treated on the watercooled sample plate. Oxygen ions are produced in the high-frequency field (27.12 MHz) of the annular electrode at a partial pressure of about $10^{-10}$ mbar. Superimposed low dc voltages (max. 500 V) between the electrode at the top of the recipient and the sample plate accelerate the oxygen ions onto the sample surface. In addition to the selective chemical etching effect of the activated oxygen a mechanical microerosion process based on the kinetic energy of the accelerated ions is degradating the polymer surface. By means of mass spectroscopy it was possible to point out that the degradation products mostly are gaseous and removed over the diffusion or turbomolecular pump [6]. The etching time of normally some hours strongly depends on the plastic deformation during microtome pretreatment in the surface layers. Otherwise artefacts would be expected.