Abstract

This research work is divided into two parts. The main objective of the first part was to study and compare the drawability and texture developed in case of polypropylene (PP)-talc composite drawn at elevated temperature to that of neat PP drawn under similar processing conditions. For a given die geometry the final draw ratio of both drawn composite and drawn neat PP increased with draw rate and leveled at higher draw rates. The ratio of final void fraction to particle
fraction in case of drawn PP-talc composite with initial filler loading of 7.5 vol. % (or 20 wt %) was found to be higher (2.6 vs. 1.8) than that of drawn PP-talc composite with initial filler loading of 16.5 vol. %. Microscopic analysis of the drawn materials showed that the voids were stretched in drawing direction and the void volume fractions leveled above an actual draw ratio (DR) of 7 for both the cases. Crystal orientation of the matrix phase in drawn PP-talc-20 wt. % composite was developed with void growth and that too leveled at a DR of 7, the average voids length in the drawing direction was found to be 5-6 times that of particle length. Despite saturation in crystal orientation as well as void growth the tensile modulus of drawn composite increased with DR. For the highest draw rate studied using a wedge die of nominal draw ratio 2, the tensile modulus attained for drawn PP-talc-20 wt. % composite was 3 times that of undrawn neat PP. For a given draw rate, the major action of void growth and polymer crystal orientation was found to have taken place in the post-die deformation zone.

X-ray diffraction (XRD) study on PP-talc composite billet before drawing suggested presence of a different crystal morphology in the matrix phase than that of neat PP. Die-drawing led to formation of highly oriented crystalline structures in PP matrix with chain axis oriented along the drawing direction. Pole figures of drawn samples exhibited well-developed texture elements of type (110)[001] and (010)[001]. These textures sharpened with DR in both drawn neat PP as well as drawn composite. For a given draw rate debonding and void growth in drawn composite resulted in less developed crystal orientation than drawn neat PP of comparable draw ratio. Analysis of the positions of maxima on the pole figures indicated that the crystalline orientation of PP phase in drawn composite progressed in two steps. In the first step the crystal orientation began in a similar manner to that of neat PP where (110)[001] type texture elements were predominantly developed. This step was accompanied by progressive debonding of the micron
sized particles. The (010)[001] type texture element became dominant in the second step when the debonding was almost entirely complete.

The second part of the research work was motivated by the aim of developing nanocomposites of high molecular weight high density polyethylene (HMW-HDPE) with enhanced mechanical properties and improved or similar processability as that of base resin. This was achieved by adding a small percentage of organoclay with appropriate compatibilizers. The very high molecular weight of the matrix made the task of organoclay dispersion with these constraints particularly challenging. This problem was addressed (a) by using a mixture of compatibilizers and (b) by carrying out the melt mixing in two stages through the use of masterbatch. X-Ray diffraction tests were carried out to confirm that the final let down compound had good dispersion. Unlike the observations made by Spencer et al., complete exfoliation of the dispersed clay could be achieved with lower loadings of compatibilizer. Injection molded bars of a let-down formulation with 5 wt. % organoclay showed a modulus increase of about 20 %. Extensional melt flow tests on nanocomposites with 3 wt. % organoclay showed similar level of strain hardening to that of neat HMW-HDPE. Despite the strain hardening ability and good dispersion of organoclay, the blown films obtained from HMW-HDPE nanocomposites showed inadequate mechanical performance. The presence of low molecular weight compatibilizer was found to be the main cause of instability during film blowing operation.