Sequential and Simultaneous Biaxial Stretching of Polypropylene Films Containing β-form crystalline Structure

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This study investigated the biaxial stretching behavior of PP containing various β-crystal contents, by comparing between sequential and simultaneous processes. Extruded precursor sheets consisted of a very small amount in a ppm level of a proprietary nucleating agent. Precursor sheets were fabricated using different chill roll temperatures (60, 70, 80, 90, 100, 110 and 120°C) and resulted in high β-crystal contents, indicated by K-values of 0.77, 0.81, 0.84, 0.87, 0.87, 0.85 and 0.85, respectively. Biaxial film stretching of β -nucleated sheets was performed on a lab-scale stretching machine (Bruckner KARO IV) at the temperature of 145°C with a stretching speed of 400%/s. For stretching behavior comparison, all β –nucleated PP sheets were stretched to 5.5 x 5.5. Based on the simultaneous stretching results, biaxial yield stress of normal iPP (α-PP) was 3.3 MPa, where much lower biaxial yield stress values were apparent for all β-nucleated PP, in a range of 1.5-2.4 MPa. Interestingly low yield stress and low maximum stress during biaxial stretching of the β-PP films were dependent upon the β-crystals (both content and morphology), initially developed in the sheet extrusion process. Chill roll temperature or cooling was a critical parameter controlling morphology, the stretch behaviors and the resulting film properties. β-nucleated PP fabricated under optimum cooling condition clearly required lower energy than the normal α-PP, to deform under both sequential and simultaneous film stretching processes. The stretched β-PP films also showed good optical property, evidenced by low haze values of <1% which were comparable to the normal BOPP films. All β-PP stretched films were characterized by thermal analysis and X-ray diffraction technique to correlate between morphology, stretch behavior and some final film properties (such as gas permeation and clarity).