A three-phase micromechanical model for the elastic properties of semicrystalline polymers

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Introduction

The mechanical performance of semicrystalline materials is strongly dependent on their underlying microstructure, consisting of amorphous layers and crystallographic lamellae (figure 1). To better design products, it is important to accurately predict their properties as a function of the morphology and crystallinity.

Aggregate Model

Experimental

The degree of crystallinity and lamellar thickness of HDPE samples were measured by WAXS and SAXS (figure 2). Tensile tests were also performed to obtain the elastic modulus.

Composite Inclusion Model

The behavior of microscopically heterogeneous semicrystalline material has been modeled by an aggregate of layered two-phase composite inclusions [1]. Here a three-phase composite model is used, which includes the lamellar thickness and allows interlamellar properties to vary with crystallinity.

Application

The spherulitic structure of HDPE is presented by an aggregate of 2000 randomly generated inclusions (figure 4). Confrontation of the two-phase and three-phase model predictions with experimental data and the influence of the rigid-amorphous layer properties on the overall behavior can be seen in figures (5) and (6).

Reference