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Structure and Properties of Flow Induced Orientation in Semi-Crystalline Polymers

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Introduction
The toughness of semi-crystalline polymers can be improved by the addition of particulate fillers (e.g., CaCO₃ in HDPE). Also in unfilled semi-crystalline polymers toughness was found to increase in thin injection moulded samples. Since for both systems the behaviour was found to be anisotropic and process dependent, the effect of flow induced crystallization should be taken into account.

Properties of unfilled systems
A row structure is also known to exist over the complete thickness of extrudated films of HDPE or PP.

Structure in unfilled systems
Microscopic orientation

- Size of the oriented skin layer is dependent on the applied injection conditions (e.g., \( V_{inj} \) & \( T_{inj} \))
- Maximum oriented layer thickness \( \approx 500 \mu m \).
- Shish-kebab structure with twisted kebab (row structure).  

Objective: Is there a relation between the flow induced structure and the properties of semi-crystalline polymers.

Structure in 15% CaCO₃ filled HDPE

- Increasing amount of flow induced crystalline orientation increases impact toughness.
- Row oriented structure has strong anisotropic behaviour; localization perpendicular to flow direction and homogeneous deformation in flow direction.
- Flow induced orientation of crystals is probably the main concept in the mechanical behaviour of particle-modified semi-crystalline polymers.

Conclusions

References: