Molecular Aspects of Flow-Induced Crystallization of Polymers

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1. INTRODUCTION

Reminiscent of teeth, bone and sea shells, semicrystalline polymers combine strength with toughness by forming a nano-scale composite with platelet-like crystals stacked with noncrystalline material between them. The morphology and orientation distribution of the nanostructure dictate the material properties. Ultrastrong fibers, impact resistant plastics and elastic materials can all be achieved by controlling the morphology of crystallization. Flow can dramatically accelerate crystallization and induce the highly oriented crystallization needed to achieve certain properties.

2. CONCLUSIONS

We have discovered that these profound changes in crystallization kinetics and morphology follow a kinetic pathway.[1] During flow, oriented precursors form at a rate that is not limited by the usual activation barrier to nucleation—instead the rate is orders of magnitude faster and tracks the dynamics of the polymer chains in the melt.[1] Model polymers and their binary blends have shown that the rate of formation of the oriented precursors is controlled by the longest chains in the melt.[2] Nevertheless, our neutron scattering experiments show that the long chains are not the dominant species in the oriented precursors.[3] New molecular design principles based on these results are being applied in producing a range of better products, from stretchy fabrics to durable pipes.[4]

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