New models to explore the microstructure of polymer mixtures

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A well-known method for making polymer materials is to blend or mix multiple polymers. For disperse blends, two liquid polymers do not mix well with each other, leading to a so-called droplet-in-matrix microstructure which is similar to emulsions of oil and water. The material properties of the polymer blend depend on the final microstructure, so the material properties can be tuned during processing history. However, conclusively connecting the final microstructure to the processing history with numerical models is the subject of ongoing research. For his Ph.D. research, Wing-Hin Wong extended and improved existing numerical models to better describe this connection.

Polymer blends are widely used in industry as their material properties can be precisely tuned for specific applications. An important aspect of controlling these material properties is the microstructure or morphology of the polymer blend. For instance, droplet-in-matrix microstructures are formed when the volume fraction of one polymer fluid in the mixture is sufficiently small when compared to the other. Nonetheless, the final microstructure depends on the processes used to blend or mix the polymers.

Droplets and FEM

In reality, blends contain large numbers of droplets. Computational models can prove useful with regards to understanding the underlying microstructure, however there is an issue of contention. It is computationally impractical to track each individual droplet in a model of a droplet-in-matrix microstructure.

For his research, Wing-Hin Wong opted to instead to track clusters of droplets rather than individual droplets, using existing approaches as the foundation for this approach. He then extended the existing model so that they could be applied to study complex flow situations used in the processing of blends such as shear flow, eccentric cylinder flow, and Poiseuille flow. In addition, the model was also adapted so that it could be used in a continuous Finite Element Method (FEM) approach.

The model was also employed to study microstructure development in a twin-screw extruder, which is a commonly used as a mixing device in industry. In terms of predicting the relationship between the final microstructure and flows used in the processing of the polymer blends, the models developed in this research are quite promising.

More information: A phenomenological model for morphology development of disperse polymer blends in complex flows. research.tue.nl/en/publication … opment-of-disperse-p

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