

## Viscosity of polymer melts reduced jointly by filler addition and LCP fibrillation

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### Introduction

Filler loading (fiber or particulate) usually increases melt viscosity of polymers. However, for polymer materials excellent flow property is commonly required together with excellent mechanical performances. This presentation will report the viscosity reduction of polymer melts jointly by the addition of fillers and fibrillation of thermotropic liquid crystalline polymer (LCP).

### Results and Discussion

#### Rheological hybrid effect.

It is interesting to find that ternary polymer systems such as polycarbonate (PC)/glass fiber (GF)/LCP [1], polyamide 6 (PA6)/GF/LCP [2], PA6/glass bead (GB)/LCP [3], and PC/nano-silica/LCP (Figure 1) blends had decreased viscosity lower than the corresponding component polymers, filler-loaded polymers and LCP-blended polymers. Furthermore, the viscosity of these ternary polymer blends decreased with increasing filler loading. This phenomenon was termed as rheological hybrid effect with its definition of "a phenomenon in which the melt viscosity of a ternary polymer blend decreases with increasing filler loading, influenced by the minor polymer phase in the blend" [3].

Importantly, these ternary polymer systems kept their enhanced mechanical performances with improved flow property [4, 5].

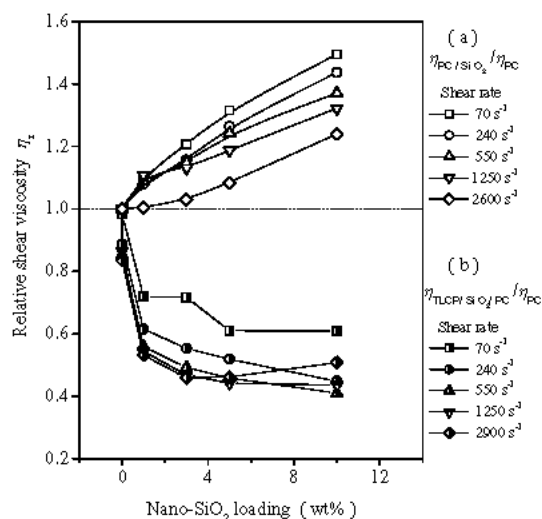


Figure 1. Effect of nano-SiO<sub>2</sub> loading on the relative shear viscosity at 285 °C: (a) PC/SiO<sub>2</sub> binary composites; (b) corresponding TLCP/SiO<sub>2</sub>/PC ternary composites with 10.7 wt% TLCP.

#### Multi-scale effect of LCP fibrillation.

It is found that this viscosity decrease correlated well with the fibrillation of LCP melt droplets in these ternary blends. LCP fibrils lubricated the melt efficiently and decreased the viscosity significantly, while LCP spheres played a little role. It is clear that this is beyond the

influence of rheology on the morphology as commonly discussed for polymer blends. Instead, the mutual influence of morphology and rheology needs deep understanding. Investigation on multi-scale effect of LCP fibrillation was conducted experimentally on different polymer/LCP blends with added fillers of various shapes at micro-meter and nano-meter scales, respectively.

In short GF-reinforced PC/LCP [1] and PA6/LCP [2] blends, LCP droplets were deformed into fibrils by the large shear rate and elongational flow at the interface of GF and LCP. In GB filled PA6, LCP droplets were deformed into fibrils by extensional action exerted by the micro-rollers of GB. This dynamic action was so strong that resulted in the formation of LCP microfibrils with an average diameter of 30 nm [5]. The formation of elongational action depended upon the migration and selective distribution of GB, which were controlled by the interfacial tensions between the components thermodynamically. In PC/GB/LCP systems [6-8], the effect of the content and size of GB on the LCP fibrillation was analyzed by the capillary parameter and hydrodynamic effects.

In nano-silica filled PC/LCP blend [9], well-developed LCP fibrils were obtained in capillary flow by both increasing nano-SiO<sub>2</sub> content and shear rate. This phenomenon was ascribed to the selective distribution of nano-silica at the PC/LCP interface, thermodynamically driven by the interfacial tensions, and inhibited transesterification between PC and LCP droplets covered by nano-silica. Then the enlarged viscosity discrepancy between PC and LCP by increasing shear rate made nano-silica migrate from the PC/LCP interface to PC matrix, enhanced the mobility of LCP phase, and promoted the coalescence and the subsequent fibrillation of LCP droplets in capillary flow.

The drastic viscosity reductions found to be due to the intimate interactions between the matrix polymer and LCP after the LCP domains became highly stretched along the flow direction (became fibrils by later cooling), which caused chain alignment and disentanglement in the neighboring matrix polymer melt [10, 11].

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### References

- [1] Zheng X.; Zhang B.; Zhang J.; Xue Y.; He J. *Int. Polym. Proces.* **2003**, *18*, 3.
- [2] Zheng X.; Zhang J.; He J. *J. Polym. Sci. Part B: Polym. Phys.* **2004**, *42*, 1619.
- [3] Ding Y.; He J.; Zhang J.; Liu C.; Chen P.; Zhang B. *J. Non-Newt. Fluid Mech.*, **2006**, *135*, 166.
- [4] He J.; Wang Y.; Zhang H. *Compos. Sci. Tech.* **2000**, *60*, 1919.
- [5] Ding Y.; Zhang J.; Chen P.; Zhang B.; Yi Z.; He J. *Polymer* **2004**, *45*, 8051.
- [6] Chen P.; Zhang J.; He J. *Polymer* **2005**, *46*, 7652.
- [7] Chen P.; Chen J.; Zhang B.; Zhang J.; He J. *J. Polym. Sci. Part B: Polym. Phys.* **2006**, *44*, 1020.
- [8] Chen P.; Wu L.; Ding Y.; Zhang J.; He J. *Compos. Sci. Tech.* **2006**, *66*, 1546.
- [9] Wu L.; Chen P.; He J. *Polymer*, **2006**, *47*, 448.
- [10] Chan C. K.; Gao P. *Polymer* **2005**, *46*, 8151.
- [11] Chan C. K.; Gao P. *Polymer*, **2005**, *46*, 10890.