MA-665: The influence of nanoparticles in precursors formation during flow

This report presents the main experimental findings. For more details:

1) Patil, N. *Flow induced crystallization of polyethylene in the presence of nano-particles*, PhD thesis Loughborough University 2010 (https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/6541).
2) Patil, N.; Balzano, L.; Portale, G.; Rastogi, S. *Influence of shear in the crystallization of polyethylene in the presence of SWCNTs*, Carbon 2010, 48, 4116-4128.
3) Patil, N.; Balzano, L.; Portale, G.; Rastogi, S. *A study on the chain-particle interaction and aspect ratio of nanoparticles on the structure development of a linear polymer*, Macromolecules 2010, 43, 6749-6759.

Goal

To explore the role of single walled carbon nanotubes as orientated precursors in flow induced crystallization of polyethylenes.

Materials and methods

The linear PE used in the present study was specifically synthesised and supplied by Dow Benelux B.V., The Netherlands in the powder form obtained through the slurry process, polymerised using a Zeigler-Natta catalyst. The polymer consists of very broad molar mass distribution (M_w = 246,000 g/mol; PDI = 24.2). The single walled carbon nanotubes (SWCNTs) of high purity grade with less than 15% ash content having high aspect ratio (L/D>>1) were obtained from Unidym Inc., USA. The diameter and length of the tubes range between 0.8-1.2 nm and 100-1000 nm respectively.

The wavelength of 1.24 Å and the sample to detector distance of 6.06 m was maintained in all experiments. The 2D-SAXS patterns were acquired with an acquisition time of 10 s. The experimental conditions are given schematically.

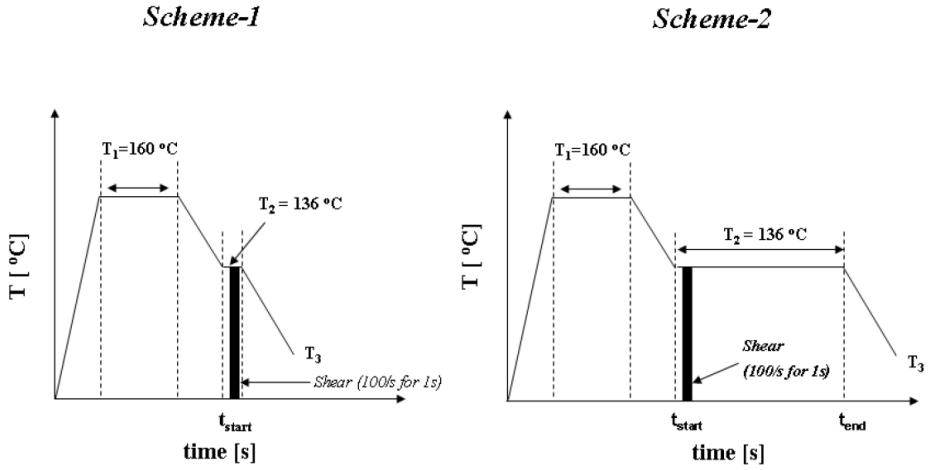

Figure 1: The schematic representation of flow and thermal application during shear experiments.

Results

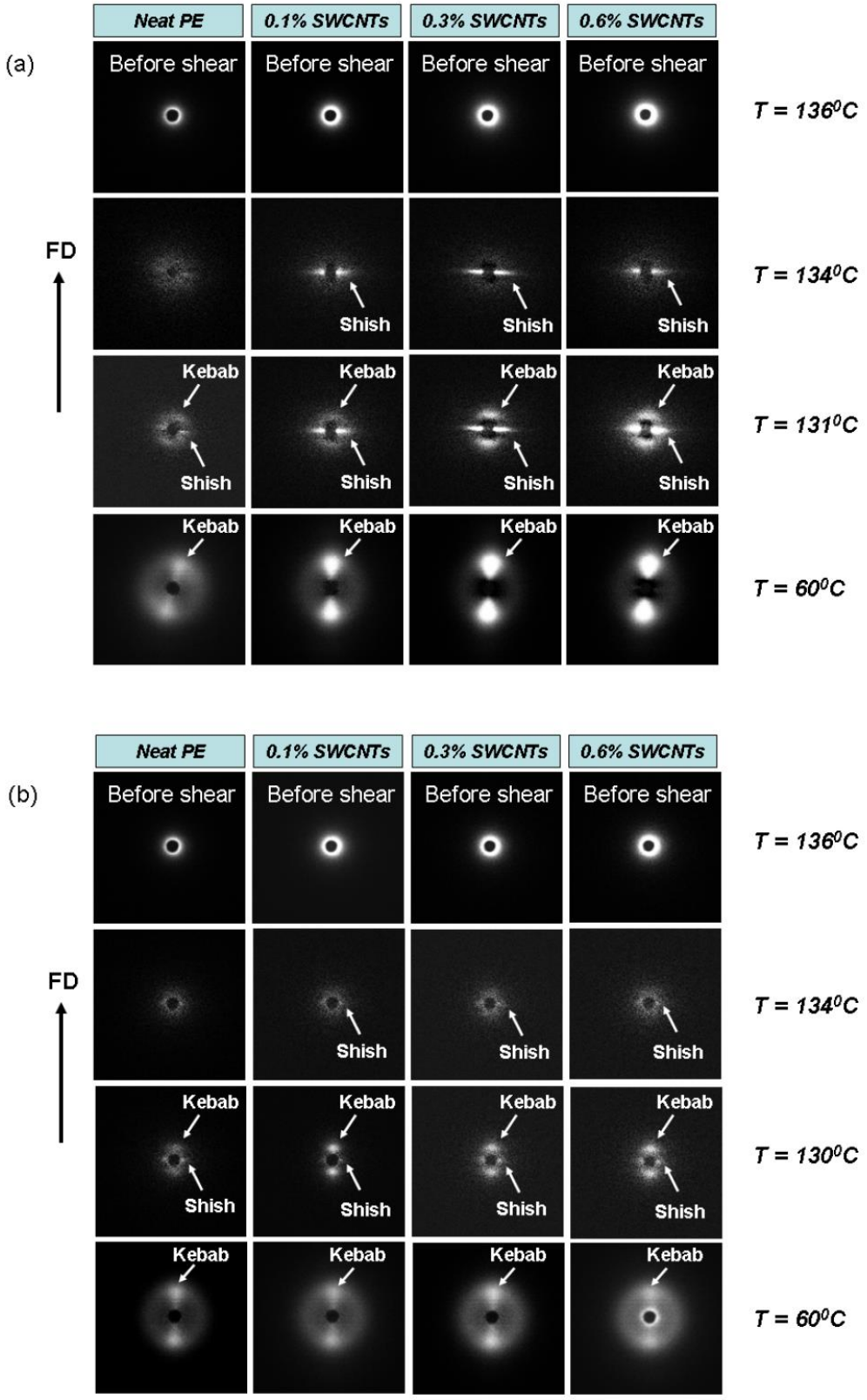

Figure 2: 2D-SAXS patterns of SWCNT/PE composites collected at selected at selected temperatures while cooling after the application of two different shear rates at the same temperature and time (a) 100 $s^{-1}$for 1 s at 136°C (b) 50 s^{-1} for 1 s at 136°C.

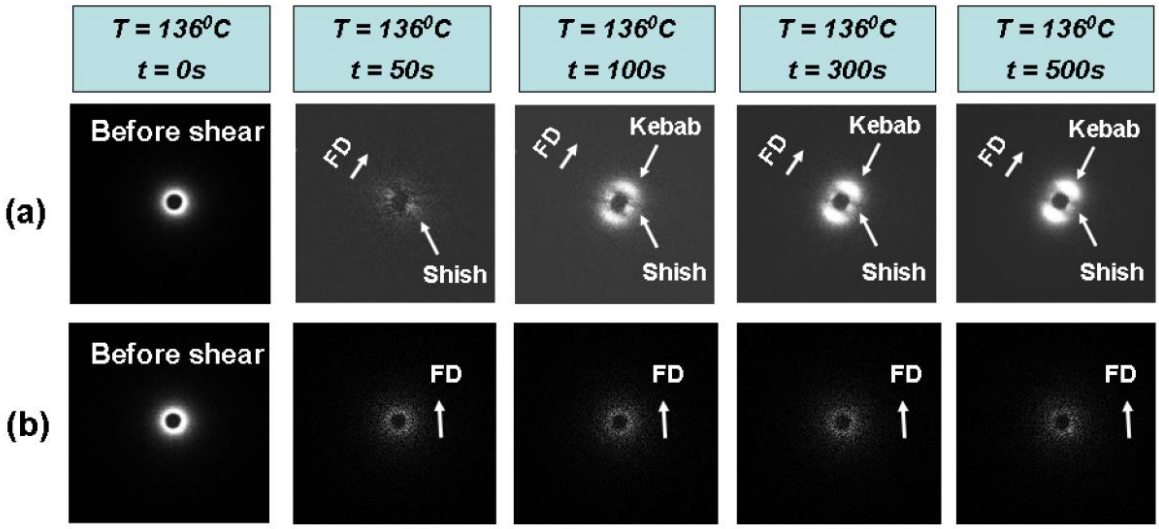

Figure 3: The two dimensional SAXS patterns of PE at selected times as a function of time at isothermal temperature of 136° for 600 s. (a) SAXS patterns acquired after the application of strong shear of 100 s^{-1} for 1s. (b) SAXS patterns after the application of shear rate of 50 s^{-1} for 1 s.

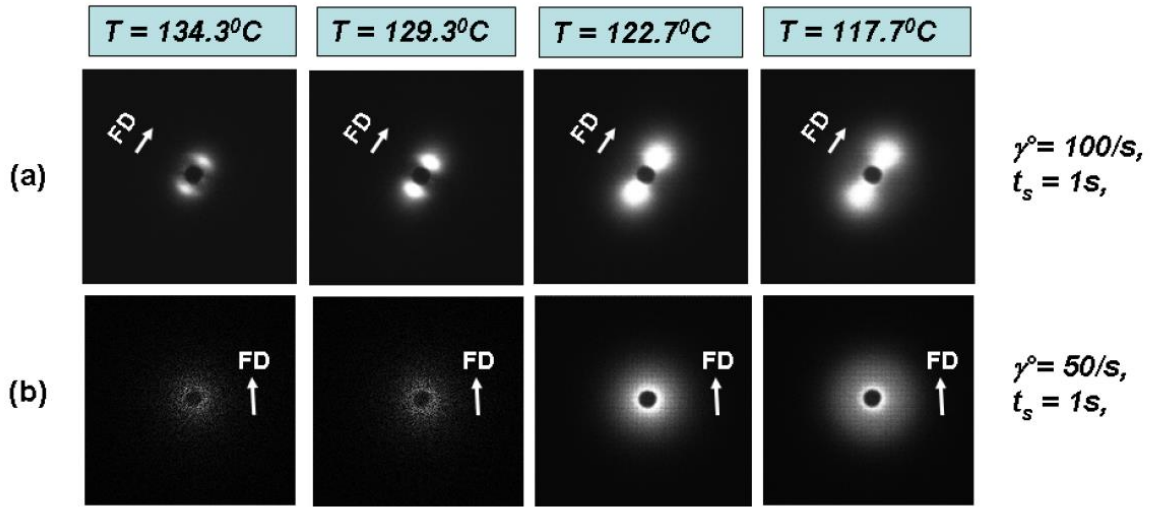

Figure 4: The acquired 2D-SAXS patterns in neat polymer at differemt temperatures while cooling to room temperature at different shear rates.

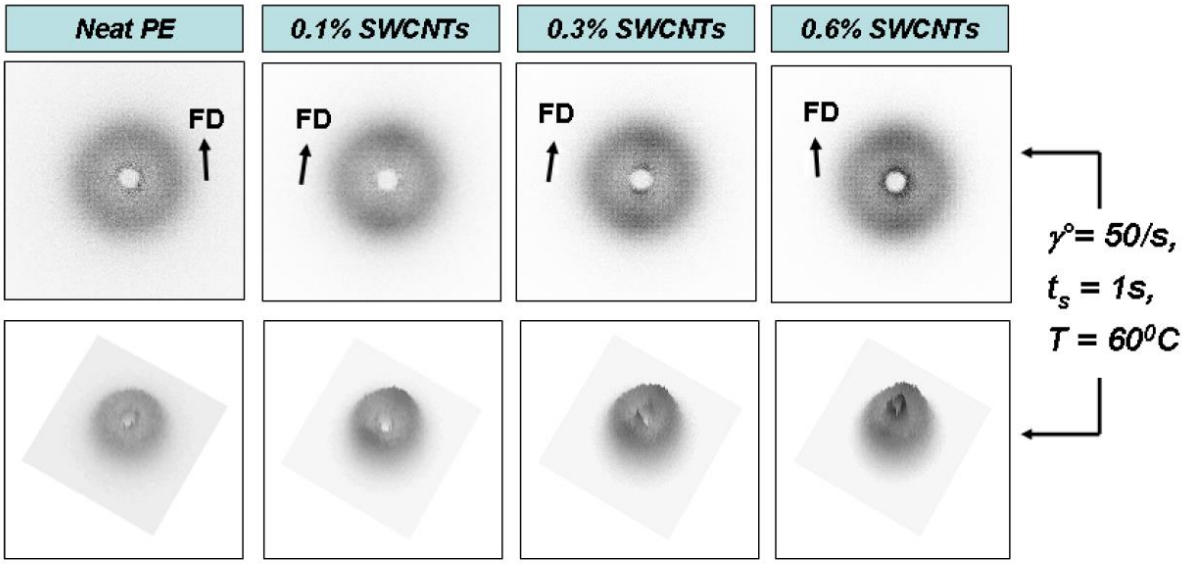

Figure 5: 2D-SAXS patterns of different SWCNT/PE samples acquired at 60°C after the application of shear ($\gamma = 50\ s^{-1}$ for 1 s) at 136°C. The sheared samples are annealed at 136°C for 600s prior to cooling at a rate of 10°C/min (following scheme 2 above).

Conclusions

The presence of SWCNTs under shearing conditionsaccelerated crystallisation kinetics and promoted the development of anisotropic structures, similar to shih-kebab. The enhanced oriented structure formation in SWCNT/PE composites as compared to neat polymer, even afte the application of low shear at isothermal conditions has implications on chain relaxation in the polymer melt.