Relationship Between Entanglement and Crystallization of Polymer Melt : Preliminary Study and Equipment Design

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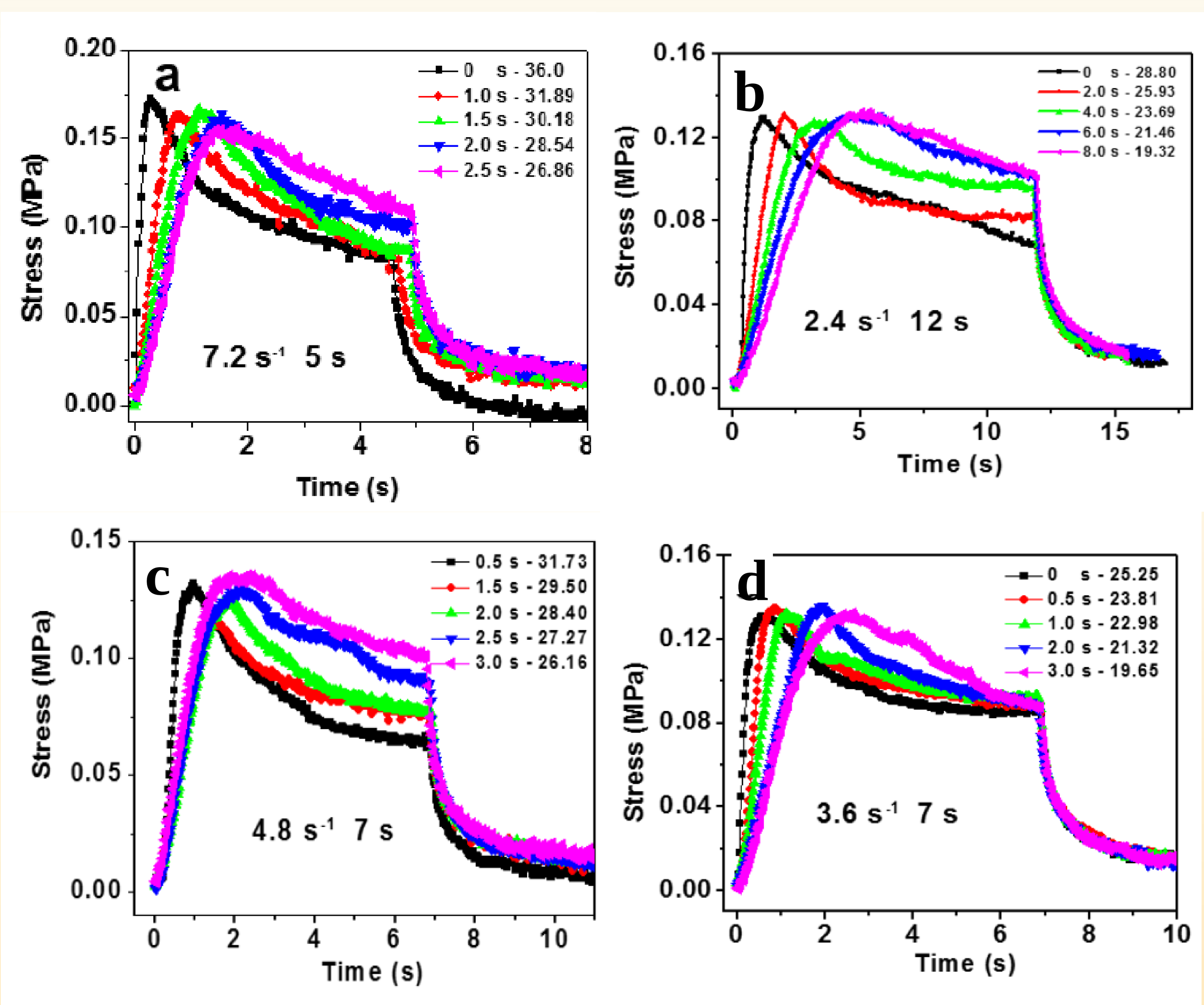
Introduction

For polymer melt or concentrated solution, the entanglement interactions between adjacent chains make the polymer system more like a transient network. Different from the disentangled polymer chains in dilute polymer solutions, entangled polymer solution or melt always display some special properties such as nonlinear rheological behavior and non-quiescent relaxation. So the crystallization behavior of entangled polymer chains are also different from the disentangled ones . And a reasonable mechanism should to be built between crystallization in FIC study and nonlinear rheological behavior.

However, though we can get different entanglement state of polymer chains by using the method mentioned above, when the melt cooling to the crystallization temperature the deformed chains and entangled network are relaxed due to the slow cooling rate and the crystallization behavior cannot directly correspond to the entanglement state. So we need a new equipment which can cool down the melt as fast as possible after shearing under high temperature.

Experiments and data



•Figure 1 Stress-Time curves of different shear rate and shear time. (a)7.2 s^{-1}, 5s; (b)2.4 s^{-1}, 12s; (c)4.8 s^{-1}, 7s and (d)3.6 s^{-1}, 7s.

•When we used our PTV device to investigate the rheological properties of iPP melt in nonlinear rheology region under high temperature(above the melting point of iPP), we found that samples with the same final shear rate but different accelerated velocity showed different stress in the region after yielding, as shown in Figure 1. Usually, the magnitude of the stress of this region represents the entanglement state of polymer chains and different magnitude of the stress means that the entanglement state of macromolecular chains is different. This make it possible for us to study the relationship between chain entanglement and crystallization of polymer melts.

Methods

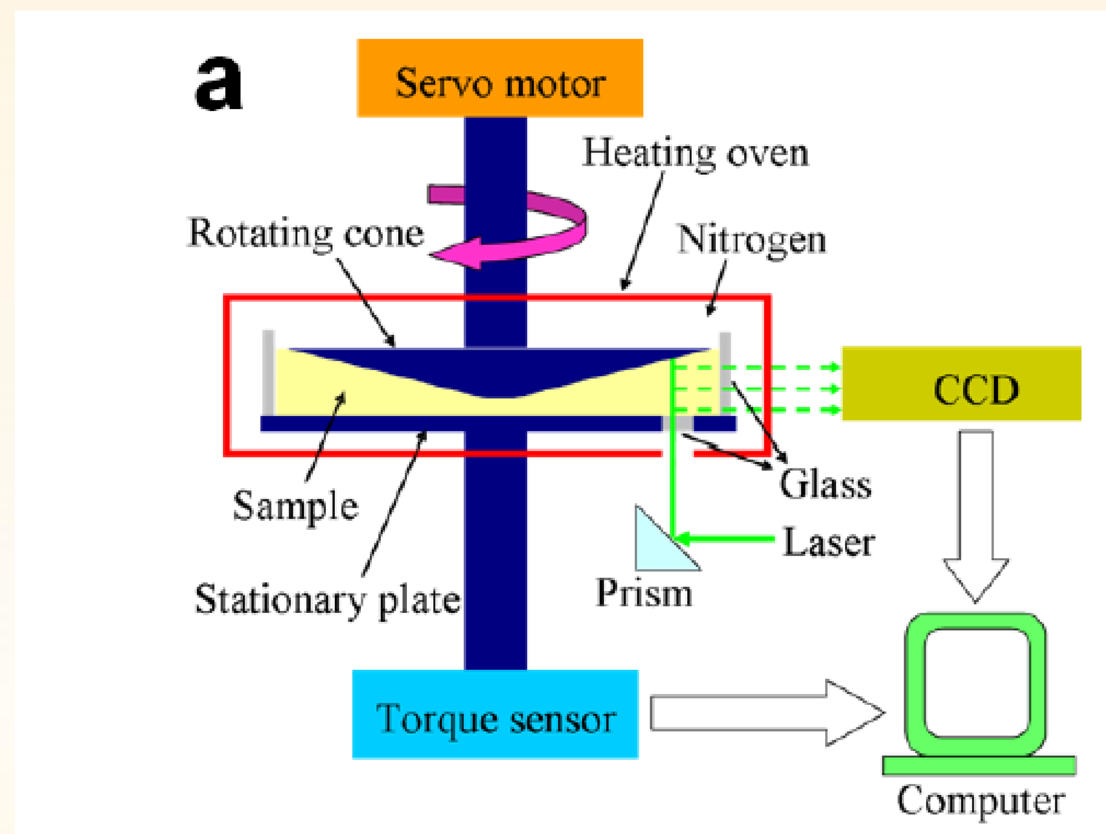


Figure 2 Schematic of flat- vertebral plate shear rheometer with PTV method

Development of methodology

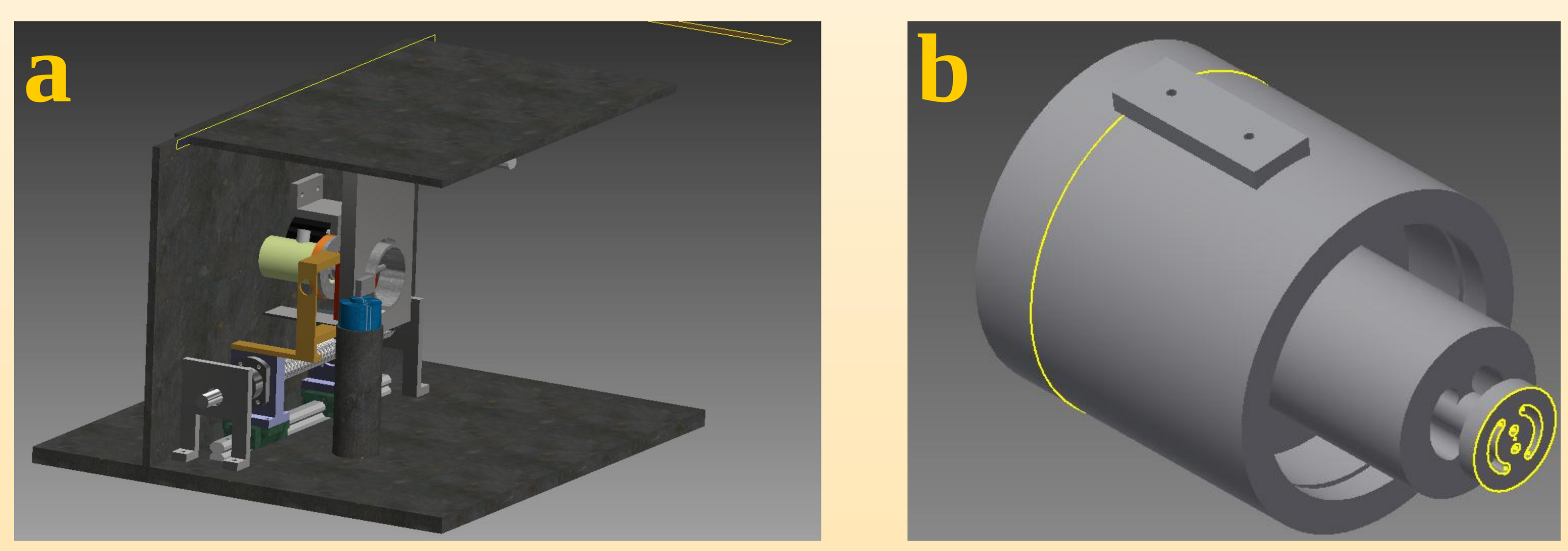


Figure 3 Schematic of T-Jump equipment. (a) set-up diagram and (b) flat plate of shear device with silicon oil cooling system

Figure 3 shows the set-up diagram of T-Jump equipment and the detail of flat plate. The flat plate and vertebral plate both have cooling system with the medium of silicon oil. When the cooling stage begin, the oil are pumped into the cooling circuit which arranged under the surface of two plates by the pump, and the cooling could be accelerated

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