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Entangled Polymer Melt Dynamics Studied By Low-Field NMR

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Proton Multiple-Quantum (MQ) NMR is a powerful technique to investigate polymer dynamics due to its sensitivity to molecular motions on very different timescales. Entangled melts exhibit dynamic processes that cover a wide range of timescales, starting from fast ps-scale segmental reorientation up to diffusive and cooperative motions on the ms-s-scale. In this work, we apply MQ NMR to linear poly(cis-1,4-isoprene) and poly(isobutylene) of different molecular weight above the glass transition over suitable ranges of temperature, in order to establish the dynamic regimes predicted by the tube model, and, for the first time, to extract actual time scale information. This directly complements many neutron scattering studies, which are restricted to the sub-μs-timescale. Measurements on PIB-grafted silica particles with different molecular weights and different chain densities on the surface of the particle are also shown. The data is analyzed by establishing scaling laws which can be directly associated with different dynamic regimes predicted by the tube/reptation model. Full analytical analyses based on a correlation function which explicitly includes segmental, Rouse, and reptation dynamics are discussed.

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