Experimental extraction of viscoelastic properties through static force spectroscopy

Goal: perform experimental validation of the method recently published[1] for measuring viscoelastic properties.

Hypothesis: in bulk measurements it is known that the distribution of relaxation times scale with the molecular weight[2], however this has not been analyzed quantitatively at the nanoscale. By the methods previously developed in [1] it should be possible to evaluate quantitatively trends of the distribution of relaxation times with varying molecular weights.

Strategy: perform force curves in polystyrene films with different molecular weights. In the lab we already have polystyrene with narrow distribution of molecular weights that can be used for film preparation. Besides it is a polymer that has been thoroughly studied and a vast amount of data is reported which makes it suitable for validation purposes. We also have spherical tips with large radius appropriate for quantitative analysis (according to the manufacturer).

Experimental feasibility evidence:

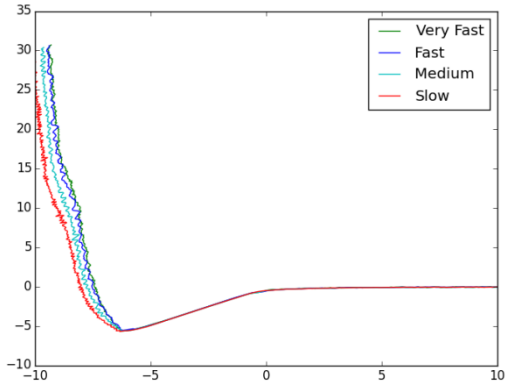

Fig. 1 Force (nN) vs. distance (nm) curves for 5 different velocities (ranging from 125 nm/s to 1000 nm/s) performed over a polystyrene sample of molecular weight: 1.2 k, spin casted with a 500 rpm speed. File: 170419. Cantilever: ContE-G (brand budget sensors) silicon AFM probe, stiffness: 303 pN/nm.

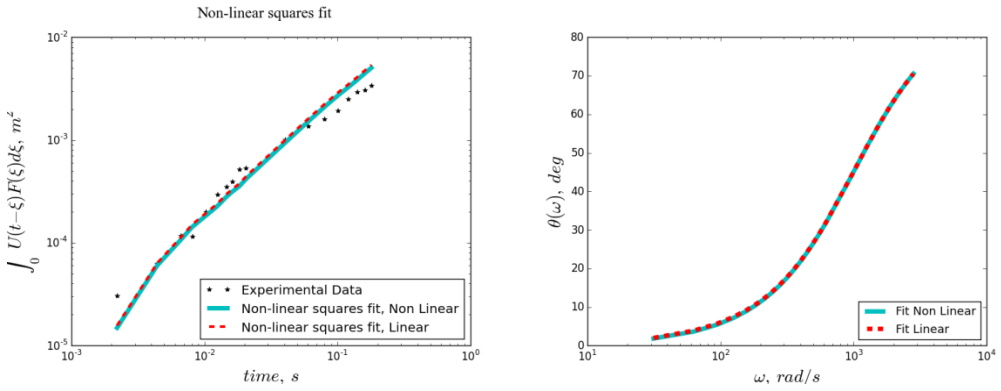

Fig. 2 Left figure: non-linear square fit performed over experimental data (the one presented in Fig. 1) for the case of 125 nm/s. Cyan line refers to the case when no linearity in force is assumed and the error is minimized with Eq. 16 in ref: [1]. The red dashed line refers to the case when linearity in force is assumed and the error is calculated through Eq. 15 in ref: [1]. Right figure: plot of loss angle vs. frequency calculated with the parameters obtained through non-linear square optimization processes. The plot shows a good agreement between both methods of optimization.

Project timeline (additions/corrections are welcome)

Activity\week (initial and final date)	07/17—07/21	07/24—07/28	07/31—08/04	08/07—08/11	08/14—08/18	08/21—08/25	08/28—08/31
Preparation of polymer solutions - Enrique							
Film spin coating – Miead							
Experimental FD curves using spherical tips – Miead, Babak							
Code preparation for automated data processing - Enrique							
Data processing/data visualization – Enrique							
Manuscript preparation – Enrique, Miead, Babak							

References

1. López-Guerra, E.A., B. Eslami, and S.D. Solares, *Calculation of standard viscoelastic responses with multiple retardation times through analysis of static force spectroscopy AFM data.* Journal of Polymer Science Part B: Polymer Physics, 2017.
2. Jackson, J., M. De Rosa, and H. Winter, *Molecular weight dependence of relaxation time spectra for the entanglement and flow behavior of monodisperse linear flexible polymers.* Macromolecules, 1994. **27**(9): p. 2426-2431.