

## Supplementary Information

### Inverse integral transformation method to derive local viscosity distribution measured by optical tweezers

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#### SI1. Stability of spring constant

The spring constant,  $k_i$ , plotted with respect to the solution viscosity at several distances from the wall is shown in Fig. SI1. Here,  $k_i$  was calculated by  $f_c$  measured using the PSD roll-off method; furthermore, it was almost constant, particularly at a position 50  $\mu\text{m}$  from the wall.

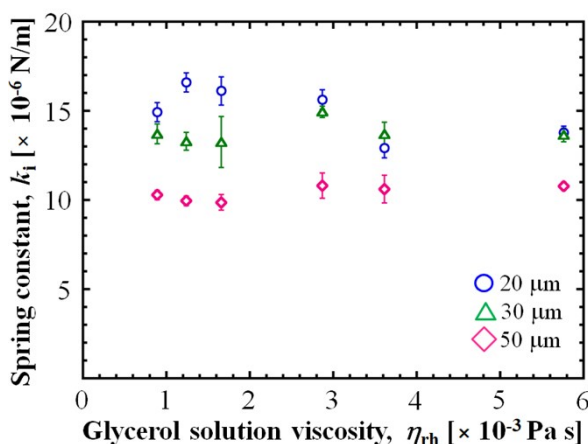


Fig. SI1 Spring constant at several distances from the wall

#### SI2. Rheological properties of sample solutions

To obtain the basic information of the sample solutions, the shear viscosity of each solution was measured using a rheometer (MCR301: Anton Paar) with a cone-plate device at shear rates of 10 to 1000  $\text{s}^{-1}$ . Fig. SI.1 shows the shear viscosities of the PEO and Ethoquad O/12 solutions. The concentrations of the PEO and Ethoquad O/12 solutions were adjusted to cover similar ranges of viscosity. The zero shear viscosities of all sample solutions are summarized in Table SI2. As mentioned in the main text, the shear viscosities measured at a shear rate of 10  $\text{s}^{-1}$  were used as the zero shear viscosities, which represent the viscosities,  $\eta_{rh}$ , as measured by a rheometer.

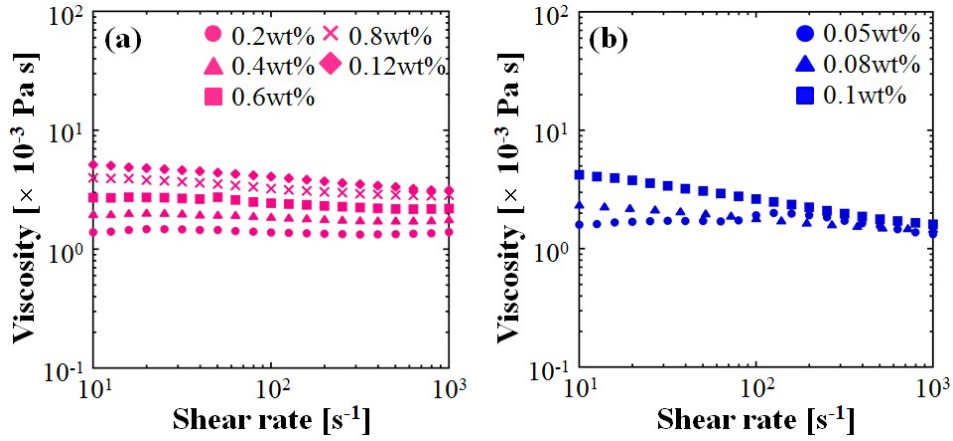


Fig. SI2 Shear viscosities of (a) PEO and (b) Ethoquad O/12 solutions as measured by the rheometer.

Table SI1. Zero shear viscosities of the sample solutions.

|   |      | Zero shear viscosity<br>$\eta_{th} [\times 10^{-3} \text{ Pa}\cdot\text{s}]$ |
|---|------|--|
| Milli-Q ultrapure water                     |      | 0.89   |
| Glycerol sol. concentration<br>[wt%]        | 10   | 1.24   |
|   | 20   | 1.66   |
|   | 30   | 2.87   |
|   | 40   | 3.61   |
|   | 50   | 5.76   |
| Ethylene glycol sol. concentration<br>[wt%] | 10   | 1.14   |
|   | 20   | 1.47   |
|   | 30   | 1.93   |
|   | 40   | 2.56   |
| PEO sol. concentration<br>[wt%]             | 0.02 | 1.39   |
|   | 0.04 | 1.98   |
|   | 0.06 | 2.73   |
|   | 0.08 | 3.99   |
|   | 0.12 | 5.52   |
| Ethoquad O/12 sol. concentration<br>[wt%]   | 0.05 | 1.40   |
|   | 0.08 | 2.24   |
|   | 0.10 | 7.00   |

### SI3. Examples of PSD fitted using the Lorentzian function and Eq. (5).

Fig. SI3 shows a comparison of the two fitting functions on the same PSD of a relatively high concentration solution. One is the Lorentzian function and the other is Eq. (5), used in the formulation

of the IITM. For the EG solution, which is a Newtonian fluid, the Lorentzian function fits the PSD well even at a high concentration of 40 wt%. Conversely, in the case of the PEO 0.12 wt% solution, which is above the polymer entanglement concentration, the Lorentz function does not fit the PSD well, although Eq. (5) does. Eq. (5) also achieves a better fit on the PSD of a highly viscoelastic Ethoquad O/12 0.1wt% solution.

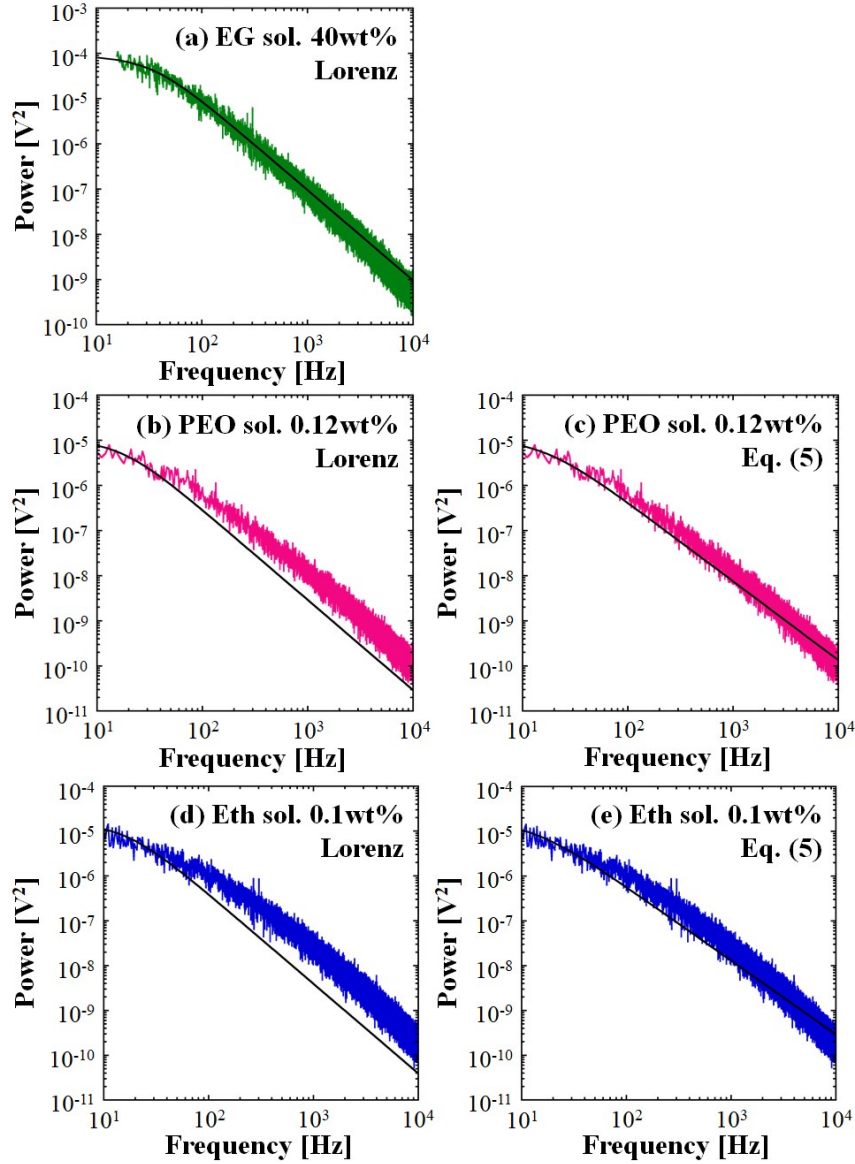


Fig. S13 Comparison between the Lorentzian function fitting and Eq. (5) fitting proposed on the same power spectra of a relatively high concentration solution. (a) For EG 40 wt% solution, the Lorentzian function fits well. The PSD of the PEO 0.12wt% solution fitted by (b) the Lorentzian function and (c) Eq. (5). The PSD of the Ethoquad O/12 0.1wt% solution fitted by (d) the Lorentzian function and (e) Eq. (5).