Electronic Supplementary Material (ESI) for Soft Matter.

Supplementary Information for Microfluidic Rheology of Methylcellulose Solutions in Hyperbolic Contractions and the Effect of Salt in Shear and Extensional Flows

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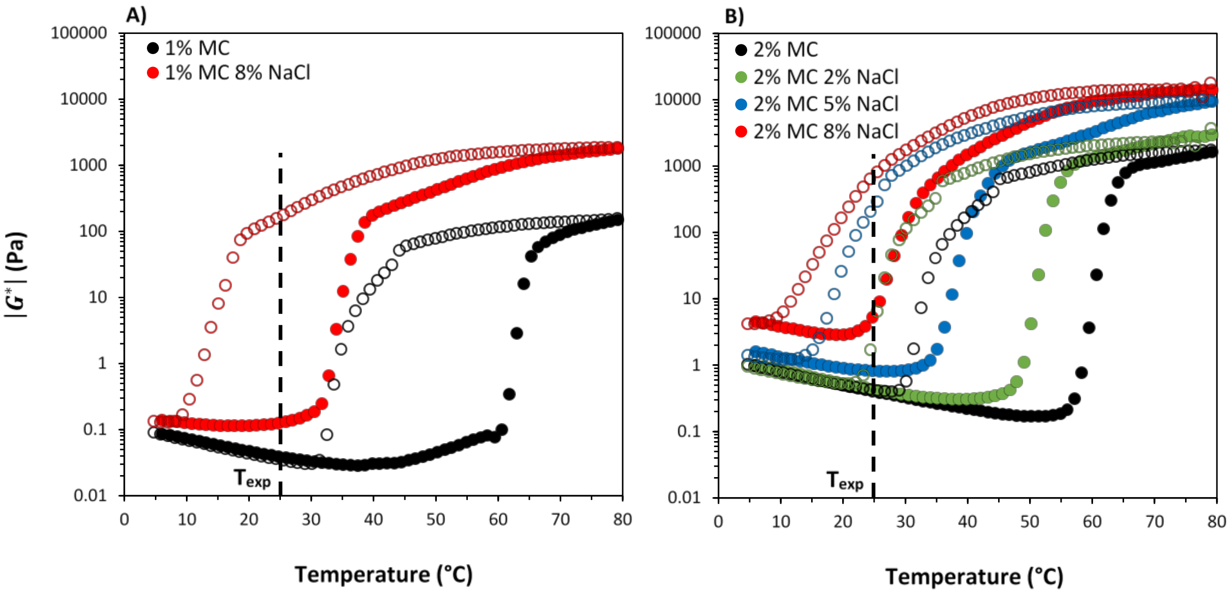

Figure S1: Complex shear modulus ($|G^*|$) from oscillatory shear rheology as a function of temperature for (A) 1 wt% MC150 and (B) 2 wt% MC150. A temperature sweep rate of 1°C min^{-1} was used, with strain fixed at 1% and angular frequency fixed at 1 s^{-1}. The closed circles denote moduli measurements during a heating ramp while the open circles denote moduli measurements during a cooling ramp. The dotted line denotes the approximate temperature at which microfluidics experiments take place (T$_{exp}$). Based on work by Arvidson et al (2013), the sol-gel transition temperature is not dependent on the frequency.[1]

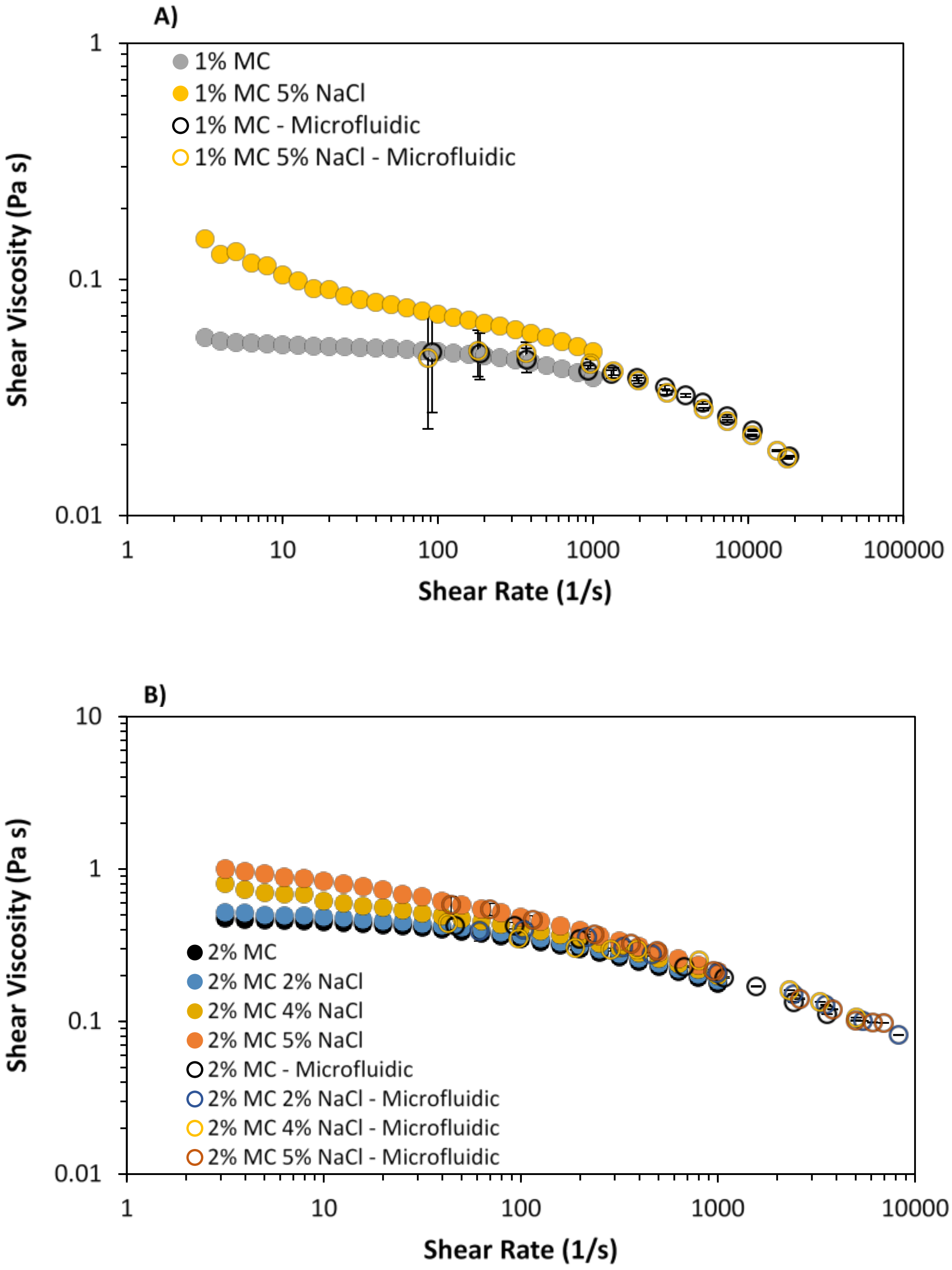

Figure S2: Steady shear viscosity plotted against shear rate for both 1% (A) and 2% (B) by weight MC solutions in the presence of added NaCl. This data was taken using a cone and plate geometry rather than the microfluidic slit rheometer described in the main body of this work. Data from the microfluidic rheometry is also included in this figure for comparison.

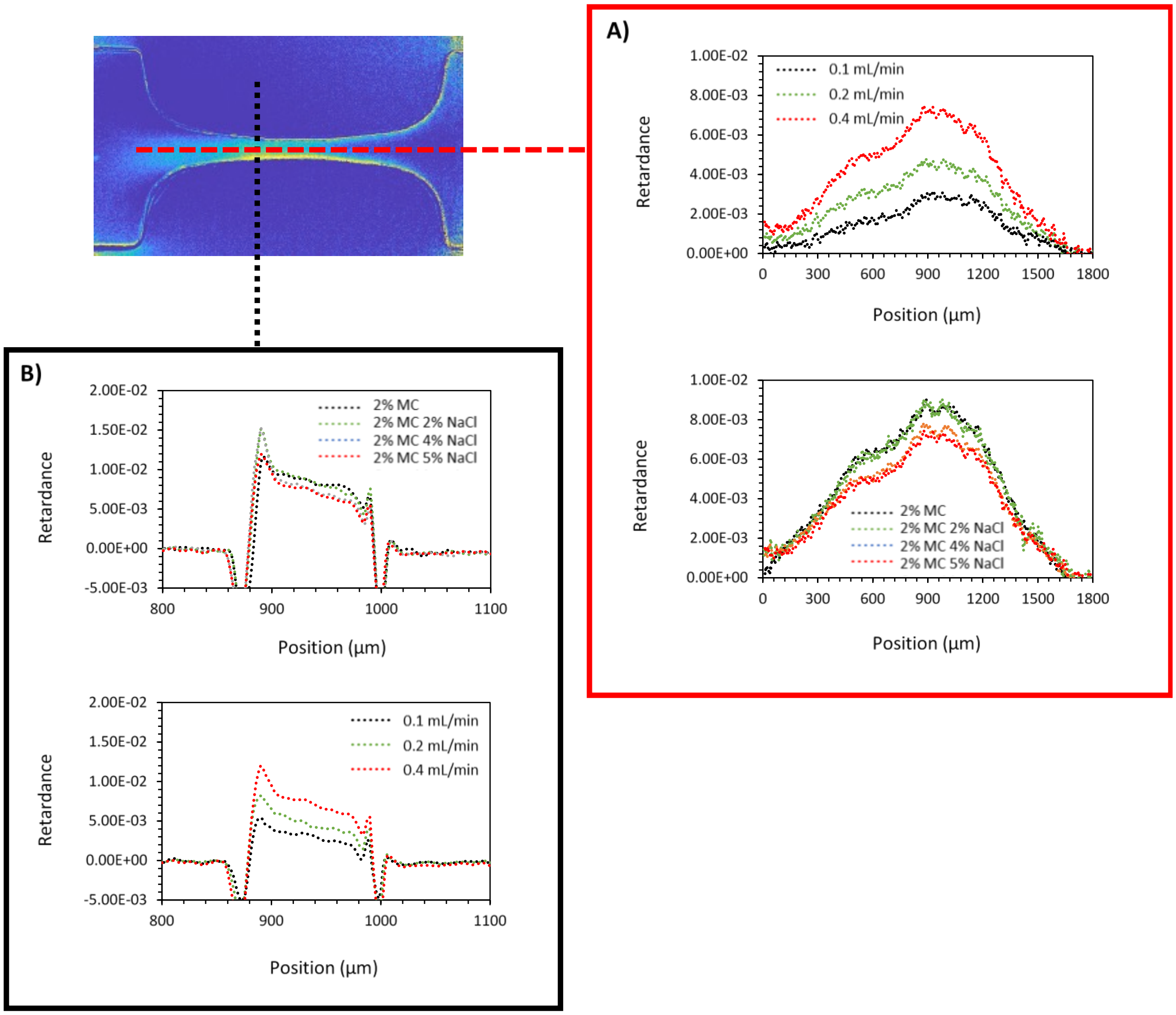

Figure S3: Shown above are both vertical and centerline cross-section analyses for different MC150 solutions. Given in (A) are centerline measurements of retardance for 2 wt% MC150 in 5 wt% NaCl at varying flow rates (top) and measurements at 0.4 mL/min for varying salt concentrations and 2% MC (bottom). Given in (B) are vertical cross-section measurements at 0.4 mL/min for varying salt concentrations and 2 wt% MC (top) and measurements for 2wt% MC150 in 5 wt% NaCl at varying flow rates (bottom). Lines shown represent a moving average over a 10 µm range.

Apparent Trouton Ratio. For fluids with viscoelastic properties undergoing planar extension, the Trouton ratio can be defined as a function of extension rate via the relation:[2] $Tr = \frac{\eta_e(\dot{\varepsilon})}{\eta_s(2\dot{\varepsilon})}$, where η_e is the extensional viscosity, η_s is the shear viscosity, and $\dot{\varepsilon}$ is strain rate. For a Newtonian fluid, the expected value of the Trouton ratio in this planar extensional flow field is 4, and it is generally expected that solutions with viscoelasticity will produce larger values than this.[2] Trouton ratios for the 1 wt% MC solutions range from ∼3.2-3.7 at deformation rates near 100 s^{-1} to ∼1.3 at rates near 3000 s^{-1}. Trouton ratios for the 2 wt% MC solutions have much greater variations due to salt concentrations, with a range of ∼0.6-3.1 at extension rates near 30 s^{-1} and a range of ∼0.9-1.3 near 500 s^{-1}. The results echo those found in Figure 4 for the extensional viscosity of these solutions, with increasing salt concentrations resulting in larger Trouton ratios and higher deformation rates leading to lower Trouton ratios. However, it should be noted that the apparent Trouton ratio found here should not be considered the same as the traditional Trouton ratio, and comparisons using values from dynamic mixed flow systems such as these should be done with care.

1. S. A. Arvidson, J. R. Lott, J. W. McAllister, J. Zhang, F. S. Bates, T. P. Lodge, R. L. Sammler, Y. Li and M. Brackhagen, *Macromolecules*, 2013, **46**, 300-309.
2. D. M. Jones, K. Walters and P. R. Williams, *Rheologica Acta*, 1987, **26**, 20-30.