Supplemental Information

The Rheology of Aqueous Solutions of Ethyl Hydroxy-Ethyl Cellulose (EHEC) and its Hydrophobically Modified Analogue (hmEHEC) II: Extensional Flow Response in Capillary Break-up, Jetting and in a Cross-Slot Extensional Rheometer

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Schematic for cellulose ethers

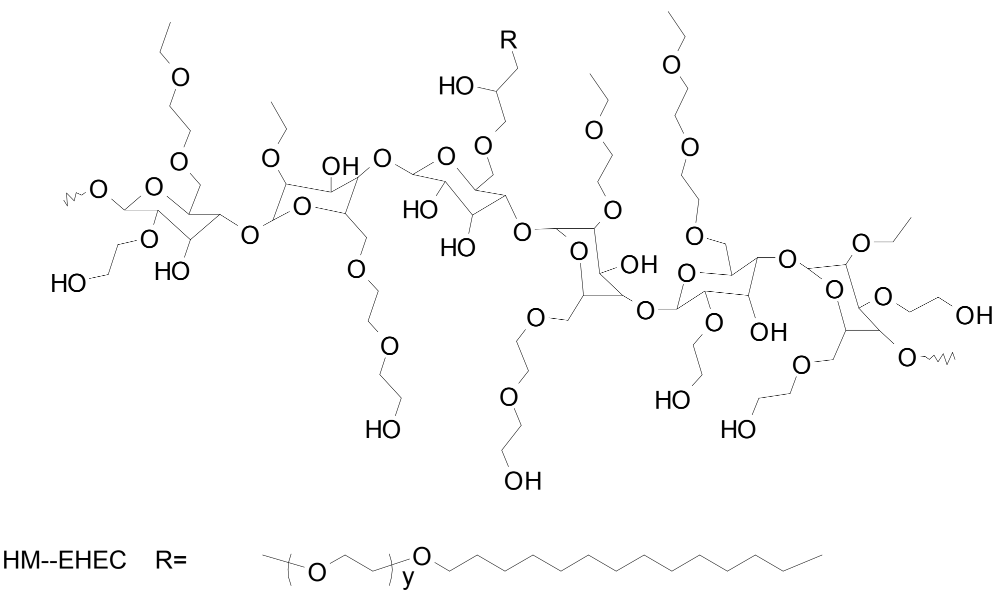
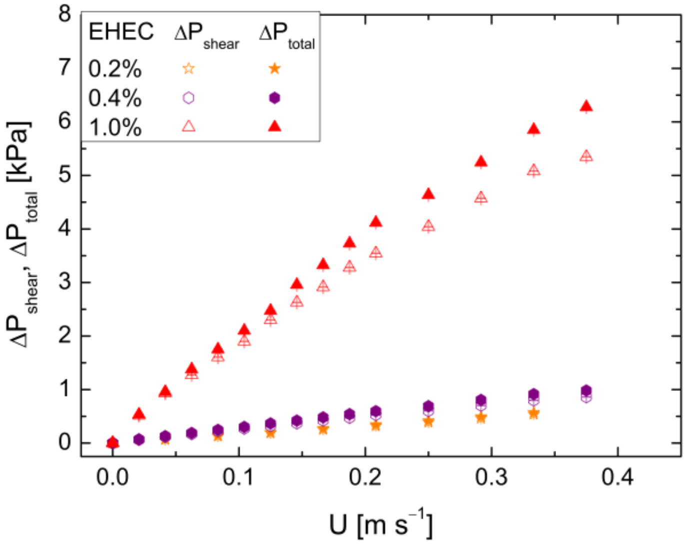
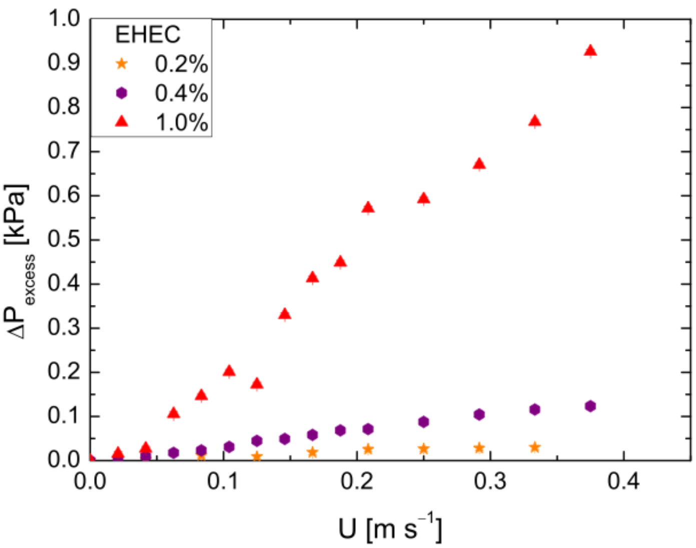


Figure ES1 Schematic of ‘tethered’ cellulose ethers: Hydrophobically modified ethyl (hydroxyethyl) cellulose (hmEHEC), with the C-14 (tetradecyl) hydrophobic side-group denoted by R and value of y can vary.

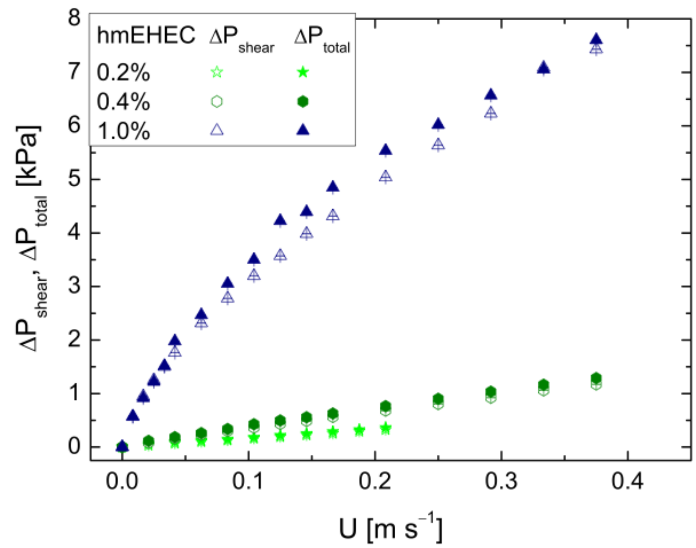
Pressure data

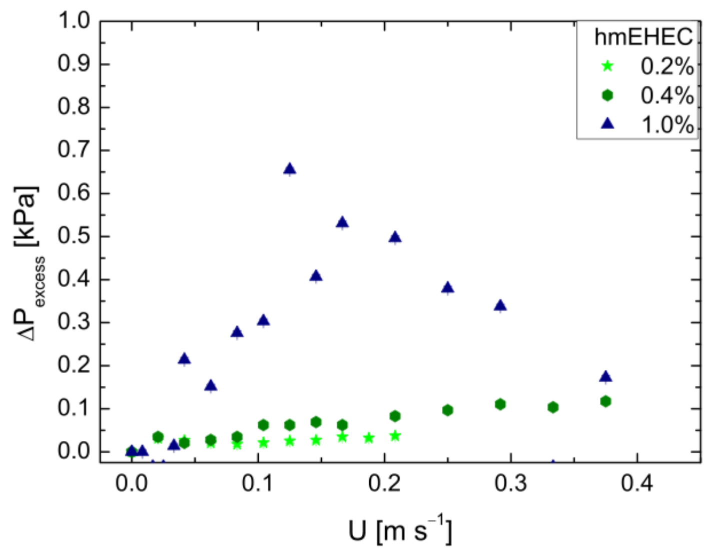
The continuous flow through the cross-slot device is driven at a controlled rate using a precision syringe pump (Harvard PHD-Ultra). The flow from the syringe pump, labeled (1) in Figure 2c, is split into two channels to provide the flow into the opposing inlets of the cross-slot (3). The two outlets are connected together so they remain at equal pressure and do not generate an unbalanced flow. One of the inlet channels is fitted with a 35 kPa gauge pressure transmitter (GE Druck) (2) to measure the pressure drop across the flow cell. Effluent was ejected to a Petri dish (5) and discarded to waste. The syringe pump delivers volume flow rates in the range 0.1 mL.min^{-1} $\leq Q \leq$ 10 mL.min^{-1}. This provides nominal extension rates at the stagnation point of 40 s^{-1} $\leq \dot{\varepsilon}_{CS} \leq$ 4000 s^{-1}. By closing the two needle valves, labeled (4), the pressure drop can also be measured for steady viscous shearing flow of fluid around a single corner of the cross-slot (ΔP_{shear}). Subsequently, the pressure drop is measured with the two needle valves open (ΔP_{total}) to generate a stagnation point flow and the excess pressure drop ($\Delta P_{excess} = \Delta P_{total} - \Delta P_{shear}$) arising as a result of the additional extensional component in the flow field is computed. It has previously been shown that the extensional stress difference $\Delta\tau$ in the stretching fluid is proportional to the excess pressure drop [5, 64] or $\Delta\tau \propto \Delta P_{excess}$. The pressure data is presented here in Figure ES2 and Figure ES3 for aqueous solutions of EHEC and hmEHEC respectively. Notice that at low flow rates, the pressure due to extensional component of flow field is computed as a difference of two small numbers, and the error bars in the low deformation rate region are relatively high.





ES2: Pressure drop measured for steady viscous shearing flow (ΔP_{shear}) of aqueous EHEC solutions around a single corner of the cross-slot. The total pressure drop (ΔP_{total}) is measured in cross-slot device across a stagnation point created when all four channels are open. (See text for details). The excess pressure drop ($\Delta P_{excess} = \Delta P_{total} - \Delta P_{shear}$) arising as a result of the additional extensional component in the flow field is computed by taking difference between two pressure measurements.





ES3: Pressure drop measured for steady viscous shearing flow (ΔP_{shear}) of aqueous hmEHEC solutions around a single corner of the cross-slot. The total pressure drop (ΔP_{total}) is measured in cross-slot device across a stagnation point created when all four channels are open. (See text for details). The excess pressure drop ($\Delta P_{excess} = \Delta P_{total} - \Delta P_{shear}$) arising as a result of the additional extensional component in the flow field is computed by taking difference between two pressure measurements.