Supporting Information for

Conformation of Methylcellulose as a Function of Poly(ethylene glycol) Graft Density

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Materials and Methods

A more detailed synthesis procedure is as follows. 250 mg (1.33 M anhydroglucose or 1.66 x 10^{-6} M polymer) of 150 kg/mol MC was dissolved in 15 mL of aqueous 1M NaOH solution in a 20 mL glass vial. To facilitate dissolution, the solution was stirred in an ice bath for 1 h. Then, the sample was brought to room temperature, and the vial was closed off with a rubber septum. Allyl bromide (with a density of 1.4 g/mL) was cannulated into the solution to avoid rapid evaporation in different stoichiometries for controlled allylation. The various formulations are as follows: ~ 4 mol allyl bromide: 1 mol anhydroglucose or 400 μL allyl bromide, 2 mol allyl bromide: 1 mol hydroxyl group or 200 μL allyl bromide, 1 mol allyl bromide: 1 mol hydroxyl group or 100 μL allyl bromide, 0.5 mol allyl bromide: 1 mol hydroxyl group or 50 μL allyl bromide, 0.4 mol allyl bromide: 1 mol hydroxyl group or 40 μL allyl bromide, 0.3 mol allyl bromide: 1 mol hydroxyl group or 30 μL allyl bromide, 0.2 mol allyl bromide: 1 mol hydroxyl group or 20 μL allyl bromide, and 0.1 mol allyl bromide: 1 mol hydroxyl group or 10 μL allyl bromide. Each solution was left to stir overnight at room temperature.

Each solution was then neutralized with ~ 15 mL of 1M HCl solution.15 mL of 1M HCl is close to enough volume to neutralize the 15 mL 1M NaOH solutions, except for the most allylated MC solutions, which required slightly less than 15 mL of HCl. The pH was monitored closely with pH strips during the titration. The resulting 30 mL solutions of 250 mg allylated MC and 800 mg NaCl were then precipitated in 10x acetone and dried under vacuum overnight. The result is a fine white powder of around 1g in quantity.

For NMR analysis the samples were re-dissolved in deuterium oxide. Detailed NMR spectra are shown in Figure S1a. Each spectrum is an average of 64 scans with a 10 s delay time. Percent allylation was measured by integrating the “e” peak at 4.5 ppm to 1, and comparing it to the “a” and “b” allyl peaks at 5.3 and 6 ppm. The formulations resulted in 28%, 15%, 10%, 4%, 1.8%, 1.5%, 0.6% allylation respectively. We note that the percent allylation is reaction time dependent since the reaction does not go to completion during the 24 hours at room temperature.

For the second step of the reaction, thiol-ended PEG was grafted onto allylated MC. 150 mg of the MC NaCl powder was re-dissolved in 4 mL of water in a 5 mL glass vials. Based on the estimated amount of salt present, the mixture has approximately 50 mg of allylated MC. The exact amount is not essential because thiol-PEG was added in excess. PEG was added at the estimated 3x molar amount of allyl groups, along with ~5% total polymer weight of IRGACURE. The solution was stirred for an hour and exposed to UV (254 – 365 nm) for 1 h with stirring. The solutions were then dialyzed against pure water for 3 days and freeze dried. For NMR analysis the samples were re-dissolved in deuterium oxide.

Detailed NMR spectra are shown in Figure S1b. Each spectrum is an average of 64 scans with a 10 second delay time. Percent allylation was measured by integrating the “e” peak at 4.5 ppm to 1, and comparing it to the “f” and “h” PEG peaks at 3.63 and 3.31 ppm. The formulations resulted in 33%, 26%, 11%, 5%, 3.4%, 2%, 0.7% PEG-ylation respectively. We show in insert iii in Figure S1b that any evidence of allyl hydrogens is gone.

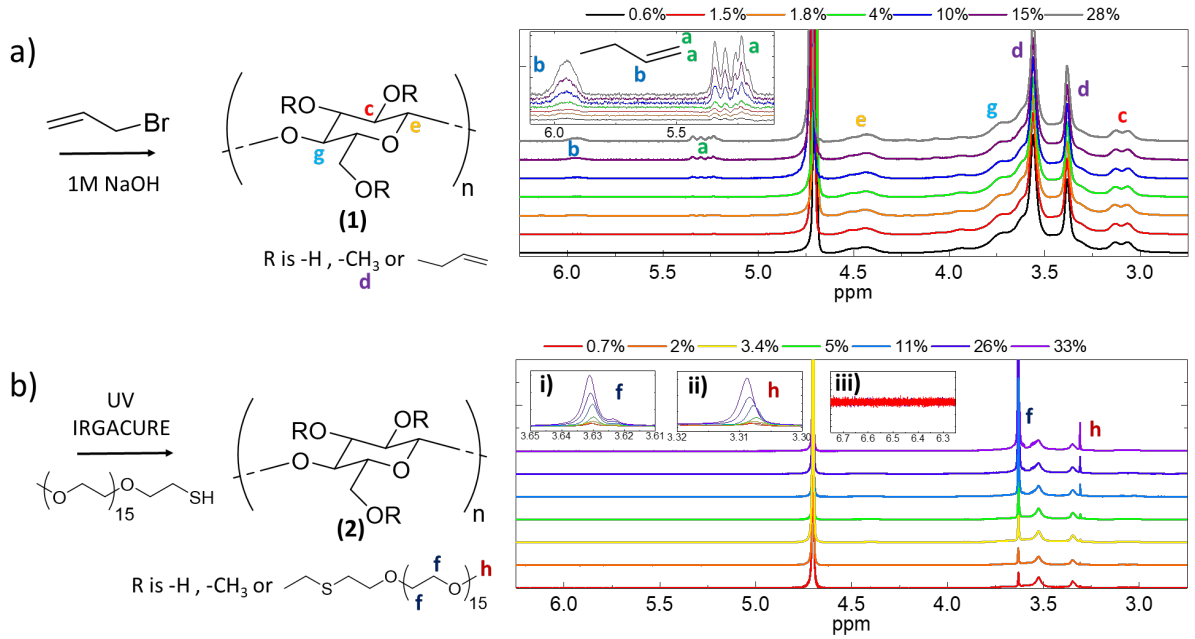

Figure S1. ^{1}H NMR analysis of the two-step thiol-ene click chemistry. a) NMR spectra for step one. b) NMR spectra for step 2.

Each MC-*g*-PEG polymer was re-dissolved in pure water at 1 wt%. For SLS, 7 mL of each concentration was made by dilution from the 1 wt% stock, and filtered into 20 mL clean scintillation vials. For SLS, average polymer intensity is measured as a function of angle and concentration. The solvent intensity is subtracted, and the polymer Rayleigh ratio is calculated with respect to a standard, in this case toluene, for each angle.

$$\frac{KcI_{toluene}(\theta)}{(I_{solution}(\theta)-I_{solvent}(\theta))R_{toluene}} = \frac{Kc}{R_\theta} = \frac{1}{M}\left(1 + 2A_2Mc + \frac{R_g^2 q^2}{3} + \cdots\right) \quad \text{(S1)}$$

To determine the weight-averaged molecular weight of the coils, M_w, the second virial coefficient, A_2, and the radius of gyration, R_g, we measure the quantity $\frac{Kc}{R_\theta}$ of the solution as a function of both the coil concentration and the scattering angle. For a solution of a constant concentration, the scattered intensity is averaged at the detector for different angles and plotted against $k'c + \sin^2\theta/2$, where k' is an arbitrary constant (equal to 5000 in our case). Repeating the procedure for different concentrations results in a Zimm plot. From the independent concentration and angle trends, two extrapolations are made, one for zero angle ($q \to 0$) and the other for zero concentration ($c \to 0$). The zero angle line for the assumptions outlined above is linear, with a y-intercept equal to $1/M_w$, and slope $2A_2/k'$. The zero concentration line is also linear, with a y-intercept equal to$1/M_w$, and slope $\frac{(4\pi^2 n^2)R^2}{3M\lambda^4}$. From the slopes and intercept of both trends, the quantities, M_w, A_2 and R_g are determined.

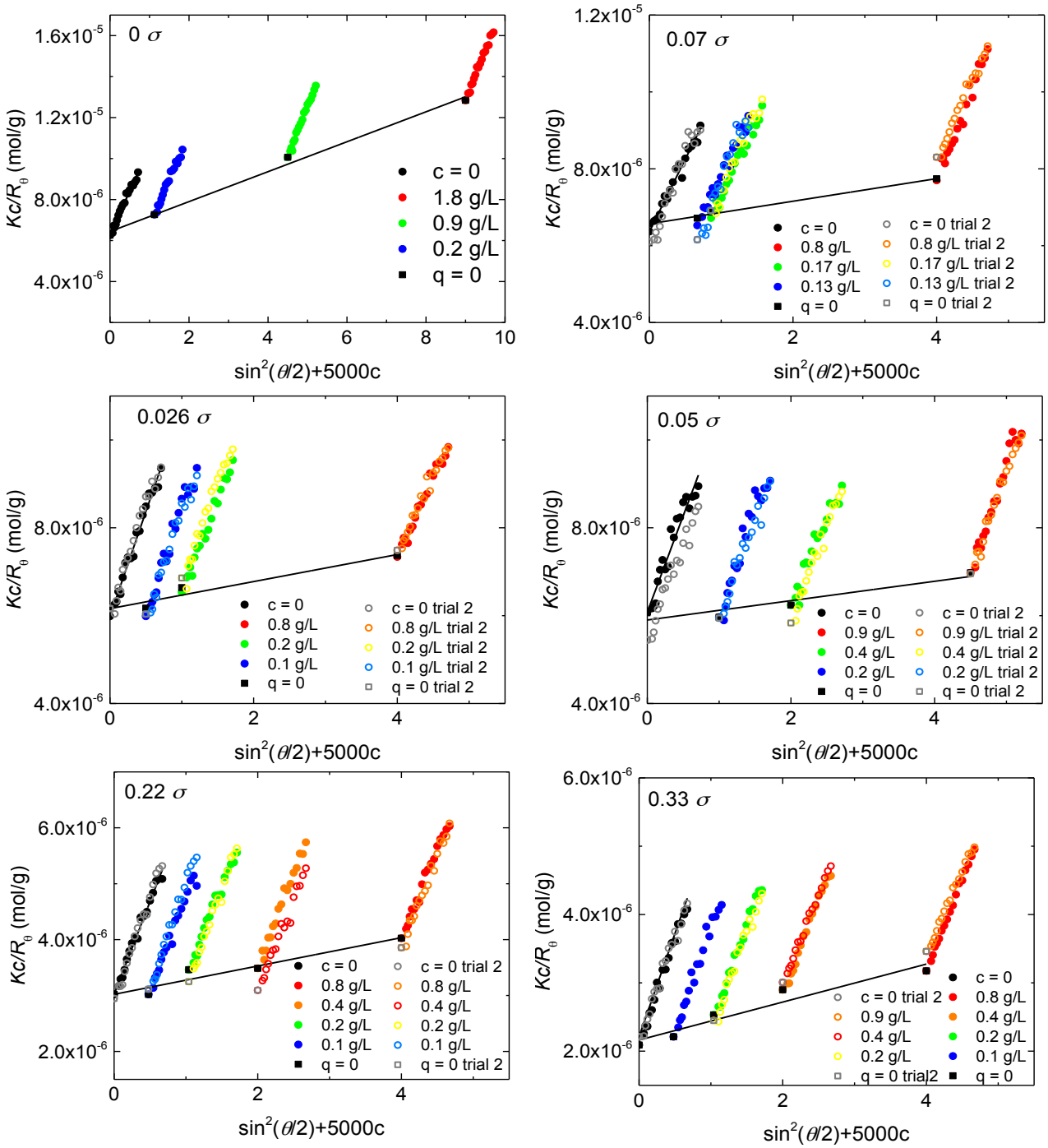

Figure S2.Zimm plots of 2%-22% grafting density MC-g-PEG. Two repeat trials are overlaid. With the exception of 22% PEG, the repeat trial was of the same solution. A new solution was prepared for the 22% PEG second trial.

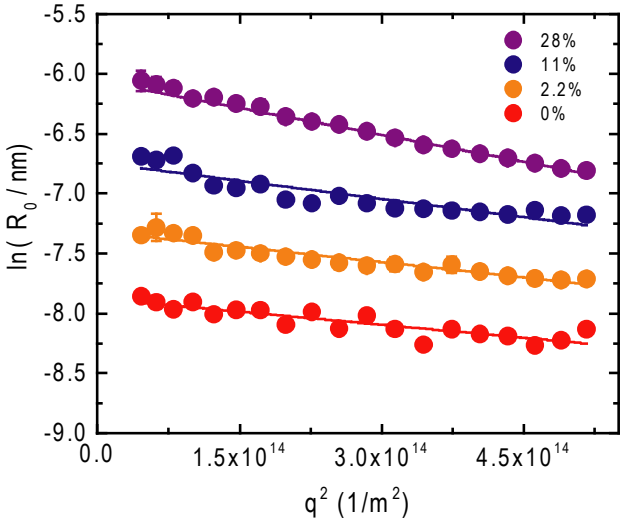

Figure S3. Guinier plots of MC-*g*-PEG for grafting densities of 0-28%. Each plot was scaled for clarity.

We used the 1 g/L solutions for DLS analysis. For DLS, the intensity intensity-intensity correlation function, $g_2(q,t) = \frac{<I(t)I(t+\tau)>}{<I(t)>^2}$, at a specific scattering vector q and lag time τ, is related to the electric field autocorrelation function $g_1(q,t)$by the Seigert relation:

$$g_2(q,t) = a(1 + \beta|g_1(q,t)|^2) \qquad \text{(S2)}$$

Here a is a baseline and β is related to the non-zero cross-sections of the scattering volume and detector pinhole. The field autocorrelation function $g_1(q,t)$ for a solution of independently diffusing molecules is a single exponential of decay rate Γ and decay time τ:

$$g_1(q,t) = \exp(-\Gamma t) = \exp\left(-\frac{t}{\tau}\right) \qquad \text{(S3)}$$

The decay rate is related to the diffusion coefficient *D*:

$$\Gamma = Dq^2 \qquad \text{(S4)}$$

We estimate the hydrodynamic radius R_H of the solute from the diffusion coefficient by the Stokes-Einstein equation.

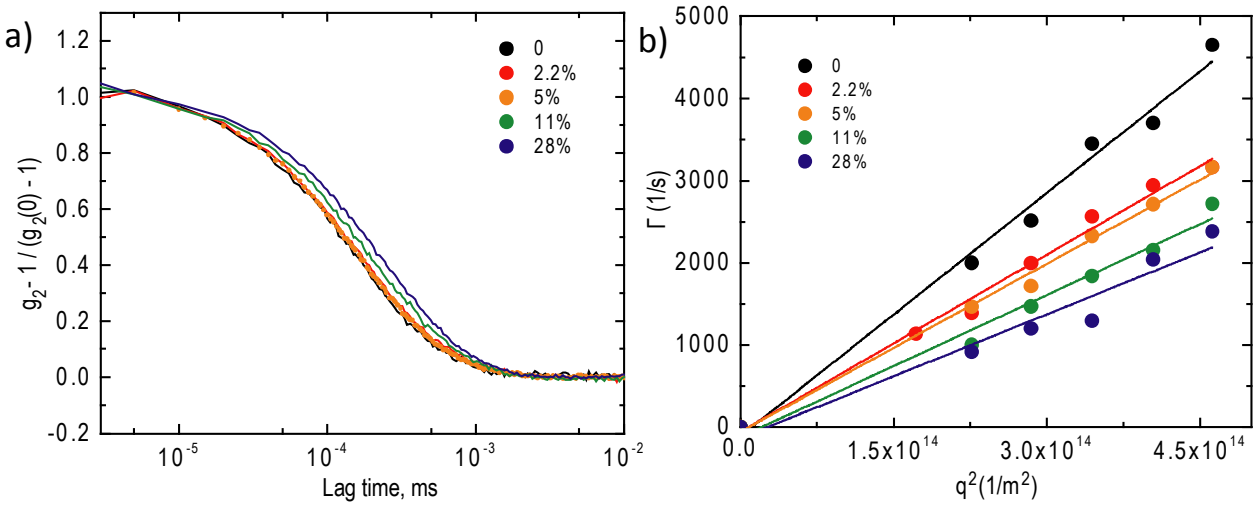

Figure S4. DLS analysis of MC-*g*-PEG. a) The normalized correlation function as a function of the lag time at 90°. The relaxation time increases as the grafting density increases. b) The relaxation rates from the peak of the distribution from REPES analysis as a function of the square of the scattering vector and grafting density. From the slope, the diffusion coefficient is determined. The diffusion coefficient decreases as a function of grafting density.

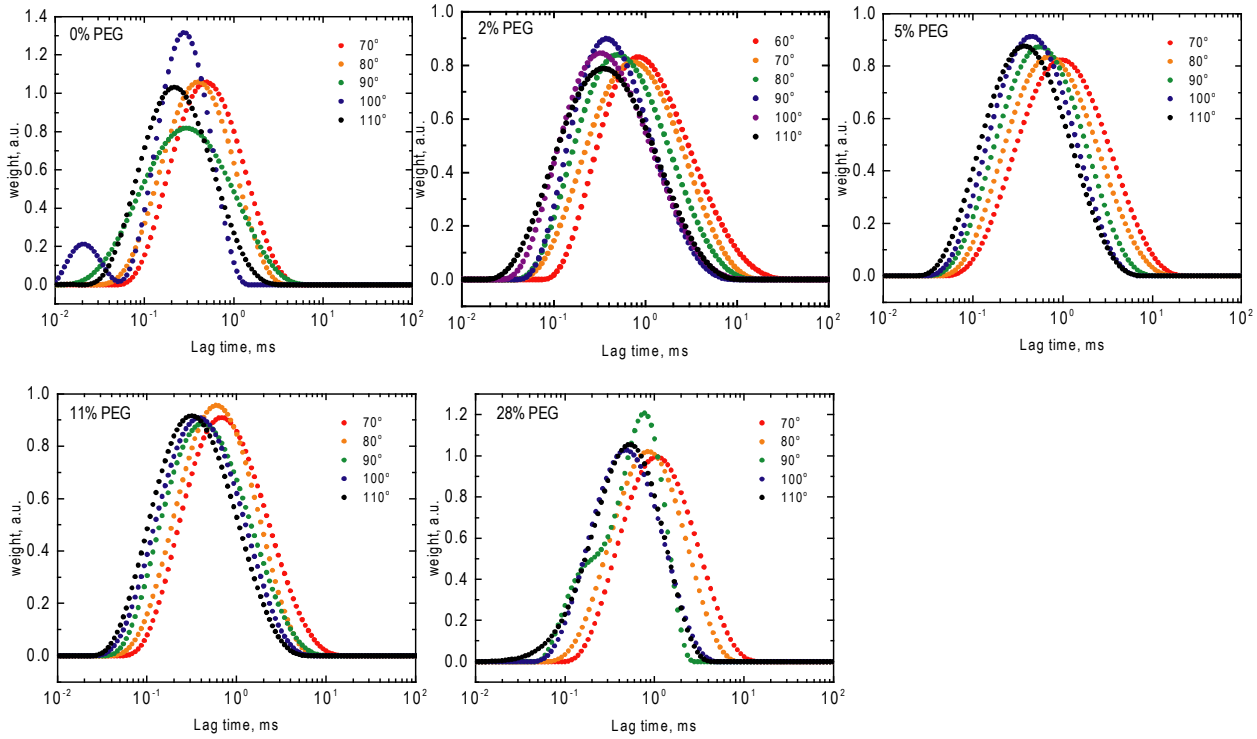

Figure S5. REPES results for different grafting densities as a function of angle.