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Characterizing polymerization dynamics using fluorescent molecular rotors and magnetoelastic sensors

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The dynamics of polymerization are critical in many medical applications; for instance, polymers used to fill aneurysms must be timed accurately. Two distinct methods were examined for their ability to probe the polymerization kinetics of different polymers and to predict the onset of polymerization. Molecular rotors are a class of fluorophores with two de-excitation pathways: fluorescence emission and intramolecular rotation. Highly viscous solvents provide a constrained environment in which intramolecular rotation is inhibited, and radiation is the preferred pathway. It is hypothesized that during polymerization steric hindrance of the intramolecular rotation leads to increased fluorescence emission intensity. Magnetoelastic (ME) sensors have been used to measure fluid viscosity. In a time varying magnetic field, a magnetoelastic strip oscillates at its viscosity-dependent resonant frequency creating a magnetic flux that is detected. Subsequently, viscosity can be analyzed by measuring quantities such as resonance frequency, signal voltage, and Q-factor. In this study, fluorescent molecular rotors and magnetoelastic sensors were evaluated for their efficacy in monitoring the polymerization dynamics of acrylamide gels, collagen, and sol-gels. The ME sensor was effective in characterizing the polymerization dynamics of acrylamide and sol-gel, where a reduced Q-factor indicated mechanical dampening of the oscillation in the polymerized state. For unknown reasons, the ME sensor was unable to characterize the polymerization of collagen. However, the molecular rotors sensed the polymerization of collagen and sol-gel though a marked increase of emission intensity. Molecular rotors deteriorate from ammonium persulfate (APS), a strong oxidant and catalyst for cross-linking in the acrylamide system. While ME sensors are effective in characterizing several polymerization reactions, molecular rotors are more effective in monitoring the polymerization of proteins such as collagen. The results also demonstrate the possibility of using molecular rotors as novel probes capable of characterizing the polymerization dynamics of various biopolymers significant to medicine.