Temperature Effect on Shear Thickening Responses

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Shear thickening fluids (STFs) are increasingly being investigated in various applications ranging from improving the ballistic impact resistance of body armor to damping the vibration of alpine skies to shielding spacecraft structures from micrometeoroid/ orbital debris (MMOD) impact. Spacecraft MMOD shields can be subjected to wide temperature variation, often more than ±100 ^{o}C. Therefore, an understanding of shear-thickening responses as a function of temperature is critical. Here we report the effect of temperature on the onset and the extent of shear-thickening for various STFs. In addition to varying the mass fractions of the dispersed phase, the interactions between the dispersed and continuous phases were controlled by altering the surface chemistry of suspended particles, the molecular architecture, and the molecular weight of the suspending media. STFs were prepared by suspending fumed silica nanoparticles with different surface functionalities in polyethylene glycol (molecular weight of 200 g/mol and 400 g/mol) and polypropylene glycol (molecular weight 700 g/mol). Rheological investigations were performed in a shear-rheometer over a temperature range of -60 °C (melting point of the continuous phase) to +50 °C. The critical shear rate marking the onset of shear-thickening decreased significantly with decreasing temperature, and the critical shear rate at each temperature scaled with the inverse of the suspending-media viscosity at that temperature. In addition to shear-rheology, the microstructure of fumed-silica in different suspending media was investigated using Small Angle Neutron Scattering (SANS).