Did you know……..that the viscosity of a synthetic latex is both particle size and shear rate dependent? And that it is extremely dependent upon solids content as that approaches 45- 50%? In many ways the rheological behavior of latexes follows the rules of other particulate dispersions, but there are some notable exceptions due to the manner in which the latex particles are rendered colloidally stable. First, and in keeping with other dispersed phase fluids, the dependency of latex viscosity, η, on the solids content (actually, the volume fraction of the polymer, φ) is very non-linear. However, at the very lowest solids content the relationship is linear and follows the well- known Einstein relationship, $\eta/\eta 0 = 1 + 2.5\ \varphi$, where $\eta 0$ is the viscosity of the continuous phase, in our case, water. The ratio ($\eta/\eta 0$) is called the "relative viscosity", ηR. As the solids content gets higher than about 15-20%, the viscosity begins to rise non-linearly and becomes near exponential (for narrow particle size distributions) above ~50%. This is shown in the figure below where φm has a value of about 0.63. This is the reason that one has to resort to biomodal particle size distributions when trying to achieve reasonable viscosities at solids contents above 60%. .
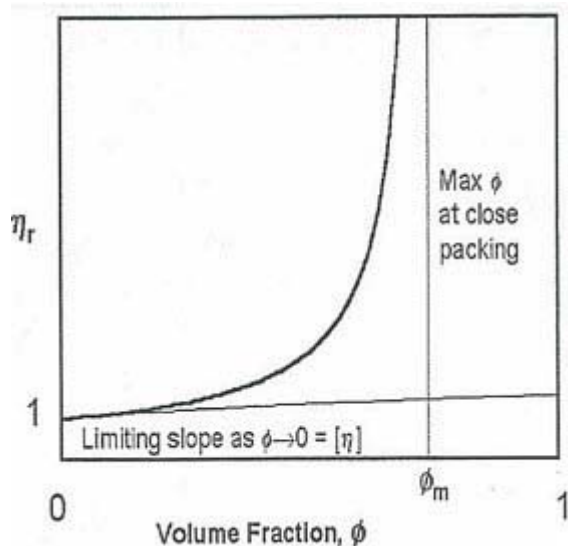
Because each latex particle is surrounded by some sort of adsorbed surfactant to keep the system colloidally stable, and that the surfactant moves with the latex particle in a shear field, the "effective volume" of each particle is larger that of the base polymer particle itself. This effective layer may be only 5 nm thick, but being at the extremity of the sphere, it represents a significant amount of "extra" volume. Clearly this effect is more easily seen for small particle sized latexes (50-70 nm) than for larger ones but it is real and has been well studied. In addition, when the colloidal stability is derived from ionic surfactants, the effective layer is sensitive to the ionic strength of the aqueous phase. A well-known trick employed to lower latex viscosity has been to add a little monovalent salt (e.g. NaCl) to the latex (short of destabilizing the latex!), thereby compressing the so-called double layer around the particles and thus lowering the

viscosity. Lastly, because the latex particles have to move around each other as they are set in motion in a shear field, the measured viscosity is dependent upon the extent of shear. This is easily seen for latexes in the 40% solids range even when using simple rheometers such as the Brookfield viscometer (a coaxial cylinder device). The figure below (taken from a published article by H.M. Laun in Angew. Makromol. Chem., 123/124, 335 1984 for a styrene-ethyl acrylate copolymer latex) shows how complicated the latex rheology can be over large ranges of shear rates (or in this case, the related shear stress, σ). Note how the viscosity becomes shear "thinning", or pseudoplastic, as the solids content (volume fraction) increase above 30%.
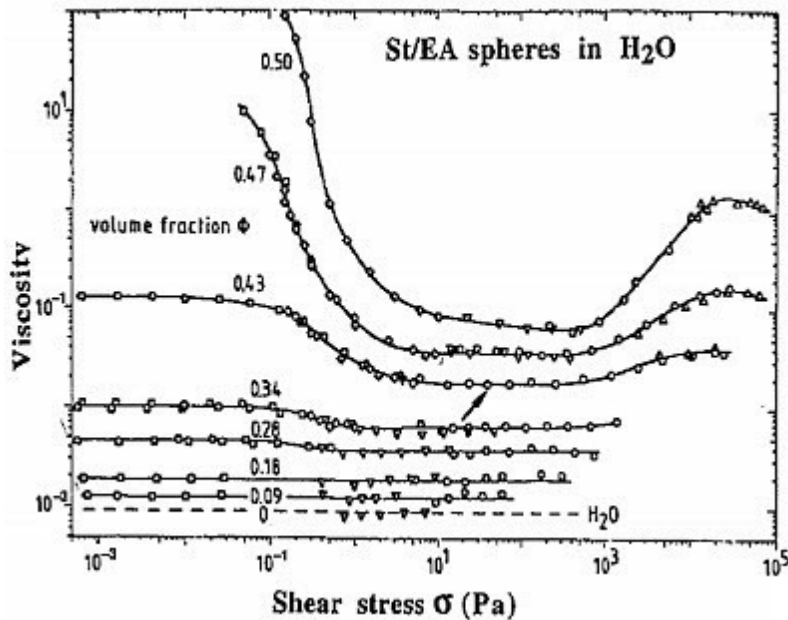
These topics are discussed in detail in our STEP 9 workshop, Rheology Fundamentals &Applications for Synthetic Latices and Associated Coating Formulations. As always, we welcome your comments and questions by contacting us via our website.
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