An osmotic approach to suspension normal stress analysis

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An approach will be presented and supported by experimental data wherein the normal stresses in dispersed particulate two-phase flows are shown to be a direct extension of the osmotic pressure. The presence in Brownian (or "colloidal") dispersions of an equilibrium osmotic pressure and the shear-induced normal stresses in a (noncolloidal or colloidal) dispersion of near-hard-sphere type will be shown to both have the tendency to drive a dilution of the suspended solids. By an experiment based on the semi-permeable membrane concept used to measure osmotic pressure, the radial normal stress in a cylindrical Couette flow of a concentrated monodisperse suspension is measured by the change in level of a manometer tube of pure fluid in communication with the sheared region through a semipermeable membrane (cloth screen for this case). An analysis is presented which identical to an approach used for describing shear-induced particle migration, and the connection to shear-induced diffusion is also addressed. It is noteworthy that the equilibrium osmotic pressure is number-density dependent whereas the sheared normal stress is primarily volume-fraction dependent.