

where:

$$\chi_s = (1/2\beta) \left\{ 1 + \left[\beta^2 / \sqrt{1 - \beta^2} \right] \ln \left(\left(1 + \sqrt{1 - \beta^2} \right) / \beta \right) \right\} \quad \text{for } \beta < 1, \quad [4a]$$

and

$$\chi_s = (1/2\beta) \left\{ 1 + \left[\beta^2 / \sqrt{\beta^2 - 1} \right] \arcsin \left(\sqrt{\beta^2 - 1} / \beta \right) \right\} \quad \text{for } \beta > 1 \quad [4b]$$

In fitting the data, the need to incorporate R_c with η , and a well-defined single-globule term (in addition to the volume-fractal) in the first bracket of eq. [1], is strong evidence for a solid volume-fractal phase. A well-defined single-globule term arises because, unlike the case of fractal pores in clays and porous rocks, nearest-neighbor solid particles cannot exist inside each other, i.e., their centers cannot approach, on average, to within R_c . This correlation-hole effect means that, for length-scales of order R_0 , the individual particles are seen as distinct objects, even when incorporated into an aggregated structure. For a spheroid of aspect ratio, β , the form-factor for a single globule, $F^2(Q)$, is given by:

$$F^2(Q) = \frac{\pi}{2} |\Delta\rho|^2 V_p^2 \left| \int_0^1 \frac{J_{3/2}(QR_o[1 + (\beta^2 - 1)X^2]^{1/2})}{(QR_o[1 + (\beta^2 - 1)X^2]^{1/2})^{3/2}} dX \right|^2 \quad [5]$$

where $V_p = (4\beta\pi R_o^3/3)$, $J_{3/2}(x)$ denotes a Bessel function of order 3/2, and X is an orientational parameter, here integrated over all orientations of the spheroid with respect to Q . Use of a mildly spheroidal globule shape avoids the pronounced Bessel function oscillations for spheres ($\beta = 1$), which can perturb the fit at high Q . Satisfactory fits are

obtainable with both mildly oblate ($\beta = 0.5$) and mildly prolate ($\beta = 2$) aspect ratios, giving globule sizes equivalent to a 5 nm sphere for cement.

The surface fractal term in eq. [2] includes ξ_s , the mean upper limit of surface-fractal behavior at which the measured smooth surface area per unit sample volume is S_0 . (The term, $\Gamma(5-D_s)$ is a mathematical gamma function.) The BACKGROUND term refers to the incoherent flat background scattering, and it is usually subtracted out of both data and fits for convenience.