Polymer Properties Quiz 12 April 15, 2016

Vilgis and Winter [Vilgis TA and Winter HH, *Colloid and Polymer Science* **266** 494-500 (1988).] describe a critical gel in Figure 2 as a gel where local clusters grow to span the entire sample. Vilgis states: *Directly at the percolation threshold, when the power law in G' and G'' is observed, no length scale matters, in contrast to regimes below the gel point where the size of the typical cluster is the characteristic length scale and above the gel point where the size of weakly linked regions dominate. At the percolation threshold the number of structures with relaxation times \tau = 1/\omega is given by N(\omega) = \omega^{ds-1} where d_s is the spectral dimension and in this case is equal to the connectivity dimension c. For percolation gels, at frequencies higher than a critical frequency, G' is proportional to G'' and both scale with a power of frequency related to d_s. Consider that the dynamic strain is related to the dynamic stress by the response function*

$$\varepsilon(t) = \int_{0}^{t} \sigma(t') \mu(t-t') dt', \text{ and that}$$

$$G^{*}(\omega, p_{c}) = a S (i\omega)^{n} \qquad (1)$$

$$\eta^{*} = (G^{\prime 2} + G^{\prime 2})^{1/2} / \omega \qquad (2)$$

For the critical percolation threshold gel, where η^* is the complex viscosity and G*is the complex modulus. Also, consider that for a simple system, such as a sphere in a viscous fluid $\tau \sim \eta/kT$,

- a) Sketch the response function for a Hookean elastic, Newtonian fluid, and a damped harmonic oscillator.
- b) Sketch the response function for a gel at the critical threshold that follows the behavior described by Vilgis and Winter.
- c) Describe the relaxation time for a harmonic oscillator, Hookean elastic, a Newtonian fluid, and a diffusing colloidal particle (polymer).
- d) What would be the characteristic of the relaxation time for the percolation gel?
- e) Sketch the creep curve (elongation versus time) for a Hookean elastic, Newtonian fluid, and an anelastic material.
- f) Sketch the creep curve you might expect for Vilgis/Winter gel at the percolation threshold. (How does it related to the response function in part b?)
- g) Explain why a percolation gel might be useful as a sound absorbing material.
- h) Explain the behavior seen in Figure 1 below.
- i) How would the creep curve differ above and below the percolation threshold?
- j) How would the response function differ above and below the percolation threshold?







(a)

(b)

(c)

Vilgis TA and Winter HH, Colloid and Polymer Science 266 494-500 (1988).



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