Comment on "Growth of Fractally Rough Colloids"

In a recent Letter Keefer and Schaefer[1] proposed a new computer simulation model to describe the surface fractal properties of rough silica particles formed in solution. The purpose of this Comment is to emphasize that the experimental results of Ref. 1, rather than requiring a new theoretical model, may represent an experimental determination of a quantity which has been much studied theoretically—the fractal dimension of percolation clusters close to and above the percolation threshold.

This suggestion results from the close similarity between the model suggested in Ref. 1 and that of restricted valence percolation.[2] The Eden model,[3] on which the model of Ref. 1 is based, can be interpreted as a Leath[4] algorithm for constructing percolation clusters when the probability of site occupation is 1 and sites have a functionality v equal to the lattice coordination number z. In restricted valence percolation, sites are assigned a functionality $v \leq z$ and if the functionality of the sites is uniform a percolation transition will occur only if v exceeds a critical value $2 < v_c < 3$.[2] If the transition occurs it has the same exponents as in conventional percolation.[2]

The model of Ref. 1 is an Eden model with functionalities (typically of 2 or 4) randomly assigned to the sites. Thus it may be interpreted as a restricted-valence-percolation system which has site occupation probability 1 but which will display a percolation transition when the mean functionality $\langle v \rangle$ is increased above some threshold $\langle v \rangle_c$. Since restricted valence percolation is expected to have the same exponents as conventional percolation we expect the fractal dimensionality of clusters generated in this model and the corresponding physical realizations to be the same as that for conventional percolation clusters. We note that it has previously been found in kinetic gelation models that random mixing of sites of different functionality does not change the exponents from those of conventional percolation.[5]

This suggestion is supported by the closeness of the fractal dimension of silica particles, grown from a 1:1 mixture of H_2O:$Si(OC_2H_5)_4$,[1] $D = 2.84$, to that of percolation clusters in three dimensions at the percolation threshold $D = 2.50 \pm 0.17$ ($D = \Delta/\nu$, $\Delta = 2.2 \pm 0.01$,[6] $\nu = 0.88 \pm 0.02$[7]). For this mixture Keefer and Schaefer concluded that the silica particles were mass fractals; this also is consistent with their having the structure of percolation clusters close to the percolation threshold.[8] No error bounds are quoted for D in Ref. 1; however, it seems probable that if $\langle v \rangle$ is slightly greater than $\langle v \rangle_c$ for this system the slight increase in D is due to crossover from mass to surface fractal characteristics.

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