Comment on "Diffusion-Limited Aggregation in Two Dimensions"

Hurd and Schaefer (HS)[1] have reported an experiment on two-dimensional aggregation of silica microspheres in which the clusters have a fractal dimension of $D = 1.20 \pm 0.15$, which is smaller than the one ($D \cong 1.4$) of the original diffusion-limited cluster-cluster aggregation model.[2] Here, I introduce a new version of the cluster-cluster model whose 2D simulations give $D = 1.26 \pm 0.06$, in agreement with the result of HS.[1] Moreover the three-dimensional result ($D = 1.42 \pm 0.06$) might account for experiments on aluminum hydroxides.[3]

Let me use an off-lattice "hierachical" method[4] in which successive collections of clusters of the same size are built. Given a collection, the clusters are grouped into pairs to generate the new collection. Here the model differs in the way that a new cluster is built. Given the two clusters of a pair, say C_1 and C_2, I first choose a random direction in space. Then I determine the particle of C_1 (C_2) which has the largest (smallest) abscissa along this direction. Then C_2 is translated (without rotation) to a position C_2' where these two particles become, on contact, aligned along the chosen direction (see Fig. 1).

I think that this procedure is justified for polarizable clusters. Before two clusters collide, they develop opposite charges on their nearest tips (which, when the clusters are far apart, correspond to the particles defined above). The diffusion process is then biased by electrostatic attractions and the clusters stick on these tips. I neglect the repulsion between a given tip and the opposite part of the other cluster, which is of smaller intensity. Indeed, as noticed by HS,[1] this would produce further alignment of the clusters. However, I just show here that it is not necessary to take it into account.

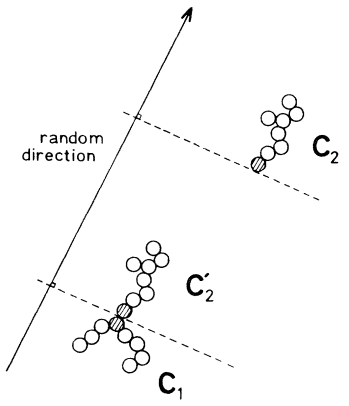

FIG. 1. Sketch of the collision process (see text).

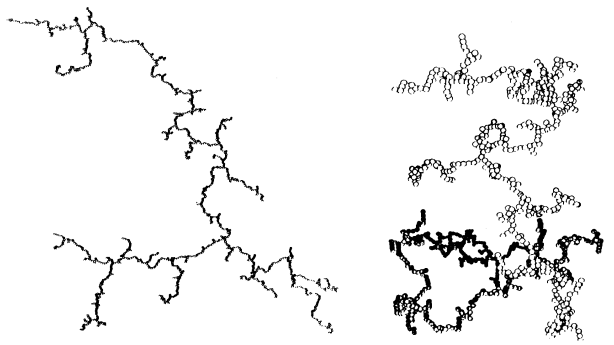

FIG. 2. Typical clusters of 1024 particles in $d = 2$ (left-hand side) and $d = 3$ (right-hand side).

I have generated 100 independent clusters of 8192 particles, up to $d = 20$ (see Fig. 2). From the behavior of the averaged radius of gyration, I get $D = 1.26 \pm 0.06$, 1.42 ± 0.05, and 1.56 ± 0.06, in $d = 2$, 3, and 4, respectively. I have also investigated the particle-cluster counterpart of this model. The clusters exhibit stick shapes with $D = 1$, in any dimension.

In conclusion, in contrast with several extensions of diffusion-limited aggregation models, which considered larger penetrations (in particular by a decrease of the fractal dimension of the cluster trajectory), the present model introduces a very simple alternative extension towards smaller penetrations.

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