Cohesion of Amorphous Silica Spheres: Toward a Better Understanding of Growth of Silicate Dust Aggregates via Coagulation in Protoplanetary Disks and Molecular Clouds

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Adhesion forces between submicrometer-sized silicate grains play a crucial role in the formation of silicate dust agglomerates, rocky planetesimals, and terrestrial planets. The surface energy of silicate dust particles is the key to their adhesion and rolling forces in a theoretical model based on the contact mechanics. Here we revisit the cohesion of amorphous silica spheres by compiling available data on the surface energy for hydrophilic amorphous silica at various circumstances. It turned out that the surface energy for hydrophilic amorphous silica in vacuum is a factor of 10 higher than previously assumed. Therefore, the previous theoretical models underestimated the critical velocity for sticking of amorphous silica spheres as well as the rolling friction forces between them. With the most plausible value of the surface energy for amorphous silica spheres, theoretical models based on the contact mechanics are in harmony with laboratory experiments. Consequently, we conclude that silicate grains with a radius of 0.1 μm could grow to planetesimals via coagulation in a protoplanetary disk. We argue that the coagulation growth of silicate grains in a molecular cloud require organic refractory mantles rather than icy mantles.