EPSC Abstracts
Vol. 7 EPSC2012-686-2 2012
European Planetary Science Congress 2012

On the shape of Venus cloud particles

L. V. Starukhina (1), **O. S. Shalygina** (2), W. J. Markiewicz (2)
(1) Astronomical Institute of Kharkov National University, Sumskaya 35, 61022, Kharkov, Ukraine (Larissa.V.Star@mail.ru)
(2) Max-Planck-Institut für Sonnensystemforschung, Katlenburg-Lindau, Germany

1. Introduction

The optical properties of planetary atmospheres are sensitive to the shape of the particles in the clouds and haze. For venusian atmosphere, ferric chloride and elemental sulfur have been suggested as candidates for the unknown UV absorber [3, 2]. The clouds were supposed to consist of liquid spherical droplets of sulfluric acid. However, at low temperatures of the upper atmosphere, sulfluric acid can be in crystalline form, which implies nonspherical shape of the particles. Below we show that, in the timescales of the atmospheric processes, the sharp edges on the surfaces of sulfuric acid crystals may be smoothed so that the particles may be considered spherical, which is not the case for other candidate particles in Venusian atmoosphere.

2. Kinetics of smoothing of particles' shapes

Consider the kinetics of surface smoothing following [1]. The temperatures in Venus upper atmosphere are too low for transport of the atoms through solid phase, either in the volume or on the surface of a crystal. Due to by many orders of magnitude faster diffusion in gas, the atoms can be transferred via gas phase, selectively evaporating from the locations of higher curvature (edges), diffusing in the surrounding gas, and condensing predominantly at the locations of lower curvature (facets) thus smoothing a particle. The two stages of the process (diffusion and evaporation-condensation processes on the surface) can be described by the two terms in the formula for smoothing time:

$$\tau = [(kT)^{3/2} r^2 / \alpha \omega^2 p_0][r(kT)^{1/2}/D + (2\pi m)^{1/2}]$$

where T is temperature, k is Boltzmann constant, r is characteristic size of the surface details of higher curvature, α is surface tension, ω is the volume per unit molecule in solid phase, p_0 and D are the pressure of saturated vapor and diffusion coefficient at temperature T, and m is the mass of molecules.

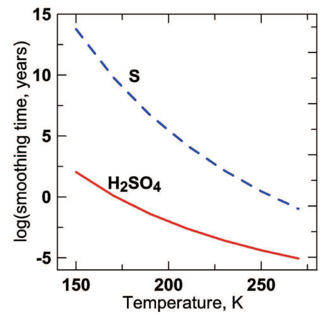

Figure 1: Smoothing times for submicron ($0.3\,\mu$m) details on the surfaces of sulfur and sulfuric acid solid particles.

Since p_0 exponentially depends on temperature: $p_0 = p_{00} \exp(-U/kT)$, temperature dependence of τ is controlled by p_0 and determined by the value of evaporation energy U. The results of calculation of τ for sulfur and sulfuric acid are shown in Fig. 1. Low values of U ($0.51\,$eV) provide higher vapor pressure for H_2SO_4, so that smoothing times are rather short, whereas high U for sulfur ($1.03\,$eV) makes its vapor pressure too low for any smoothing to occur. Vapor pressure of $FeCl_3$ is much lower than that of sulfur, so for $FeCl_3$ crystals no smoothing can be expected. In modeling of phase curves, particles of sulfuric acid may be concidered close to spherical even in solid phase.

References

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