Abstract

1 Introduction

In the kinetmatic regime (droplets are much smaller than the mean free pat of the molecules, the effluent flux is given by

$$\mathcal{F} = Nu/4 \tag{1}$$

where $N = C_{\mathrm{Si\,O_2}} - C_s$ is the molar consentration of the condensing gas, C_{SiO2} is the molar concentration of $\mathrm{SiO_2}$ gas, C_s is saturation concentration of the same gas and u is the mean velocity of the gas molecules, which can be found from the mean of the Maxwell-Botzmann distribution:

$$u = \sqrt{8k_BT/(\pi m_{SiO2})}, \tag{2}$$

where k_B is Boltzmann's constant, T is fluid temperature and m_{SiO2} is the molecular mass of $\mathrm{SiO_2}$. Hence, the units of $\mathcal{F}$ is $\mathrm{mol/m^2/s}$. The total molar rate of condensation on the surface of a particle with radius r is then given by

$$F = \mathcal{F}4\pi r^2. \tag{3}$$

From this it is clear that the volumetric change of the droplet becomes

$$\frac{dV}{dt} = FM_{SiO2}/\rho_{ms}, \tag{4}$$

where $M_{SiO2} = 60$ kg/kmol is the molar mass of $\mathrm{SiO_2}$ and $\rho_{ms} \sim 2300$ kg/m$_3$ is the true density of a microsilica particle/droplet. For a spherical particle we know that $dV = 4\pi r^2 dr$, such that

$$\begin{aligned} \frac{dr}{dt} &= \frac{dV}{dt}\frac{1}{4\pi r^2} = \mathcal{F}4\pi r^2 \frac{M_{SiO2}}{4\pi r^2 \rho_{ms}} \\ &= (C_{SiO2} - C_s)\sqrt{8k_BT/(\pi m_{SiO2})}\frac{M_{SiO2}}{4\rho_{ms}} \\ &= A(C_{SiO2} - C_s)\sqrt{T}, \end{aligned} \tag{5}$$

where $A = 0.122$.