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# Modeling and simulation of ellipsoidal droplets growing on patterned substrates during dropwise condensation

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## 1 Introduction

The aim of this study is to present a mathematical model for simulating growth of ellipsoidal droplets on patterned substrates. The application of this model will be in studying how to control the size of water droplets formed on the vitreous substrates like glasses, optical lens and car light shields. in this regard, droplets growth on two kinds of patterned surfaces (pillared and sinusoidal substrates) are studied. Up to know the process of dropwise condensation was mostly studied on flat surfaces [1, 2] or surfaces with coatings [3] that has harmful effects on environments.

The process of dropwise condensation consists of five main stages: nucleation of initial droplets, growth rate due to adsorption, growth rate due to coalescence, nucleation of new small droplets, and sliding very big droplets from the surface. As is shown in figure 1, on textured surfaces the droplets are more ellipsoids than circular.

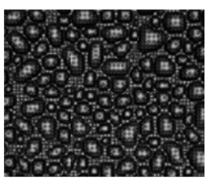

Figure 1: *Drops on textured surfaces are more ellipsoid shape*

Here we developed a novel methodology to simulate the growth rate of ellipsoidal droplets due to both adsorption and coalescence on different patterned surfaces. The results of this algorithm are validated by comparing with experimental data on 6 different patterns of pillars. The experiments are carried out on the surfaces that are textured using laser technology, without any chemical and harmful coatings.

In our model ellipsoidal droplets nucleate all around the substrate with three radius $a$, $b$, and $c$ along the axis $X$, $Y$, and $Z$ respectively. The equation of each ellipsoid is:

$$\frac{1}{a^2}(X-X_0)^2+\frac{1}{b^2}(Y-Y_0)^2+\frac{1}{c^2}(Z-Z_0)^2=1 \tag{1}$$

Ellipsoidal droplets can touch in different ways. For calculating the intersection between two ellipses in two dimension, one has to solve the system of equations of two ellipses, considering the point of (0,0) in the center of first ellipse. So the equation of the first ellipse will reduce to equation (2).

$$\begin{cases} A_1X^2+Y^2=R_1, & (2) \\ A_2(X-X_0)^2+(Y-Y_0)^2=R_2, & (3) \end{cases}$$

where $A_1=\frac{b_1^2}{a_1^2}$ and $R_1=b_1^2$, $A_2=\frac{b_2^2}{a_2^2}$, and $R_2=b_2^2$. The growth rate of ellipsoidal droplets is modeled by assuming:

$$\frac{\mathrm{d}c}{\mathrm{d}t}=(\frac{f^2.r^2}{e.c^2})\frac{\mathrm{d}r}{\mathrm{d}t}, \tag{4}$$

where $\frac{\mathrm{d}r}{\mathrm{d}t}$ is the growth rate of an sphere having the same volume as ellipsoidal drop and $e=\frac{b}{a}$ and $f=\frac{c}{a}$. $\frac{\mathrm{d}r}{\mathrm{d}t}$ can be calculated as the method developed at [1].

## 2 Results and discussion

The presented model is applied to 6 different pillared surfaces and its mean error is calculated on all the surfaces of about 10% for droplets density and 2% for droplets size that is the similarity between the droplets appearance and pillars that makes it difficult to identify the exact number of droplets.

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