Influence of contact angle and temperature on evaporation of sessile liquid droplets

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It was shown experimentally earlier, that the rate of change of the volume of an evaporating droplet depends linearly on the radius of the droplet base [1, 2]:

\[
\frac{dV(t)}{dt} = -\alpha L(t),
\]

where \(t\) is time, \(V(t)\) is the droplet volume, \(\alpha\) is a proportionality constant, \(L(t)\) is the radius of the droplet base. The latter means proportionality of total flux of vapour from the surface of a droplet, \(J\), to the radius of the droplet base, \(L\).

Computer simulations were carried out to verify the above experimental dependency (1), as well as to investigate the dependency of proportionality coefficient \(\alpha\) on contact angle, \(\theta\), and average temperature, \(T_{av}\), of the droplet surface.

The following phenomena were taken into account in our simulations: a heat conduction in the substrate, liquid droplet and surrounding air; the latent heat of vaporisation; vapour diffusion in the surrounding air; viscous flow in a droplet caused by thermocapillary tangential stress.

Convection in the air was neglected because experiments [3] have shown that there is no influence of a forced convection in the surrounding air on the evaporation rate. The Soret effect also was neglected due to small range of temperatures (less than 3 degrees) in the system under investigation.

The simulation has revealed that the proportionality coefficient \(\alpha\) substantially depends on the contact angle, \(\theta\), as well as directly proportional to the difference of saturated and ambient vapour concentrations, \(C_{sat}(T_{av}) - C_{\infty}(T_{\infty})\), at the droplet surface and in ambient air respectively. The results of simulations are in an agreement with the analytical solution obtained by R.G. Picknett and R. Bexon [4]. The only influence of the average temperature, \(T_{av}\), of the droplet surface on \(\alpha\) is the change of saturated vapour concentration \(C_{sat}(T_{av})\).

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