

Nonisothermal desorption of droplets of LiBr salt solution on a heated wall

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Abstract. Nonisothermal desorption and crystallization of droplets of aqueous salts solution of H₂O/LiBr were studied experimentally. A droplet was placed on a horizontal heated wall. The initial concentration of salt C_0 varied within 0-53 %. The wall temperature T_w varied within 80 - 235 °C and ambient air pressure was 1 bar. It was shown that the desorption time t_1 decreases sharply with increasing T_w and at $T_w < 150-160$ °C. The desorption time t_1 is the time until the onset of crystallization. The desorption time t_1 is quasi-constant at $T_w > 160$ °C and increases with growth in C_0 .

1 Introduction

The droplet evaporation was investigated in a considerable number of works [1-6]. The evaporation of drops is widely used in modern technologies [1, 3]. Gas-droplet flows are used in technical apparatuses [6]. When burning gas hydrate of methane a vapor-droplets flow is formed and a combustion temperature is significantly lowered [7]. The significant decrease in the combustion temperature sharply reduces the efficiency of the combustion technology of this natural raw material. The desorption rate and the heat transfer coefficient depend on wall properties and wettability [3]. The behavior of the desorption depends on a solution convection and a degree of turbulence of a gas flow [8, 9]. It is important to investigate the desorption process of aqueous salt solutions for a wide range of technical tasks. The behavior of salt solutions differs from the behavior of one-component liquid [10-14]. The nucleate boiling of an salt solution droplet can be divided into several characteristic regimes [14]. The following typical stages of heat and mass transfer can be distinguished depending on wall temperature T_w : 1) evaporation below boiling temperature T_b ; 2) nucleate boiling; 3) transitional stage; 4) boiling at Leidenfrost temperature T_L . Heat and mass transfer in the salt solution was investigated in [15]. Crystallization during desorption of a salt solution was considered in [16-18]. The onset of crystallization in a droplet is realized at a droplet edges and in a solution layer at a distance from the side heated wall [16, 18]. The crystallization kinetics depends on the heat and mass transfer and a degree of a solution supercooling [17]. Aqueous salt solutions can be divided into two kinds depending on the desorption behavior. The structural wall enhances heat transfer and increases the rate of the droplet evaporation [19].

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2 Experimental data

The experiments were carried out at relative air humidity of 40 %, ambient air temperature was 22 °C and ambient air pressure was 1 bar. The droplet of aqueous salt solution of LiBr was placed on the horizontal heated wall. The values of initial mass concentration of solutions C_0 were determined by the standard densimeters. Fig.1 represents the behavior of the time of crystallization onset t_1 for different wall temperature T_w and C_0 . With increasing the wall temperature for $T_w < 150$ °C, the heat transfer coefficient increases, and the evaporation time t_1 of the droplet decreases. The desorption time t_1 is the time until the onset of crystallization. The desorption time t_1 is quasi-constant at $T_w > 160$ °C and increases with growth in C_0 . It is probable that the constant value of t_1 is due to the attainment of T_s (T_s is the surface temperature of the drop) and the free convection velocity in the liquid of the maximum values (the values of these parameters reach a maximum and then practically do not change). At the boiling crisis of a one-component liquid the growth of the wall temperature leads to an increase in t_1 . However, for a salt solution, the behavior of t_1 is different. With increasing wall temperature (at the boiling crisis), the time t_1 tends to a constant value.

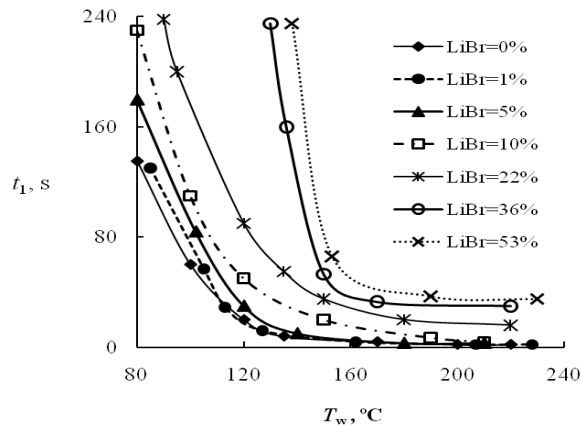


Fig. 1 The time of crystallization onset t_1 ($V_0 = 50 \mu\text{l}$).

There is a stable vapor film under a water droplet at the Leidenfrost temperature T_L . For the droplet of salt solution, this stable vapor film is absent. There are three time modes of the droplet evaporation (for $T_w > 130-160$ °C): 1) In the initial time period, the drop jumps and periodically touches the wall. Touching is accompanied by a spray of liquid. 2) The wall cools down after a while and the drop begins to evaporate like a sessile drop (without detachment from the wall). 3) The evaporation and heat transfer are realized in the presence of a crystalline crust on the droplet surface.

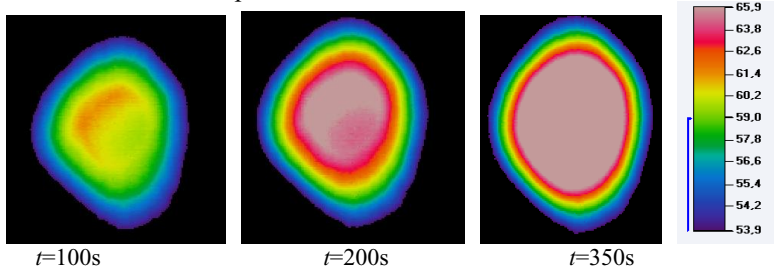


Fig. 2. Droplet thermal imaging ($T_w=70$ °C; $C_0 = 22\%$).

Thermal imaging of the droplet of LiBr salt solution is shown in Fig. 2. With increasing salt concentration, the temperature T_s on the droplet free surface becomes more uniform due to a suppression of liquid convection. A sharp increase in the concentration of salt leads to a multiple increase in the viscosity of the solution and to the suppression of convection inside the drop.

3 Conclusions

Experimental studies of droplet of water and aqueous salt solution of $H_2O/LiBr$ have been carried out.

Experimental data have shown that the behavior of aqueous solutions and water is qualitatively and quantitatively different. The desorption time t_1 decreases sharply with increasing T_w for $T_w < 150-160$ °C. The desorption time t_1 is quasi-constant at $T_w > 160$ °C and increases with growth in C_0 .

The obtained experimental dependences for t_1 can be used for the calculation of the desorber cycles of a thermal absorption pump.

The study of the evaporation of salt solutions layers was funded by FASO Russia.

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