Evaporating Progress of Hexane Droplet on the Surface of Nacl Solution

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1 Introduction

Understanding the interaction among droplets is one of the most scientific and practical importance in many applications [1]. The interaction of the same droplets on solid (rigid) substrates has been extensively studied for decades. At present, it is very meaningful to study the interaction between different incompatible droplets. In order to better understand the evaporation of hexane on the surface of NaCl solution, we will measure the radius and mass of hexane in different concentrations of NaCl solution, and the experimental results are obtained and discussed in this paper.

2 Methodology

In our evaporative lens experiments, laboratory-produced deionized water (DI) was used with a purity of 99% hexane. Subsequently, we used a salt to change the surface tension between water, hexane and air and form well-defined droplets. The experiment was carried out in the laboratory where the air temperature was maintained at 25 ± 1 °C. The surface tension of hexane is 17.89 mN/m at 25 °C. As for the surface tension of brine (γ_{sa}, mN/m), it is related to the temperature (t, °C) and salinity (s, g/kg), which can be expressed as Eq. (1).

$$\gamma_{sa} = 75.59 + 0.021352 * s - 0.13476 * t - 0.00029529 * s * t \tag{1}$$

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In our experiments, the room temperature was kept at 25 ± 1 °C, so the surface tensions of the brine with a concentration of 6%, 12%, 18% and 24% (60 g/kg, 120 g/kg, 180 g/kg and 240 g/kg) are 73.3 mN/m, 74.1 mN/m, 75 mN/m and 75.8 mN/m, respectively.

3 Resutls and Analyses

Figure 1 shows the diagram of the lens. When one droplet drops on the liquid surface, the droplet will float on the liquid surface for the balance of the surface tension and the gravity. If the droplet diameter is enough small, the gravity can be neglected, so the tension balance can be shown as Eq. (2).

$$\gamma_{sa} = \gamma_{ha}\cos\theta_1 + \gamma_{sh}\cos\theta_2 \tag{2}$$

γ_{sa}, γ_{ha} and γ_{sh} indicate the surface tension between NaCl solution and air, the surface tension between hexane droplets and air and the surface tension between hexane droplets and NaCl solution, mN/m, θ_1 and θ_2 are the contact angle for the two different parts, one is over the liquid surface and another is the under the liquid surface. For the surface tension between hexane droplets and NaCl solution, according the Good–Girifalco rule, it can be calculated as Eq. (3).

$$\gamma_{sh} = \gamma_{ha} + \gamma_{sa} - 2\varphi_{sh}\sqrt{\gamma_{ha}\gamma_{sa}} \tag{3}$$

Figure 2 shows the diameter development of the hexane droplet on the different concentrations of the brine surface. From Fig. 2, we can find that the total process of the evaporation can be divided into three stages, including the expansion stage, the stable evaporation stage and the vanishing stage.

For the expansion stage, it is resulted from the diminution of the surface tension between hexane droplets and NaCl solution. When the droplet of hexane was dripped on the surface, there was an interface between brine and hexane was formed, but it is unstable because of the diffusion of hexane to the brine. With the decrease of the concentration of hexane in the interface, the surface tension between hexane and brine will decrease. From Eq. (2), in order to keep the balance, the contact angle needs

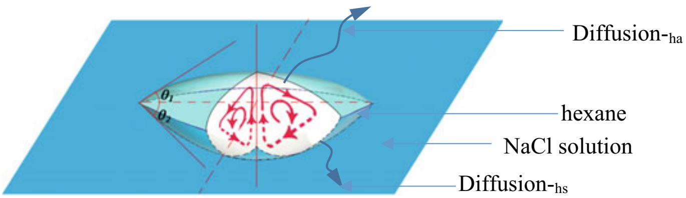

Fig. 1 Process of evaporation of hexane droplets on the surface of NaCl solution

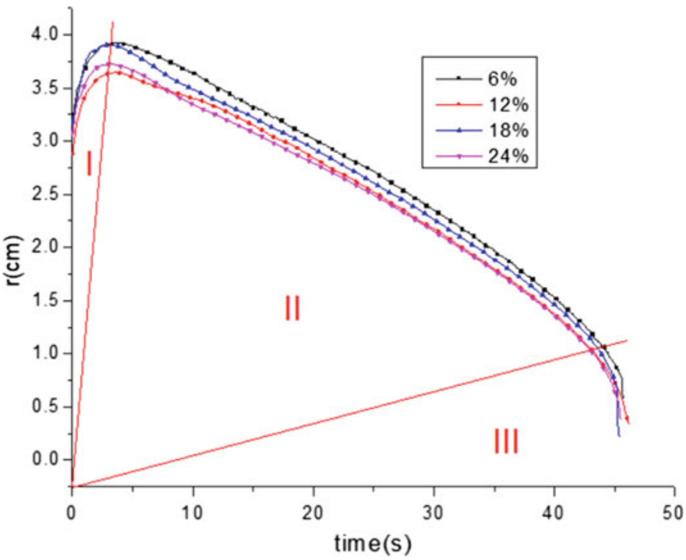

Fig. 2 Hexane-NaCl-Evaporation evaporation process

to be reduced, so the diameter will increase. When the equilibrium state between the brine and the hexane is set up, the evaporation process reaches to a stable evaporation stage. To the end of the evaporation, the contact angle θ_1 almost is zero, and hexane will be a thin film on the brine, so it vanished quickly.

As for the effect of the concentration of the brine, it depends on the surface tension balance among the brine, the air and the hexane. From Eqs. (2) and (3), if the φ_{sh} is a constant coefficient, the θ_1 and θ_2 will decrease with the concentration of the brine. So under a certain volume of hexane, with the decrease of the contact angle θ_1 and θ_2, the diameter of the hexane droplet will increase, so the evaporation process shown the characteristics in Fig. 2.

4 Conclusions

1. When the hexane droplets evaporate on the surface of the NaCl solution, it is mainly divided into three stages. The first stage was the period of the dimeter of the droplet expansion, the second stage was the period of the steady evaporation, and the third stage is the vanishing period of the droplet.
2. At the same temperature, the diameter of the expanded hexane droplets increases with the decrease of the concentration of the NaCl solution.

Reference

1. R. Iqbal, S. Dhiman, A.K. Sen, A.Q. Shen, Dynamics of a water droplet over a sessile oil droplet: compound droplets satisfying a Neumann condition. Lanqmuir **33**(23), 5713–5723 (2017)