

Enhanced solvent drying in surfactant polymer blend coating

M. Yamamura, H. Yoshihara Y. Mawatari and H. Kage

Department of Applied Chemistry
Kyushu Institute of Technology
Tobata, Kitakyushu, Fukuoka 804-8550 JAPAN

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1. Introduction

In surfactant solution drying, a surface-active molecule adsorbs at the gas/liquid interface and/or form self-assembled structures on a molecular level [1]. While the equilibrium properties of adsorbed surfactant layers have been extensively studied, the physics of the surfactant blend drying under non-equilibrium conditions is far from complete understanding, especially in organic-solvent solutions. An immiscible surfactant polymer blend is a particular intriguing class of multi-component systems in which the adsorption at the interfaces is followed by the phase separation between the immiscible components. We here provide experimental evidence that the polymer blend drying is significantly enhanced via the surfactant addition in a particular range of surfactant concentrations.

2. Experimental

The experimental apparatus is schematically shown in Figure 1. The condenser drier [2-7] consisted of a flat glass plate and a grooved aluminum plate separated by a small air gap. A transparent conductive heater was deposited on the glass plate (Kitazato, MP-10DMH) to supply energy for the solvent evaporation. The

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surface temperature of the hot glass plate, T_H , was ranged by regulating the current through the heater. The water cooling system allowed us to maintain a constant cold surface temperature of $T_c=299.5$ K above the dew point in order to prevent water condensation from the surrounding air. The initial gap clearance between the evaporating and condensing surfaces was $H_{gap}=4.5 \pm 0.05$ mm. The aluminum plate was mechanically grooved to form periodic rectangular patterns with the groove width of $a=1$ mm, the depth of $b=0.2$ mm and 1 mm pitch between grooves. The porous paper film (Wypall X60, Kimberly-Clark) was attached at both ends of the grooves to provide the driving force of the capillary liquid flows, i.e., a liquid meniscus in the pores can create a low pressure region that draws the condensate from the groove into the pores.

The solution used in this study was ternary solution of cellulose-acetate-butylate (CAB), and non-ionic-surfactant polymer (S30K), and methylethylketone (MEK) as a common solvent. The solution was deposited on a $0.03 \text{ m} \times 0.03 \text{ m}$ glass substrate with the initial film thickness of 700 microns. The decrease

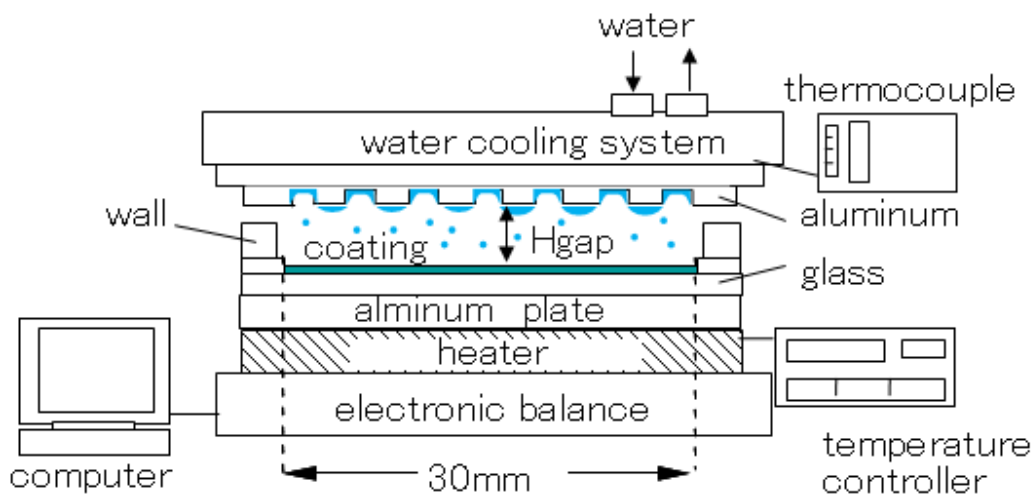


Figure 1 Experimental drying apparatus.

in mass of the film was measured by an electronic balance (Sartorius, LP620) and stored in a personal computer to calculate the solvent drying rate $r = -(1/A)(dw/dt)$ where A is the film surface area, t the time and w the mass of the film during the evaporation. The solvent drying rate was calculated based on average of 10 runs of the weight loss measurement. The static surface tension of the test solution was measured using Wilhelmy plate method for different surfactant/CAB weight ratios.

3. Result and discussion

Figure 2 shows the variations in surface tension for the CAB/MEK and S30K/MEK binary systems. The former exhibits no apparent dependence on the polymer concentration, whereas the surface tension for the latter significantly drops with increases in S30K concentrations, indicating that the S30K is surface active.

Figure 3 presents the variations in averaged drying rates with respect to the surfactant weight fraction at three different solvent to solute (CAB and S30K) weight ratios of $W=1.5\sim 2$, $2\sim 2.5$ and $3\sim 3.5$. The initial solvent weight ratio was $W_0=5$. In the constant drying period of $W = 3\sim 3.5$ in which the gas diffusion is limited, the measured drying rates are found to be independent of the surfactant weight ratio.

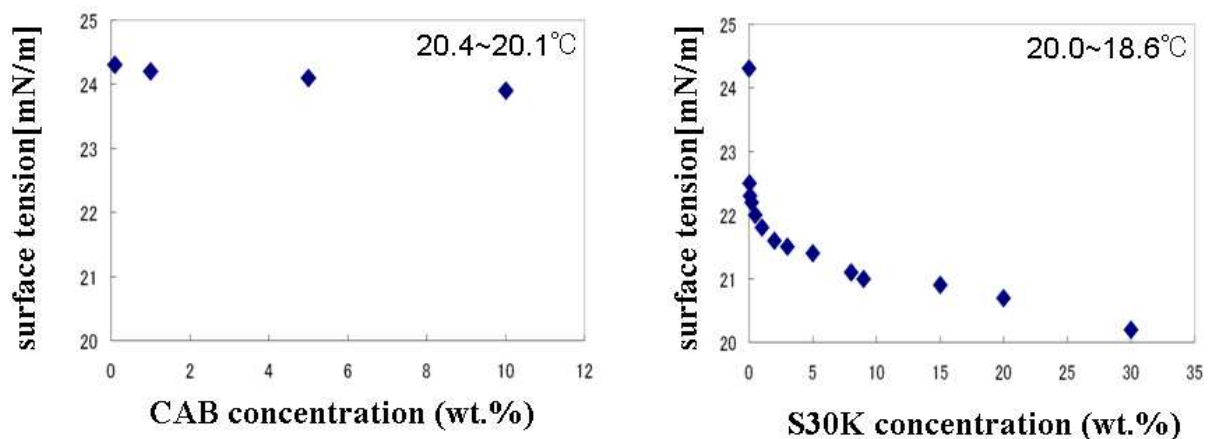


Figure 2 Variations in surface tension with concentration for two binary systems.

However, the drying rates at lower solvent contents of $W < 2.5$ first increase and then decrease with increases in the surfactant contents. This fact provides experimental evidence that the addition of the surfactant polymer enhances the evaporation of the co-solvent in a particular range of surfactant concentrations.

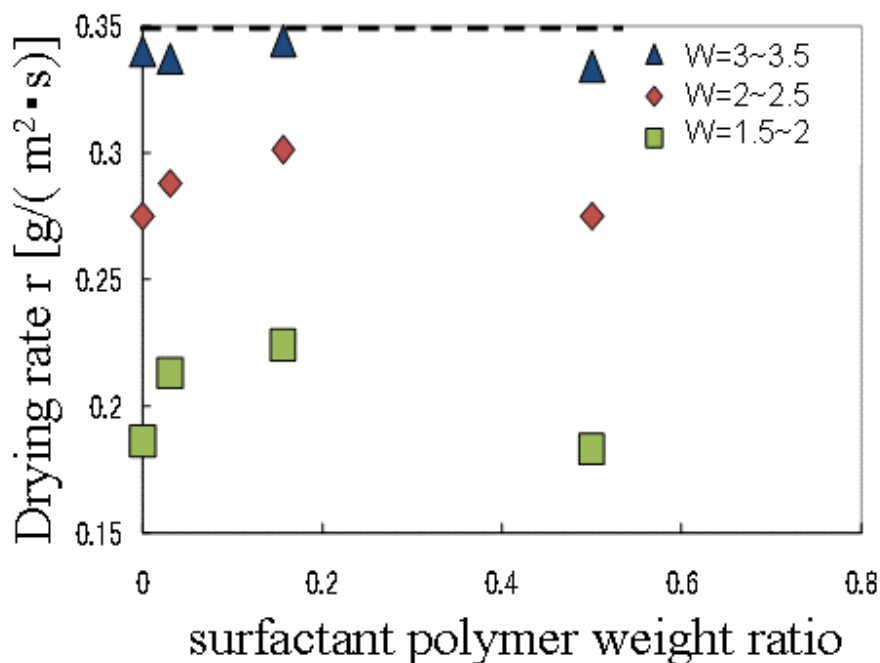


Figure 3 Variations in averaged drying rates with the surfactant concentration at three different solvent to solute weight ratios. The drying rate shows a peak at a particular S30K weight fraction of ca. 0.2.

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