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Film Rupture of Polyvinyl Alcohol in the Presence of Surfactants

Waichi NAGASHIRO, Makoto TANAKA, Tadao OKABE, and Mitsuru OIKAWA
Central Research Laboratory, Hitachi Ltd. Kokubunji, Tokyo 185

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Synopsis. It was observed that polymer film coated over a mask hole broke down on drying. The phenomenon is related to the surface chemical properties of the coating solution.

Film rupture phenomenon of polyvinyl alcohol was studied in the presence of various surfactants. Polymer film coated over a mask hole breaks down little by little on drying. The rupture starts from the center of the hole. The coating solution consists of polyvinyl alcohol, graphite and surfactants. After the drying of the solution, hardened polymer consisting of graphite remains on the inner side of the hole, making the diameter of the hole reduced. The rupture is related to the surface chemical properties of the coating solution.

Experimental

Surface tension and foam stability were measured as regards surface chemical properties of the coating solution. Surface tension was determined with a Du Noüy tension meter. Various methods have been given[1-4] for the measurement of foam stability. The present work was carried out by measuring the relative foam height from the instant the foam formation ceased. Foam formation was carried out by stirring the coating solution uniformly. The relative foam stability was estimated by the foam height 90 min after foam formation was completed.

Results and Discussion

A schematic view of the reduction mechanism of the size of a mask hole is given in Fig. 1. The suspension of polyvinyl alcohol, graphite, and surfactants is coated over the mask hole (Fig. 1—1,2). Graphite particles at the center of the mask hole move toward the edge of the hole (Fig. 1—3), while the coating solution is dried at room temperature. We observed two types of drying processes resulting from the difference in additive surfactants; in one case the coated polymer film remained unbroken on being dried (Fig. 1—4,5), in the other the coated polymer film at the center of the hole gradually broke down on being dried (Fig. 1—4′,5′).

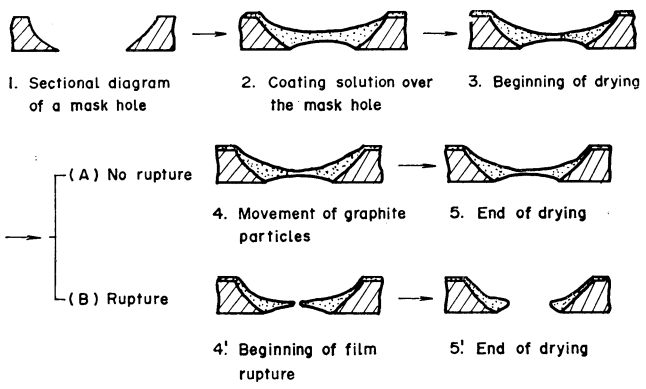

Fig. 1. Reduction mechanism of a mask hole coated with suspension solution

TABLE 1. SURFACE CHEMICAL PROPERTIES OF COATING SOLUTIONS WITH VARIOUS SURFACTANTS

Commercial name	Structure	Maker[a]	Foam stability	Film rupture[b]	Surface tension[c] (dyne/cm)
(No surfactant)			92	×	54.0
Pluronic L31	Nonion	AD	92	×	47.2
Tween 60	Nonion	KA	91	×	51.2
Tween 40	Nonion	KA	90	×	50.0
OP-30	Nonion	NC	90	×	49.3
BC-30TX	Nonion	NC	90	×	48.8
Emal 20C	Anion	KA	90	×	49.6
Pluronic L64	Nonion	AD	88	×	45.0
Pluronic F38	Nonion	AD	88	×	53.2
Demol N	Anion	KA	88	×	55.0
Tween 80	Nonion	KA	86	×	50.9
Lipomin LH	Amphoteric	LO	85	×	51.2
Pluronic F108	Nonion	AD	82	×	44.6
Ameet 105	Cation	KA	82	○	47.5
R-2020	Nonion	NC	79	○	38.7
Tween 20	Nonion	KA	75	○	47.2
Emulgen A60	Nonion	KA	75	×	45.3
R-1020	Nonion	NC	73	○	40.3
Emulgen 911	Nonion	KA	71	○	39.2
Emulgen 120	Nonion	KA	65	○	39.9
MYL-10	Nonion	NC	64	○	37.7
Emulgen 810	Nonion	KA	63	○	36.3
Emanone 1112	Nonion	KA	17	○	39.9
Pluronic L92	Nonion	AD	12	○	38.3

a) KA (Kao Atlas Co. Ltd), NC (Nikko Chemical Co. Ltd), AD (Asahi Electro Chemical Co. Ltd), LO (Lion Fat and Oil Co. Ltd). b) ×; Rupture, ○; No rupture. c) Surface tension of the solution of 0.05% additive surfactants.

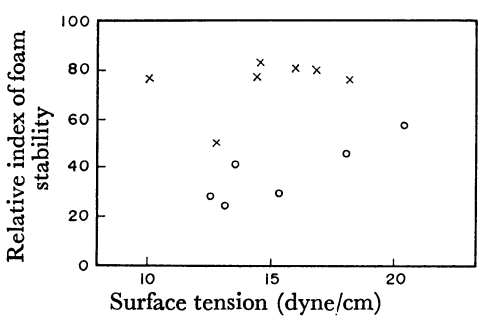

Fig. 2. Relation between foam stability and surface tension. (○; rupture, ×; no rupture)

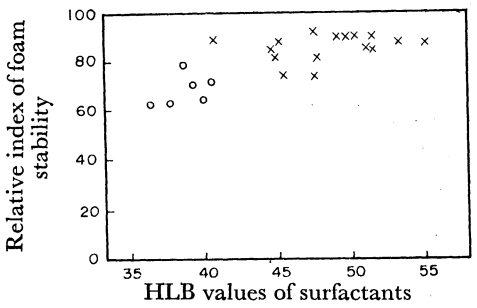

Fig. 3. Relation between foam stability and HLB value of additive surfactants. (○; rupture, × ; no rupture)

It is considered that this film rupture is related to the foam stability of the solution. The relation between film rupture and the surface chemical properties of the coating solution was studied. The results of the measurements of surface tension and foam stability of coating solutions containing various surfactants are summarized in Table 1, the film rupture being given in the order of foam stability.

The foam stability is plotted against the surface tension in Fig. 2. It is evident that film rupture occurs in a lower surface tension and lower foam stability region of a coating solution. A coating solution with a lower foam stability or a lower surface tension does not always rupture. The relation between foam stability and HLB value of surfactants is given in Fig. 3. The relation is not reliable. Film rupture does not seem to be related directly to any of the surface chemical properties of the coating solution. It occurs in the region of lower foam stability and lower surface tension.

References

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