<Superscript>

— = average value over θ direction

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SHORT COMMUNICATIONS

CLASSIFICATION OF TERNARY AZEOTROPIC DATA

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The following two necessary conditions for the existence of combinations of azeotropes in ternary systems have been presented in previous papers^{4,5}.

Cond (1) $2S_1 + 4S_2 + 8S_3 = 2$

Cond (2) The residue curve has to extend to the point at higher boiling temperature.

Theoretically, there are 113 combinations of azeotropes satisfying these conditions⁴. It is of interest to know how many combinations actually exist and which combination is the most common.

Classification of Experimental Azeotropic Data

558 experimental azeotropic data available in data books¹⁻³ are classified according to the following steps:

- 1) Determine types of all binary azeotropes in a given system. A binary azeotrope is minimum-boiling if its boiling temperature is lower than those of both pure materials and maximum-boiling if its boiling temperature is higher than both.
- 2) Determine indices of all pure materials. The index of a pure material can be determined by the existence and types of two binary azeotropes con-

taining it, as summarized in Table 3 in the previous paper⁴.

3) Determine the type and index of a ternary azeotrope if exists. A ternary azeotrope is a minimum azeotrope of index 1 if its boiling temperature is the lowest in the system and a maximum one of index 1 if its boiling temperature is the highest. Otherwise, it is a saddle-point azeotrope of index -1 .

4) Determine indices of binary azeotropes. The index of a binary azeotrope is equal to 1 if its boiling temperature is the lowest or highest in the system. If there remain binary azeotropes whose indices have not yet been determined, their indices should be given so as to satisfy **Cond (1)** and **Cond (2)**.

Table 1 gives the combinations of azeotropes and the numbers of experimental data classified into them.

Conclusions

The classification reveals that the most commonly existing combination is **Comb. 222**, that there are 75 combinations into which none of the experimental data is classified and that there exist 22 unsound data which cannot be classified into any combination since they violate either **Cond (1)** or **Cond (2)**. The distribution of experimental data shown in Table 1 might not represent real distribution since experimentalists

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Table 1 Classification of ternary systems

Comb. No.	<i>A-B</i>	Type of <i>B-C</i>	<i>A-C</i>	<i>A-B-C</i>	Conditions for boiling points	No. of Data	Comb. No.	<i>A-B</i>	Type of <i>B-C</i>	<i>A-C</i>	<i>A-B-C</i>	Conditions for boiling points	No. of Data
000	—	—	—	—		—	112	<i>m</i>	<i>m</i>	<i>m</i>	<i>S</i>		0
001	—	—	<i>m</i>	—		7	121	<i>m</i>	<i>m</i>	<i>m</i>	<i>S</i>		0
002	—	—	<i>m</i>	<i>m</i>		0	122	<i>m</i>	<i>m</i>	<i>m</i>	—	<i>A-B < B-C</i> and <i>A-B < A-C</i>	40
003	—	—	<i>M</i>	—		1	211	<i>m</i>	<i>m</i>	<i>m</i>	<i>S</i>		1
004	—	—	<i>M</i>	<i>M</i>		0	212	<i>m</i>	<i>m</i>	<i>m</i>	—	<i>B-C < A-B</i> and <i>B-C < A-C</i>	13
010	—	<i>m</i>	—	<i>S</i>		1	221	<i>m</i>	<i>m</i>	<i>m</i>	—	<i>A-C < A-B</i> and <i>A-C < B-C</i>	51
020	—	<i>m</i>	—	—	<i>A < B-C</i>	23	222	<i>m</i>	<i>m</i>	<i>m</i>	<i>m</i>		171
030	—	<i>M</i>	—	—		2	113	<i>m</i>	<i>m</i>	<i>M</i>	<i>S</i>		1
040	—	<i>M</i>	—	<i>M</i>		0	123	<i>m</i>	<i>m</i>	<i>M</i>	—	<i>A-B < B-C</i>	2
100	<i>m</i>	—	—	—		19	124	<i>m</i>	<i>m</i>	<i>M</i>	<i>M</i>	<i>A-B < B-C</i>	0
200	<i>m</i>	—	—	—		2	213	<i>m</i>	<i>m</i>	<i>M</i>	—	<i>B-C < A-B</i>	0
300	<i>M</i>	—	—	<i>S</i>		3	214	<i>m</i>	<i>m</i>	<i>M</i>	<i>M</i>	<i>B-C < A-B</i>	0
400	<i>M</i>	—	—	—	<i>A-B < C</i>	8	223	<i>m</i>	<i>m</i>	<i>M</i>	<i>m</i>		0
011	—	<i>m</i>	<i>m</i>	<i>S</i>		0	131	<i>m</i>	<i>M</i>	<i>m</i>	<i>S</i>		1
012	—	<i>m</i>	<i>m</i>	—	<i>B-C < A-C</i>	1	132	<i>m</i>	<i>M</i>	<i>m</i>	—	<i>A-B < A-C</i>	2
021	—	<i>m</i>	<i>m</i>	—	<i>A-C < B-C</i>	40	142	<i>m</i>	<i>M</i>	<i>m</i>	<i>M</i>	<i>A-B < A-C</i>	0
022	—	<i>m</i>	<i>m</i>	<i>m</i>		3	231	<i>m</i>	<i>M</i>	<i>m</i>	—	<i>A-C < A-B</i>	0
013	—	<i>m</i>	<i>M</i>	<i>S</i>		0	232	<i>m</i>	<i>M</i>	<i>m</i>	<i>m</i>		0
023	—	<i>m</i>	<i>M</i>	—	<i>A < B-C</i>	0	241	<i>m</i>	<i>M</i>	<i>m</i>	<i>M</i>	<i>A-C < A-B</i>	0
024	—	<i>m</i>	<i>M</i>	<i>m</i>	<i>A-C < B</i>	0	311	<i>M</i>	<i>m</i>	<i>m</i>	<i>S</i>		9
031	—	<i>M</i>	<i>m</i>	—		0	312	<i>M</i>	<i>m</i>	<i>m</i>	—	<i>B-C < A-C</i>	0
032	—	<i>M</i>	<i>m</i>	<i>m</i>		0	321	<i>M</i>	<i>m</i>	<i>m</i>	—	<i>A-C < B-C</i>	0
041	—	<i>M</i>	<i>m</i>	<i>M</i>		0	322	<i>M</i>	<i>m</i>	<i>m</i>	<i>m</i>		0
033	—	<i>M</i>	<i>M</i>	<i>S</i>		0	411	<i>M</i>	<i>m</i>	<i>m</i>	—	<i>A-B < C</i>	0
034	—	<i>M</i>	<i>M</i>	—	<i>A-C < B-C</i>	0	412-1	<i>M</i>	<i>m</i>	<i>m</i>	<i>m</i>	<i>A-B < C</i>	0
043	—	<i>M</i>	<i>M</i>	—	<i>B-C < A-C</i>	0	412-2	<i>M</i>	<i>m</i>	<i>m</i>	<i>M</i>	<i>B-C < A-C</i>	0
044	—	<i>M</i>	<i>M</i>	<i>M</i>		0	421-1	<i>M</i>	<i>m</i>	<i>m</i>	<i>m</i>	<i>A-B < C</i>	0
101	<i>m</i>	—	<i>m</i>	<i>S</i>		0	421-2	<i>M</i>	<i>m</i>	<i>m</i>	<i>M</i>	<i>A-C < B-C</i>	0
102	<i>m</i>	—	<i>m</i>	—	<i>A-B < A-C</i>	35	133	<i>m</i>	<i>M</i>	<i>M</i>	<i>S</i>		1
201	<i>m</i>	—	<i>m</i>	—	<i>A-C < A-B</i>	5	134	<i>m</i>	<i>M</i>	<i>M</i>	—	<i>A-C < B-C</i>	0
202	<i>m</i>	—	<i>m</i>	<i>m</i>		8	143	<i>m</i>	<i>M</i>	<i>M</i>	—	<i>B-C < A-C</i>	1
103	<i>m</i>	—	<i>M</i>	—		0	144	<i>m</i>	<i>M</i>	<i>M</i>	<i>M</i>		0
104	<i>m</i>	—	<i>M</i>	<i>M</i>		0	234	<i>m</i>	<i>M</i>	<i>M</i>	<i>m</i>	<i>A-C < B-C</i>	0
203	<i>m</i>	—	<i>M</i>	<i>m</i>		0	243	<i>m</i>	<i>M</i>	<i>M</i>	<i>m</i>	<i>B-C < A-C</i>	0
301	<i>M</i>	—	<i>m</i>	<i>S</i>		2	313	<i>M</i>	<i>m</i>	<i>M</i>	<i>S</i>		0
401	<i>M</i>	—	<i>m</i>	—	<i>A-B < C</i>	1	314	<i>M</i>	<i>m</i>	<i>M</i>	—	<i>A-C < A-B</i>	0
402	<i>M</i>	—	<i>m</i>	<i>m</i>	<i>A-B < C</i>	0	323	<i>M</i>	<i>m</i>	<i>M</i>	—	<i>A < B-C</i>	0
303	<i>M</i>	—	<i>M</i>	<i>S</i>		0	324-1	<i>M</i>	<i>m</i>	<i>M</i>	<i>m</i>	<i>A-C < A-B</i>	0
304	<i>M</i>	—	<i>M</i>	—	<i>A-C < A-B</i>	0	324-2	<i>M</i>	<i>m</i>	<i>M</i>	<i>M</i>	<i>A < B-C</i>	0
403	<i>M</i>	—	<i>M</i>	—	<i>A-B < A-C</i>	0	413	<i>M</i>	<i>m</i>	<i>M</i>	—	<i>A-B < A-C</i>	0
404	<i>M</i>	—	<i>M</i>	<i>M</i>		0	414	<i>M</i>	<i>m</i>	<i>M</i>	<i>M</i>		0
110	<i>m</i>	<i>m</i>	—	<i>S</i>		2	423-1	<i>M</i>	<i>m</i>	<i>M</i>	<i>m</i>	<i>A-B < A-C</i>	0
120	<i>m</i>	<i>m</i>	—	—	<i>A-B < B-C</i>	50	423-2	<i>M</i>	<i>m</i>	<i>M</i>	<i>M</i>	<i>A < B-C</i>	0
210	<i>m</i>	<i>m</i>	—	—	<i>B-C < A-B</i>	1	331	<i>M</i>	<i>M</i>	<i>m</i>	<i>S</i>		0
220	<i>m</i>	<i>m</i>	—	<i>m</i>		13	341	<i>M</i>	<i>M</i>	<i>m</i>	—	<i>B-C < A-B</i>	0
130	<i>m</i>	<i>M</i>	—	—		1	342	<i>M</i>	<i>M</i>	<i>m</i>	<i>m</i>	<i>B-C < A-B</i>	0
140	<i>m</i>	<i>M</i>	—	<i>M</i>		0	431	<i>M</i>	<i>M</i>	<i>m</i>	—	<i>A-B < B-C</i>	2
230	<i>m</i>	<i>M</i>	—	<i>m</i>		0	432	<i>M</i>	<i>M</i>	<i>m</i>	<i>m</i>	<i>A-B < B-C</i>	0
310	<i>M</i>	<i>m</i>	—	<i>S</i>		8	441	<i>M</i>	<i>M</i>	<i>m</i>	<i>M</i>		0
320	<i>M</i>	<i>m</i>	—	—	<i>A < B-C</i>	1	334	<i>M</i>	<i>M</i>	<i>M</i>	<i>S</i>		0
410	<i>M</i>	<i>m</i>	—	—	<i>B-C < A</i>	0	343	<i>M</i>	<i>M</i>	<i>M</i>	<i>S</i>		0
420-1	<i>M</i>	<i>m</i>	—	<i>m</i>	<i>A-B < C</i>	0	344	<i>M</i>	<i>M</i>	<i>M</i>	—	<i>B-C < A-B</i> and <i>A-C < A-B</i>	0
420-2	<i>M</i>	<i>m</i>	—	<i>M</i>	<i>A < B-C</i>	0	433	<i>M</i>	<i>M</i>	<i>M</i>	<i>S</i>		0
330	<i>M</i>	<i>M</i>	—	<i>S</i>		0	434	<i>M</i>	<i>M</i>	<i>M</i>	—	<i>A-B < B-C</i> and <i>A-C < B-C</i>	0
340	<i>M</i>	<i>M</i>	—	—	<i>A-B < A-C</i>	0	443	<i>M</i>	<i>M</i>	<i>M</i>		<i>A-B < A-C</i> and <i>B-C < A-C</i>	0
430	<i>M</i>	<i>M</i>	—	—	<i>A-C < A-B</i>	0	444	<i>M</i>	<i>M</i>	<i>M</i>	<i>M</i>		0
440	<i>M</i>	<i>M</i>	—	<i>M</i>		0							

have been interested in the vapor-liquid equilibria in systems containing water. The number of undiscovered combinations will be considerably reduced if experiments are intentionally made in order to fill blanks in Table 1, though all of them may not be discovered.

Nomenclature

<i>A</i>	= lowest-boiling component
<i>B</i>	= intermediate-boiling component
<i>C</i>	= highest-boiling component
<i>M</i>	= maximum azeotrope
<i>m</i>	= minimum azeotrope
<i>S</i>	= saddle-point azeotrope

S_1	= sum of indices of pure components
S_2	= sum of indices of binary azeotropes
S_3	= sum of indices of ternary azeotropes

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EFFECT OF DROP DIAMETER ON BREAKUP OF LIQUID DROP IN A SIMPLE SHEAR FIELD

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Dispersion operations in liquid-liquid systems are important in such separation processes as liquid-liquid extraction and ion exchange and in reaction processes such as emulsion polymerization. The mechanism of breakup of liquid drops has not yet been clarified sufficiently. Various factors seem to affect the breakup step of a liquid drop. The mechanism of breakup in a shear force is most important. Many studies were carried out by Taylor⁵⁾, Troza *et al.*⁶⁾, Bartok and Mason¹⁾, Cox²⁾ and Ito *et al.*⁴⁾ However, in these studies, the effect of drop size on breakup was only considered in the dimensionless shear rate G^* based on the linear theory. But the effects of the inertia terms cannot be neglected for large drops.

In the present research, the effect of drop diameter on breakup of liquid drops was investigated by introducing a dimensionless diameter. As the result it is shown that the dimensionless critical shear rate at burst is proportional to the square root of the dimensionless drop diameter in a range from 2.0×10^{-3} to 20.0×10^{-3} , which is equivalent to a range of real diameter from 0.5 to 5.0 mm.

1. Experimental Apparatus and Procedure

The schematic diagram of the apparatus is shown in Fig. 1. The apparatus used was similar to that used

by Flumerfelt¹⁾. A simple shear field without curvature was produced between two parallel belts moving in opposite direction. The endless belts were made from 2.0-mm rubber sheet. Each belt was tightly stretched over a driving roller and a subordinated roller. Supporting guide plates were installed to suppress the minute vibration of the belts. A variable-speed drive was separately connected to each sprocket.

As the fluid systems studied, castor oil was used for the continuous phase and various silicone oils were used for the dispersed phase. The viscosity ratio of the fluids of dispersed and continuous phases was changed in a range from 2.8×10^{-3} to 4.0. The interfacial tensions were measured by using the DuNoüy tensiometer. It was measured to be 4.0 dyne/cm for all

- ① Rotors attached to variable speed motor
- ② Belt (50 mm width)
- ③ Belt guide
- ④ Droplet

Fig. 1 Schematic diagram of apparatus

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