噴霧油滴の電荷

The Electric Charge on Sprayed oil Droplets IV

(Effect of Additives in Lubricants on The Charge of Droplets)

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Spraying five kinds of lubqicant with paraffin hydrocarbon structure as main constituents, not containing any additive, the electric charge on droplets were measured using Millikan's oil drop method.

The results of measurement showed that additives in lubricants made the charge on droplets much larger, in comparison with the charge on droplets of same kinds of lubricant containing additives.

Furthermore, the charge on droplets of mixed lubricants made adding a little amount of lubricant SAE 10W containing additives to large amount of same lubricant SAE 10W not containing any additive were measured and the effect of additives in lubricants on the charge on droplets was made sure.

1. Iutroduction

In the previous paper,[1] the results of measurement of the electric charge on sprayed oil droplets of five kinds of lubricant with naphthene hydrocarbon structure as main constituents, not containing any additive, and five kinds of lubricant with paraffin hyrdocarbon structure as main constituents, but containing additives, were reported. In comparison between the results of measurement of these two groups of lubricant, it was shown that there was a definite difference in larger electric charge on droplets. Namely, the larger electric charge on droplets of the lubricants with naphthene hydrocarbon structure were less than 10e, while those of the lubricants with paraffin hydrocarbon structure were larger than 30e. At that time, it was not obvious that the definite difference depends on either the difference in chemical structure of the main constituents of these two groups of lubricant or the effect of additives in lubricants.

In order to investigate the origin of the difference in larger electric charge on droplets, five kinds of lubricant with paraffin hydrocarbon structure as main constituents, not containing any additive, RPM the primium motor oil HD SAE 10W, 20W, 30, 40, and 50 were obtained from Caltex Oil Co. in Philipine, and measurement of charge on droplets of these lubricants were carried out.

2. Measurement

The measurements of the electric charge on droplets of lubricants SAE 10W, 20W, 30, 40 and 50, were carried out using the apparatus, with the distance of two electrodes 0.636 cm, used in the previous work and fall time t_d and rise time t_u, in which droplets moved downward under the gravity and upward under the

gravity and the electric force throuth the fixed distance 0.082 cm in the electrodes, were measured. The radius of droplets observed were the order of 10^{-4}cm, because the larger one fell too fast to measure and the smaller one too slow. The voltage applied to the electrodes was selected so suitably that the rise time of droplets might be in convenient range for measurement.

Furthermore, fall time t_d and rise time t_u of droplets of 1%, 5%, 10% and 17% mixed lubricants made adding the lubricant SAE 10W containing additives to the lubricant SAE 10W not containing any additive were measured in the same way.

The measurement values t_d and t_u of every droplet were plotted in t_d-t_u plane, and the electric charge on droplets were estimated, comparing the points plotted with the algebraical curves represented by the following equation,

$$t_u = \frac{K/q \cdot t_d}{(t_d)^{3/2} - K/q}, \quad \cdots\cdots(1)$$

where

$$K = 9\sqrt{2}\frac{\pi\eta^{3/2}\cdot\ell^{3/2}}{E(\sigma-\rho)^{1/2}\cdot g^{1/2}}, \qquad E = \frac{V}{300d}. \quad \cdots\cdots(2)$$

Equation (1) is derived from the following two equations :

$$4/3\pi a^3(\sigma-\rho)g = 6\pi\eta a v_d \quad \cdots\cdots(3)$$

$$4/3\pi a^3(\sigma-\rho)g + 6\pi\eta a v_u = qE \quad \cdots\cdots(4)$$

where $v_d = \ell/t_d$ and $v_u = \ell/t_u$.

The curves represented by equation (1) were drew using the following values ;

$\eta = 1.86\times10^{-4}$ gr/cm sec : viscosity of the air

$\ell = 0.082$ cm : moved distance of droplets

$\rho = 0.001$ gr/cc : density of the air

$g = 980$ cm/sec^2 : accelaration of gravity

$d = 0.636$ cm : distance of two electrodes

σ = 0.867 gr/cc for SAE 10W and mixed lubricants : density of oil
0.872 gr/cc for SAE 20W
0.875 gr/cc for SAE 30
0.877 gr/cc for SAE 40
0.880 gr/cc for SAE 50

q = 10e, 20e for lubricants not containing any additive
20e, 40e, 50e, 100e, 200e and 400e for mixed lubricants.

3. Results and Discussion

The results of measurement of the charge on sprayed droplets of lubricants with paraffin hydrocarbon structure as main constituents, not containing any additive, are shown in Fig. 1, 2, 3, 4 and 5. These figures show that there is no droplete had larger charge than 20e. There is so much difference between these values and the charge on droplets of lubricants containing additives, reported in the previous paper. The values of the charge on droplets of lubricants with additives were larger than 300e and one of those the value of SAE 10W is shown

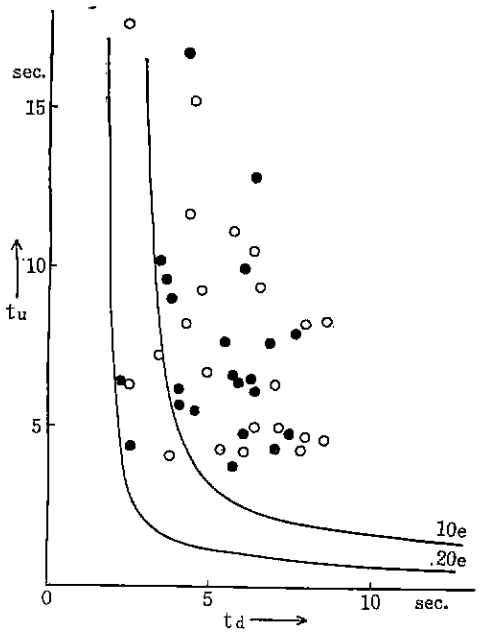

Fig. 1 td and tu of SAE 10W not containing additives, at 29.2° C, 800V.
○ : Positively charged droplets.
● : Negatively charged droplets.

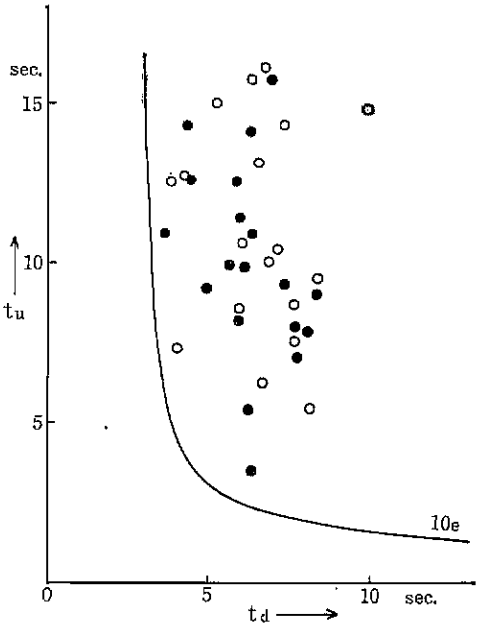

Fig. 2 td and tu of SAE 20W not containing additives, at 28.8 °C, 800V.
○ : positively charged droplets.
● : Negatively charged droplets.

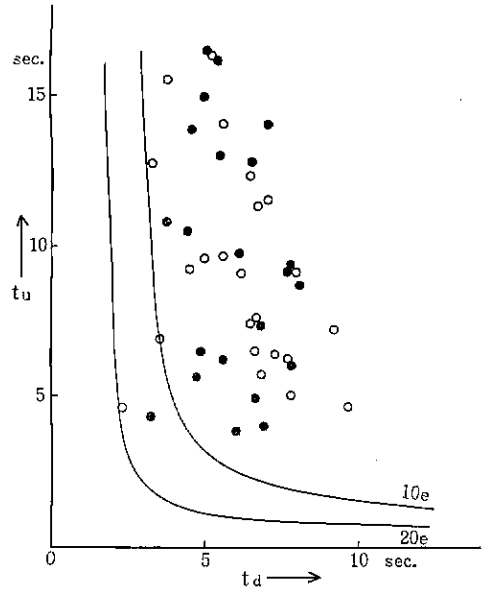

Fig. 3 td and tu of SAE 30 not containing additivs, at 29. 4°C, 800V.
○ : positively charg ed droplets.
● : Negatively charged droplets.

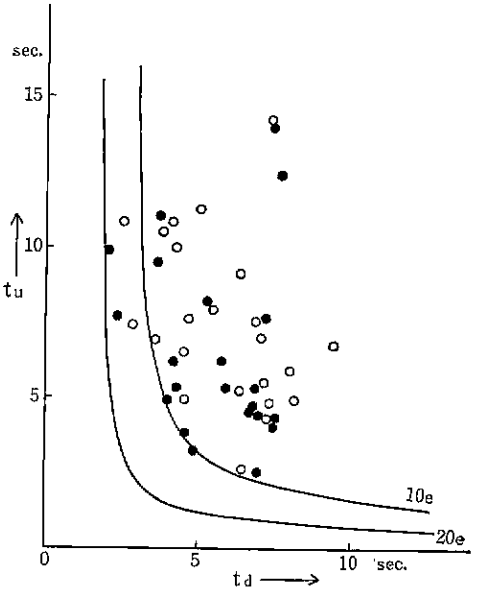

Fig. 4 td and tu of SAE 40 not containing additives, at 29. 0°C, 800V.
○ : Positively charged deoplets.
● : Negatively charoed doplets.

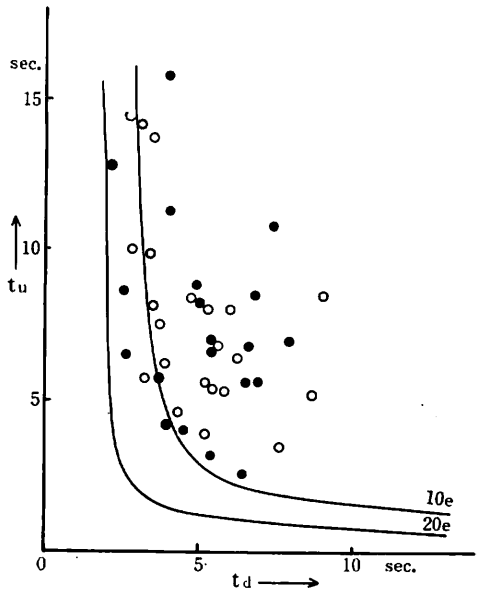

Fig. 5 td and tu of SAE 50 not containing additives, at 29. 2°C, 800V.
○ : Positively charged droplets.
● : Negatively charged droplets.

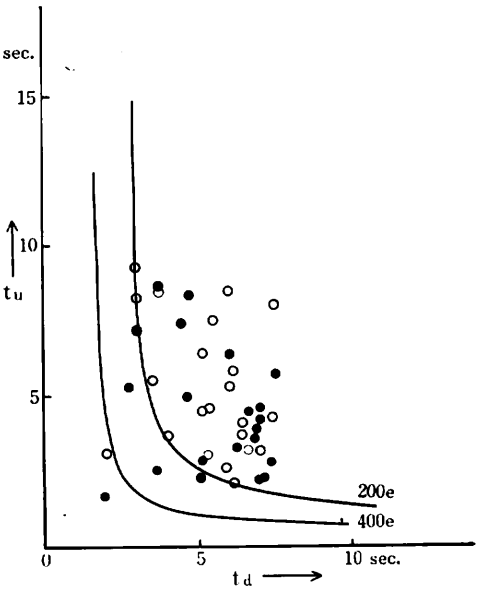

Fig. 6 tda nd tu of 10W containing additives, at 18. 2°C. 40V.
○ : Positively charged droplets.
● : Negatively charged doplets.

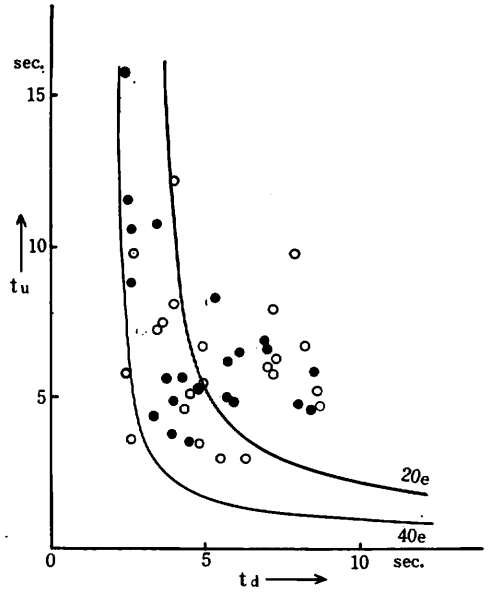

Fig. 7 td and tu of 1% mixed SAE 10W, at 28 8°C. 300v.
○ : Positively charged droplets.
● : Negatively charged dsoplets.

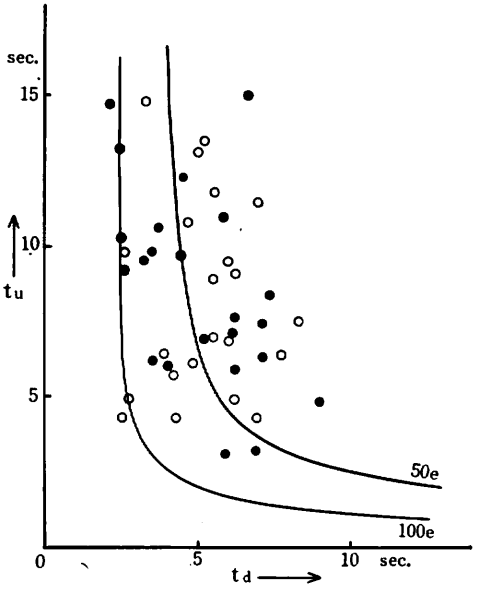

Fig. 8 td and tu of 5% mixed SAE 10W, at 28. 9°C, 110V.
○ : Positively charged droplets.
● : Negatively dharged droplets.

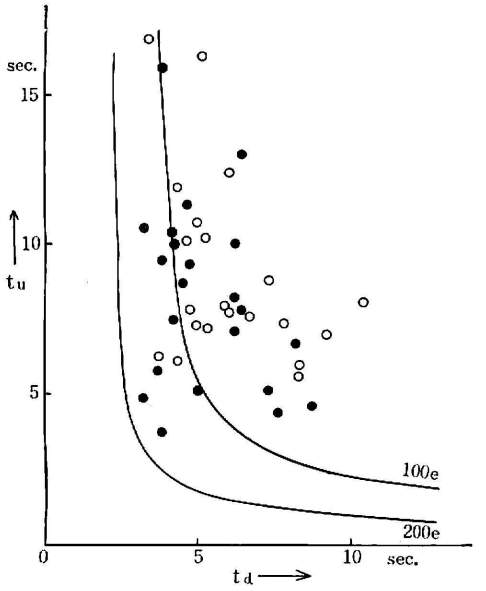

Fig. 9 td and tu of 10% mixed SAE 10W, at 29.1°C, 60V.
○ : Positively charged droplets.
● : Negatively charged droplets.

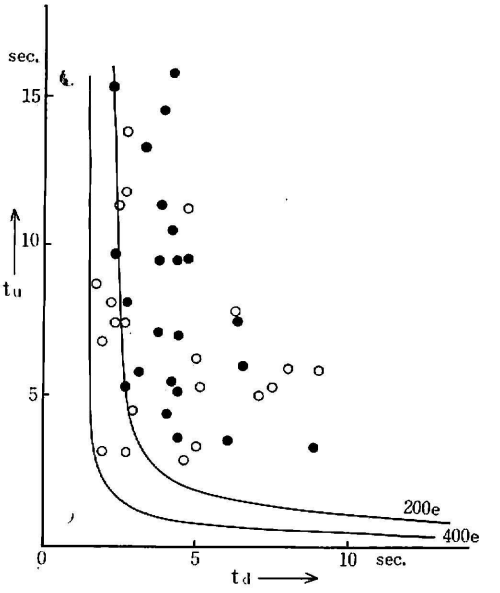

Fig. 10 td and tu of 17% mixed SAE 10W, at 29.1°C, 60V.
○ : Positively charged droplets.
●: Negatively charged droplets

in Fig. 6. It seems that the great difference comes from the additives in lubricants.

Furthermore, as shown in Fig. 7, 8, 9 and 10, the effect of additives on the charge on oil droplets is obvious from the results of measurement of the charge on droplets of mixed lubricants made adding a little amount of lubricant SAE 10W containing additives to the same lubricant SAE 10W not containing any additive. The amount of additives in 1% mixed lubricant must be quite small, but so small amount of additives make the charge on the droplets larger than twice as much (see Fig. 1 and 7).

In previous paper, the charge on droplets of lubricants with naphthene hydrocarbon structure as main constituents, not containing any additive, were measured. The larger charge on droplets of those lubricants were larger than 60e and less than 100e excepting covus oil. As shown in Fig. 1, 2, 3, 4 and 5, the larger charge on droplets of lubricants with paraffin hydrocarbon structre as main constituents, not containing any additive, are about 20e excepting SAE 20W.

It is not obvious that the difference between the charge of the lubricants with naphthene hydrocarbon structure and that of the lubricants with paraffin hydrocarbon structure, both not containing any additives, depends on either the difference in chemical structure of the main constituents of two groups of lubricant or not. Because a quite small amount of additives can change the

charge on droplets of lubricant.

Refernce

(1) K. Miyagi : Bull. Arts and Sci. Div., Ryukyu Univ. (Math. and Nat. Sci.) 8 (1965) 12.