

APPLICATION OF DIELECTRIC SPECTROSCOPY FOR EHD CONTACT

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ABSTRACT

Dielectric spectroscopy enables the evaluation of molecular dynamics through the observation of relaxation phenomena in response to external electric field acting on permanent dipoles within materials, known as dielectric relaxation. Suzuki et al. performed dielectric spectroscopy using parallel plate capacitor for several types of polar oils and reported that these oils exhibit dielectric relaxation [1]. Furthermore, they revealed that the relaxation frequency shifts to higher frequency with increasing temperature or decreasing pressure. In this study, we extended dielectric spectroscopy to the EHL formed by polar oil in the ball-on-disc-type apparatus.

The experimental conditions are listed in Table 1. Trioctyl trimellitate was used as the test lubricant which viscosity is 320 cSt at 20 °C and operated in the fluid lubrication regime. Under pure rolling conditions and a contact pressure of 415 MPa (Fig. 1a, black plots), dielectric spectroscopy of the EHL revealed a decrease in ϵ_r' and a peak in ϵ_r'' due to dielectric relaxation, observed at 10^4 Hz. Here, ϵ_r' and ϵ_r'' represent the real and imaginary parts of complex permittivity, respectively. By contrast, when the pressure was reduced to 228 MPa (Fig. 1a, red plots), also under pure rolling conditions, a high-frequency shift of the relaxation frequency to $10^{5.5}$ Hz was identified. Assuming that the heat generation in the EHD contact is negligible because no slip occurs under these conditions, the high-frequency shift in the relaxation frequency can be attributed to the decrease in viscosity due to the pressure decrease. With the pressure kept at 415 MPa and the slip/roll ratio ($v_{ball} > v_{disc}$) varied from 0 to +0.5, the relaxation frequency shifted from 10^4 Hz to 10^5 Hz (Fig. 1b). The cause of the high-frequency shift is considered to be the enhancement of dipole mobility associated with the temperature increase of the EHD contact due to shear heating.

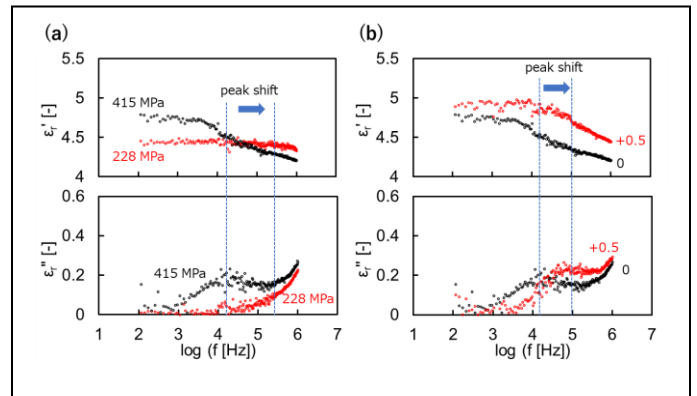


Fig.1 Behaviors of complex permittivity under AC frequency sweeping; (a) dependence on pressure (pure rolling condition) and (b) dependence on slide/roll ratio (constant pressure).

Table 1 Experimental condition

Voltage [V]	0.5 ~ 1.5
Frequency [Hz]	$10^2 \sim 10^6$
Entrainment Speed [m/s]	0.3
Slide/Roll Ratio [-]	0, +0.5
Pressure [MPa]	228, 415

REFERENCES

- [1] Suzuki, A. and Masuko, M., “A simple formula for the dielectric relaxation time—temperature—pressure relationship of lubricating oils and its application to viscosity prediction,” *Lubrication Science*, 16, 3, 2004, 239–253.