Dielectric measurements

The measurement was conducted under constant temperature condition. The low-frequency dielectric measurement of the two microemulsion systems were performed on a 4294A precision impedance analyzer (Agilent Technologies, made in Japan) that allows a continuous frequency measurement from 40 Hz to 110 MHz. After calibration and test, the voltage applied to the AC electric field was 500 mV. A dielectric measurement cell with concentrically cylindrical platinum electrodes [38] was employed and connected to the impedance analyzer by a 16047E spring clip fixture (Agilent Technologies, made in Japan). The original data capacitance C and conductance G, obtained from measurements, which was corrected by the measured parameters such as cell constant C_l, the stray capacitance C_r and the residual inductance L_r (obtained by using ethanol, water, and KCl solution) according to Schwan's method. The permittivity ε and the conductivity κ were calculated according to $\varepsilon = (C - C_r)/C_l$ and $\kappa = G\varepsilon_0/C_l$, ($\varepsilon_0 (= 8.854 \times 10^{-12} F/m)$ is permittivity of vacuum). The numerical value of the DC conductivity was read from the low frequency platform in the dependence graph of the conductivity on the frequency.

Determination of relaxation parameters

Dielectric relaxation can be characterized by a series of dielectric parameters, which can be obtained by fitting the experimental data with the Havriliak-Negami equation [1].

$$\varepsilon^*(\omega) = \varepsilon' - j\varepsilon'' = \varepsilon_h + \sum_i \frac{\Delta\varepsilon_i}{\left(1 + (j\omega\tau_i)^{\alpha_i}\right)^{\beta_i}} \tag{1}$$

where $\varepsilon'' = (\kappa - \kappa_l)/\omega\varepsilon_0$, κ_l is the low-frequency limit of conductivity, ε_h is the high-frequency limit of relative permittivity, i is the number of relaxation, $\Delta\varepsilon$ is the relaxation intensity, ω(=2πf, f is measuring frequency) is the angular frequency, $\tau (= 1/2\pi f_0$, f_0 is relaxation frequency) is the relaxation time, α $(0 < \alpha \le 1)$ and β $(0 < \beta \le 1)$ both are parameters related to the distribution of relaxation time. The curve-fitting was carried out with the Levenberg Marquardt method to minimize the sum of the residuals for the real part ε' and the imaginary part ε'' of the complex permittivity：

$$\chi = \sum_i [\varepsilon_e'(\omega_i) - \varepsilon_t'(\omega_i)]^2 + \sum_i [\varepsilon_e''(\omega_i) - \varepsilon_t''(\omega_i)]^2 \tag{2}$$

where the subscripts e and t respectively refer to experimental and theoretical values, and ω_i is i th angular frequency.

References:

1. Hanai, T.; Imakita, T.; Koizumi, N., Analysis of dielectric relaxations of w/o emulsions in the

light of theories of interfacial polarization. *Colloid and Polymer Science* **1982,** 260, (11), 1029-1034.