Dynamics of Water-Ethanol Mixtures Studied by Light Scattering

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Generally when two kinds of liquids are mixed, the superposition of two relaxation processes would be expected, however for water and monohydric alcohol binary mixtures only a single primary relaxation still remains in spite of water and monohydric alcohol show different relaxation processes.[1)] It means that molecules move not independently but cooperatively. Since alcohol molecules have two opposite interactions between water molecules; hydrophobic hydration and hydrogen bonding (HB). Therefore, the alcohol molecules are enhancing or destroying hydrogen bonded network with the balance of two interactions. This network is the key in the unusual behavior of physical properties of those. Many works[1-3)] for those systems were carried out but still we don't have any clear picture about dynamics, e.g. cooperative motions, dynamical structures and so on. In this work, we present the dynamics for H_2O-C_2H_5OH mixtures by Brillouin scattering and Raman scattering.

Fig. 1 shows the equipment for this Brillouin scattering which has been developed by us. It is characterized with a nonscanning angular dispersion-type the Fabry-Perot Interferometer (ADFPI) by the use of a solid etalon and a multichannel detector such as a high-sensitive charge-coupled-device (CCD) detector. A nonscanning APFPI enables us to measure with high spectral resolution and in shorter acquisition time than that of Sandercock type FPI. So we can monitor the time dependence of acoustic properties such as the transient changes during liquid-glass transitions, which need a fast cooling rate.[4)]

From analysis for Brillouin spectra, we can derive the hypersonic longitudinal sound velocity V and the absorption. Fig. 2 shows that the concentration dependence of V at room temperature and high temperatures. V is related to the longitudinal elastic constant M defined by $M = \rho V^2$ (1) where ρ is the density. From Fig. 2, we can see one peak in each line and the concentration at the peak shifts to lower with the increase of temperature. It means that the changes of dominant dynamical properties depend on the concentration markedly.

We also studied Raman scattering. As shown in Fig. 3, we can find the variation of concentration of Raman spectra in ν (OD) band for D_2O-C_2H_5OH mixtures. Those spectra show not only lower intensity but also change of line shape with the increase of concentration. This result indicates that the change is coming from the variation of the clusters formed by HB.

On the basis of those results, we discuss the dynamics of H_2O/ D_2O -C_2H_5OH mixtures.

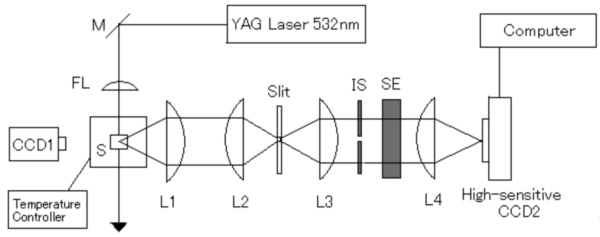

Fig. 1. Block diagram of the experimental setup.

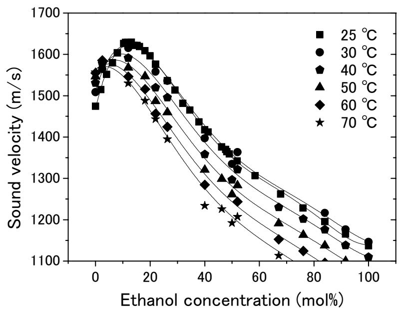

Fig. 2. Sound velocity of H_2O-C_2H_5OH mixtures at different temperatures. Solid lines are fit results of data at each temperature.

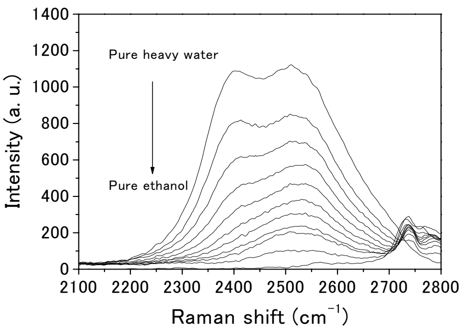

Fig. 3. Concentration dependence of Raman spectra of ν (OD) band in D_2O-C_2H_5OH mixtures.

References

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