Low Molecular Weight Organogelator of a Long-Chain Amidoamine Derivative Acts as Heat-Induced Gel and Soft Template for Ultrathin Gold Nanowires

Takeshi Kawai, Yoshiro Imura, Clara Morita and Hiroshi Endo

Tokyo University of Science, Department of Industrial Chemistry,
Kagurazaka 1-3, Shinjuku-ku, Tokyo, Japan
*e-mail: kawai@ci.kagu.tus.ac.jp

In recent years stimuli-responsive materials have been extensively studied because of their potential application. In particular, heat-induced gelation materials, which undergo a thermally reversible transition from a low viscosity solution to a rigid gel upon an increase in temperature, have attracted considerable attention as injectable drug-delivery systems. Heat-induced gelation has been observed in aqueous solutions of some kinds of low-molecular-weight compound, however, the number of such reports is limited. We demonstrated that a long-chain amidoamine derivative (C18AA) acts as a normal organogelator in toluene, exhibiting a phase transition from gel to sol on heating, but changes to a heat-induced gelator upon addition of HCl aqueous solution to the toluene gel. In order to investigate the difference in the molecular assembly of C18AA between the sol and gel states of the heat-induced gel, we obtained optical microscopic images respectively. The heat-induced gelation is caused by a change in the underlying C18AA molecular self-assembly from an oil-in-water emulsion to a bicontinuous-like coalescence emulsion. We also show that the thermal response of the heat-induced gel of C18AA is highly sensitive and that the sol-gel transition is completed over a narrow temperature range of ~3 °C. Interestingly, the transition temperatures decreased linearly with increasing C18AA concentration. In addition, the rigidity of the gel was independent of C18AA concentration. This indicates that the sol-gel transition temperature can be controlled simply by changing the C18AA concentration. The existence of a linear region in the transition temperature and C18AA concentration over a wide temperature range of 5 – 55 °C provides opportunities for potential application in useful new stimuli-responsive materials. Further, we also demonstrate that the fabrications of gold nanowires with about ~2 nm wide and a few micrometer long by the use of C18AA as a soft template. Interestingly, the nanowires were aligned parallel to one another. The spacing between the nanowires was ca. 5nm, which is identical with the interlayer spacing of the lamellar structure of C18AA in the organogel.

Figure. Molecular structure of C18AA, and temperature dependence of \( \eta_s^{\circ} \) of C18AA toluene gel and heat-induced gel. Inset shows digital photographs of heat-induced gel (a) at 50 °C (b) at 10 °C.