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Anisotropic Elasticity of Magnetically Ordered Agarose Gel

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INTRODUCTION

The magnetic orientation effects have been reported for organic materials. High polymer gel formed in strong magnetic fields showed the optical anisotropy. The anisotropic property was appeared as the birefringence for the agarose gel exposed to the magnetic field.[1] It was considered that the molecule ordered gel was formed under the influence of the magnetic fields because the observation of the birefringence was the evidence of the ordering of the high polymers in the gel. The elastic anisotropy is expected to measure for the ordered gel. In this study, the storage modulus is investigated for the agarose gel formed under strong magnetic fields, and the origin of the magnetic field-induced anisotropy is discussed with the gelation mechanism.

EXPERIMENT

Hot agarose solution was pored into a rectangular cell with path length of d=10.0 mm and was exposed to the magnetic fields of up to 10T. The gel was formed naturally in cooling process. The ultrasonic wave of 5 MHz propagated to measure the elastic modulus of the gel at T=283.2 K in zero magnetic fields. The reflection method was used to determine the sonic velocity c in the gel. The elastic modulus (hardness) m' was calculated according to $m'=\rho c^2$, where ρ is the density of the sample. The hardness was investigated along the perpendicular and parallel directions to the magnetic flux as a function of the exposed field.

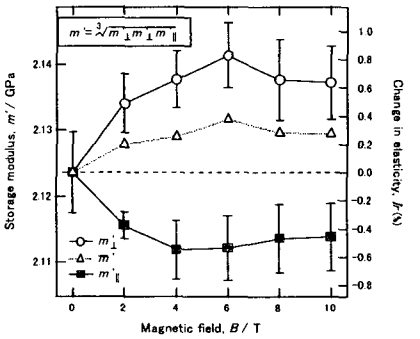

Fig. 1. Exposed magnetic field dependence of the storage modulus and the change in elasticity for 2.0 wt.% agarose gel.

RESULTS AND DISCUSSION

The storage modulus for 2.0 wt.% agarose gel depended on the exposed magnetic field as shown in Fig. 1. The hardness forthe perpendicular direction to the magnetic flux of the exposed field was increased and saturated above 6T. On the other hand, that along the magnetic flux was decreased and the same saturation tendency was observed above 4T. The averaged hardness was also increased slightly and saturated. Furthermore, the other experiments showed that the each hardness was proportional to the agarose concentration up to 5wt.%, and the hardness depended on the cooling rate. As a result of the discussion for the change in the hardness with the previous results of birefringence and the gelation model, all the origin of the magnetic field-induced anisotropic change was determined: the mechanical and optical anisotropic structure was formed under the influence of magnetic field because the molecule domains with large anisotropic susceptibility oriented to the magnetic flux.

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Magnetic Characterization of FeRh Nanoparticles

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Magnetic nanoparticles have attracted great interest because of their potential applications in ultrahigh-density magnetic recording, highly sensitive magnetic sensor, and advanced nanocomposite permanent magnets.FeRh is one of the interesting materials which shows the first order transition around 80°C from anti-ferromagnetic (*AF*) to ferromagnetic (*F*) sate in bulk and thin film systems[1]. This transition is very sensitive to composition, heat treatment, and so on. This is particularly significant in case of thin films which are constrained by substrates, preventing a volume change to occur. For this reason, a study using particles is much suitable. FeRh nanoparticles are synthesized by high temperature co-reduction of Iron (II) chloride tetrahydrate and Rhodium (III) acetylacetonate in the presence of stabilization and reduction agents[2]. In this study, the magnetic properties of FeRh nanoparticles are characterized by using XRD, EDX, TEM and VSM. Post-annealing was carried out under vacuum.

From XRD results, the as-deposited nanoparticles reveal a typical chemically disordered fcc structure and partially ordered CsCl-type structure are existed after increasing temperature and time duration. Figure 1 shows temperature dependence of the magnetization (A) and coercivities (B) of annealed (600 °C-6 hours) $Fe_{38}Rh_{62}$ nanoparticles. The sharp increase of magnetization from 160 to 220 °C is evidently due to the phase transition from *AF* to *FM*. The small decrease of magnetization from 220 to 250 °C can be explained as a structural phase change. In cooling process; magnetization increases first and then decreases. It seems to exhibit a magnetic phase transition at about 140 °C. This behaviour is very different with that of thin film system and showing a higher magnetic phase transition temperature.

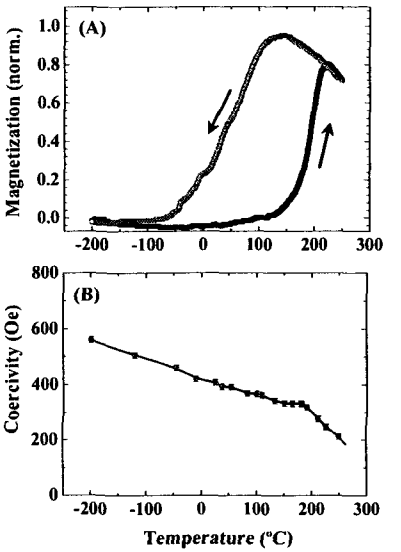

Fig. 1. Temperature dependence of magnetization measurement (A) and coercivities (B) of annealed (600°C-6 hours) $Fe_{38}Rh_{62}$ nanoparticles, respectively.

The coercivities of annealed $Fe_{38}Rh_{62}$ nanoparticles are decreased from 560 to 210 Oe after measurement of -200 to 250 °C, respectively. This decrease is not clear in this sate; the more experimental evidence is needed to confirm this. We have prepared various compositions of Fe-Rh nanoparticles and annealing conditions. The detail results will be reported.

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