Friction Properties of Polymer Hydrogels Studied by Resonance Shear Measurements and Sum Frequency Generation Vibrational Spectroscopy

Huai-Yin Ren[1], Masashi Mizukami[2], Tadao Tanabe[2], Hidemitsu Furukawa[3], Kazue Kurihara[1,2]

([1]WPI-AIMR, Tohoku University; [2]Institute of Multidisciplinary Research for Advanced Materials, Tohoku University; [3]Graduate School of Science and Engineering, Yamagata University)

Introduction: Frictional behaviors of polymer hydrogels have been extensively studied by various means[1], such as tribometry and rheometry. Low friction of polymer hydrogels was reported with friction coefficient as low as 10^{-3}. Such low values were in the same range as those in some biological systems, e.g., animal cartilage. In this study, the origins of low friction of gels were investigated by taking advantage of the resonance shear measurement[2] and sum frequency generation vibrational spectroscopy (SFG)[3]. Effects of various factors on changes in resonance shear curves for contacted gel-silica surfaces were clarified, i.e., normal load, elastic deformation of gels and addition of water on the gel surfaces. The friction of gels was calculated by analyzing the resonance curves using a proposed physical model. On the other hand, the characteristics of the interfacial water of polymer gels were studied by SFG.

Experimental: Water equilibrium swollen states of PAMPS/PDMAAm double-network (DN) gel and the single network PDMAAm gel and as-prepared state of PAMPS gel were used. These gels were synthesized by free radical polymerization[4].

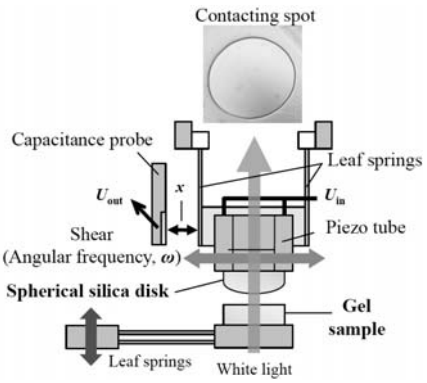

Fig. 1 Schematic diagram of the resonance shear measurement

Fig. 2 Schematic illustration of gel sample cell used for SFG.

Results: Lateral oscillation was applied at various frequencies. A small but sharp peak was observed when planar surface of DN gel was brought in contact with the upper spherical surface (setting, see Fig.1). Both frequency and intensity of the peak increased with increase of the normal load. Elasticity and friction of gels were calculated by analyzing the curves with a proposed model. Both the elastic parameter and friction force of gels increased with increasing the normal load. Friction coefficient of the gels exhibiting values in order of 10^{-2} ~10^{-3}, coincided with those studied by a tribometer. This result suggested the elasticity of gels majorly contributed to the friction of gels under the high normal load. The effects of addition of water and structure and components of gels on the friction of gels were also studied.

SFG spectroscopy revealed relatively strong icelike ν(OH) peaks related to the low friction in cases of DN gel and PAMPS gel by SFG measurements (setting, see Fig.2).

REFERENCES

[1]J. P. Gong, et al. *Soft Matter*, **2**, 544 (2006). [2]K.Kurihara, et al. *Rev. Sci. Instrum.*, **69**, 2096 (1998). [3] M. Kasuya, et al. *J. Phys. Chem. C*, **117**, 13540 (2013). [4] J.P. Gong, et al. *Adv. Mater.*, **15**, 1155 (2003).