CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval Jan. 4, 2015 承認者 Approver J. Suzuki 提出日 Date of Report 2014/12/26
実験課題番号 Project No. 2013P0401 実験課題名 Title of experiment Structural properties of soft matter and the dynamics of soft confined water 実験責任者名 Name of principal investigator Dr. Shinichi Takata 所属 Affiliation JAEA	装置責任者 Name of Instrument scientist 鈴木淳市 装置名 Name of Instrument/（BL No.） BL15 利用期間 Dates of experiments 2013/05/10 21:00 ~ 2013/05/13 09:00 2014/03/30 10:00 ~ 2014/04/01 10:00

1．研究成果概要（試料の名称、組成、物理的・化学的性状を明記するとともに、実験方法、利用の結果得られた主なデータ、考察、結論、図表等を記述してください。

Outline of experimental results (experimental method and results should be reported including sample information such as composition, physical and/or chemical characteristics.

Hierarchical structure and dynamics of soft matter such as polymers and aqueous solutions of amphiphilic molecules are important to show characteristic features of these materials. In addition, existence of water molecules within soft matter matrix is essential for physical properties of soft matter. In this project, we focus on the nanometer-scale structure and slow dynamics below orders of micro-eV of soft matter as well as water molecules will be investigated by means of neutron scattering.

（A） Hydrogels

The freeze-dried double-network hydrogels (DN-polymers) are a cross-linked aqueous polymer networks having unique mechanical properties (Tominaga, *et al*., 2012). The DN polymers under a relative humidity (RH) of 80% could sustain almost the same Young's modulus of the DN polymers at 0% RH, around 10^2 MPa. In addition, The DN-polymers have maximum of both Young's modulus and fracture stress in around 30% RH, and its water quantity is ~7wt%, while plastics contain slight water leads mechanical properties decrease largely. Small-angle neutron scattering (SANS) was applied to investigate the static structure of the humidity dependence on the DN-polymers. We got SANS results in un-deformed conditions for the DN-polymers made of poly-(2-acrylamido-2-methylpropane sulfonic acid) sodium salt (PNaAMPS) and polyacrylamide (PAAm).

Experiment method

The water-swollen DN-gels [1,2] were prepared with 2-acrylamido-2-methylpropanesulfonic acid (Toagosei Co., Ltd, Japan) and were neutralized by NaOH. 2-Acrylamide-2-methylpropanesulfonic acid sodium salt was used as the monomer for first network, purified acrylamide was used as the monomer for the second network and purified N,N′-methylenebisacrylamide was used as the cross-linker for the first network with 2-oxoglutaricacid as the UV initiator (Wako Pure Chemical Industries, Ltd., Japan). The DN-gels were then freeze-dried by EYELA FDU-2100 (Tokyo Rikakikai Co., Ltd., Japan), which creates the DN-polymers [6]. The DN-polymer samples were placed in a dry state with a glove box evacuated by a turbo-pump (VPT-030, ULVAC Kiko, Inc.,

Japan) to remove light water. After the drying process, heavy water (435767-100G, Aldrich Chemical Company) vapours were introduced into the system for more than an hour to generate certain relative humidity (RH). The humidity conditions were as follows: 0% (dry state), 23%, 40%, 68% and 79%. Measurements of all the humidity conditions were prepared by the same sample. The SANS measurements were performed with a small- and wide- angle neutron scattering instrument, TAIKAN (BL15), which is in the Materials and Life Science Experimental Facility (MLF) of the Japan Proton Accelerator Research Complex (J-PARC).

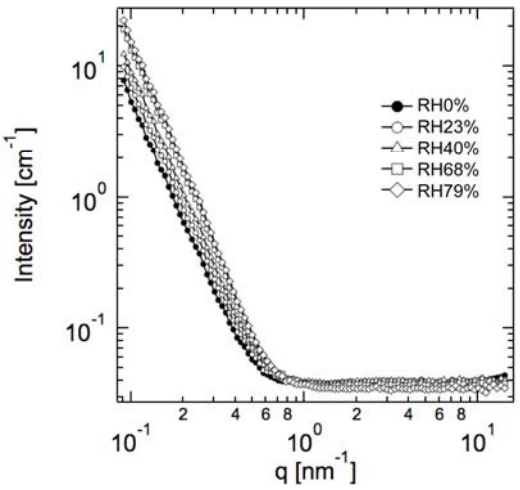


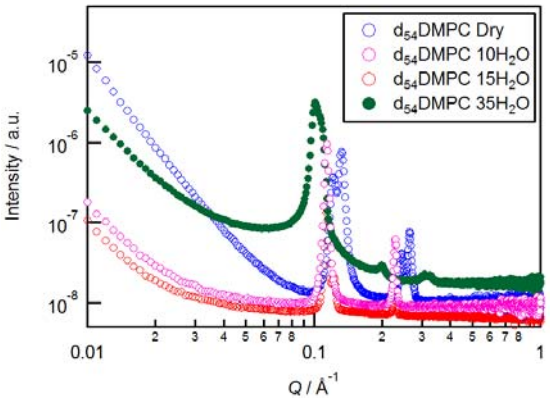
Fig. 1SANS profiles obtained from the DN-polymers under different humidity conditions. The relative humidity is 0% (dry state, closed circle), 23% (open circle), 40% (triangle), 68% (square) and 79% (diamond).

The SANS profiles of the DN-polymers under various RH conditions are shown in Fig. 1. The intensity below $q = 2 \times 10^{-3}$ nm^{-1} increases with increasing RH. The power law behaviour is observed in this q-range with an exponent of approximately −3.1 for all RH conditions. The samples studied here are dried, porous materials synthesized via radical polymerization and intrinsically have a random structure. Therefore, it is reasonable to assume the SANS intensities originate from the nanoscale interfaces of polymer networks.

The adsorption behaviour of water molecules in the polymer network of the DN-polymers could be interpreted as follows: There is no change in the polymer network structure larger than d (= $2\pi/q$) = 20 nm, which is comparable to the pore size below 79% RH.

（B）DMPC / water systems

Phospholipids which are one of the important components of biological membrane make bilayers in water and studied as model membrane. Many studies are reported for the phospholipid /water systems from various points of view. In this project, the dynamics of hydrated water on DMPC was investigated by using quasi-elastic neutron scattering. The dynamics might be related to the bilayer structure of DMPC / water systems. In order to investigate the structure of the samples measured by QENS, SANS measurements by TAIKAN were performed in the 2013 JAEA project. The obtained SANS profiles are shown in Fig. XX. With increasing the water content, the layer distance corresponding to the peaks around 0.1 Å-1 increased. However the incoherent scattering due to the adsorbed water was large. In order to improve and clarify the detained structure, new samples for TAIKAN which composed of d54DMPC and D2O will be regulated and will be measured in 2014.



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