（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

MLF Experimental Report	提出日 Date of Report 2017/1/31
課題番号 Project No. 2016A0075 実験課題名 Title of experiment Structural analysis of layers of amphiphiles at the interface of nematic liquid crystals and a solid substrate 実験責任者名 Name of principal investigator, Fumiya Nemoto 所属 Affiliation High Energy Accelerator Research Organization	装置責任者 Name of responsible person Norifumi L. Yamada 装置名 Name of Instrument/(BL No.) BL16 実施日 Date of Experiment 2016/5/24-26, 6/26-27

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Samples are as follows; Nematic Liquid Crystal (NLC) 4-cyano-4'-pentylbiphenyl (5CB, C18H19N) mixed with fully-deuterated surfactant, cetyltrimethylammonium bromide (CTAB, C19D42BrN). The mixed mole fraction φ = $5e^{-6}$, $1e^{-5}$, $5e^{-5}$, $1e^{-4}$, $5e^{-4}$, which is previously observed and determined by polarized optical microscopy. These samples are employed as model systems mimicking the alignment agents mixed with NLCs used for vertically-aligned mode LC displays.

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

The purpose of this work is to clarify the relation between alignment of LC and condensed structure of surfactant at the interface between the substrates and NLCs. Thus, we proposed the in-situ neutron reflectivity (NR) measurement to evaluate the thickness and density of surfactant layers at the interface. To enhance the contrast, protonated NLCs and deuterated surfactant were used for the NR measurement, while the organic molecules are hardly distinguished by X-ray reflectivity measurement. In this work, we investigated the structure of surfactant with the object of how it grows depending on its concentration φ, thus we measured NR varying φ.

A 1 cm-thick silicon substrate coated with 800 Å -thick silicon dioxide (SiO_2) layer (buffer layer) was put on the sample bath, and the reflected beam intensity at the interface of sample and SiO_2 were accumulated. Substrates were UV-irradiated in advance to enhance hydrophilicity of the surface. Even though the surfactant layer (approximately 20 Å for the monolayer) was expected to be too thin to be observed, we could evaluate it from the difference in the total thickness between two conditions; with and without the surfactant layer.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

Fig. 1 shows the NR profiles for a substrate with air, with pure LC and with LC mixed with surfactant, obtained by this experiment. Different profiles were observed depending on samples. These profiles are well reproduced assuming the model consisting of the buffer layer with air, pure LC on buffer layer and pure LC on buffer layer absorbed by single surfactant monolayer, respectively. The fitting procedure was performed using Motofit on Igor based on the Parratt formalism. Fig. 2 illustrates φ dependence for thickness of surfactant layer *d* obtained by the fitting. Increasing φ causes an increase of *d*. Since the molecular length of surfactant is about 25 Å, this effect is due to the change in orientation of surfactant from horizontal to vertical on increasing φ. The threshold thickness of surfactant layer for the orientation of LC is about 20 Å, because the optical microscopy showed that the LC alignment changed from horizontal to vertical at $\varphi = 5e^{-4}$. These results indicate that the change in orientation of surfactants due to an increase of absorbed surfactant molecules on the substrates, causes the change in orientation of LC both from horizontal to vertical on increasing φ. In summary, we successfully observed the surfactant monolayer at the substrate in the presence of LC slabs for the first time, and determined the relation between LC alignment and structure of surfactant layer directly.

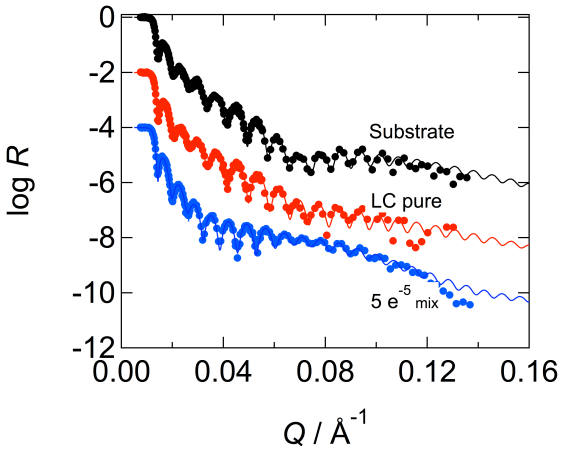

Fig. 1 NR profiles for various conditions. Data points were obtained by experiment and solid lines indicate the fitting results.

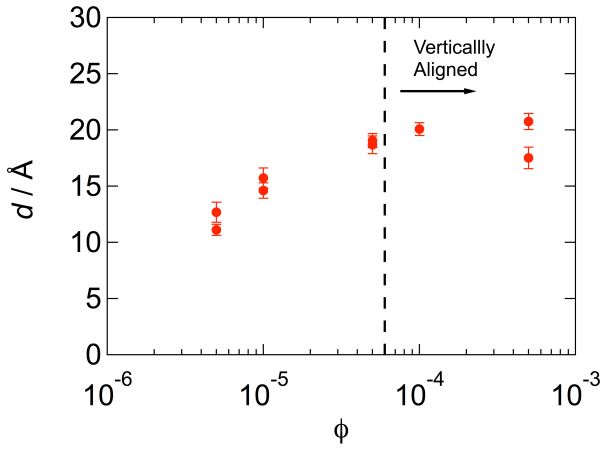

Fig. 2 Concentration dependence of the thickness of surfactant layer. On the right of the dashed line, LCs vertically aligned.