(Project use)

CROSS TOKAI **Experimental Report** J-PARC	Date of Approval 2016/1/18 Approver Jun-ichi Suzuki Date of Report 2016/1/18
Project No. 2014P0803 Title of experiment Development and application of on-beam SEOP based 3He spin filter at BL15 Name of principal investigator Takayuki OKU Affiliation J-PARC Center	Name of instrument scientist Jun-ichi Suzuki Name of Instrument/(BL No.) TAIKAN / BL15 Date(s) of experiment(s) 2014/05/21-2014/05/23

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

We performed polarized small-angle neutron scattering demonstration experiments on silver behenate ($C_{22}H_{43}AgO_2$). In this study, we aim to separate coherent and incoherent neutron scattering components from silver behenate by using polarized ^{3}He gas as a neutron spin analyzer. Schematic drawing of the experiments is shown in Fig. 1. The polarization analysis set up consists of a supermirror based neutron spin polarizer, a neutron spin flipper, a sample area, a polarized ^{3}He gas analyzer with a magnetic environment device and 2D detector bank. The size of the ^{3}He cell was 35 mm in diameter and 55 mm in length. The pressure length-product of the cell was 11 amg･cm. The distance between the sample and the polarized ^{3}He cell was almost 10 mm. So the ^{3}He cell analyzer had a coverage angle of 26 degree.Considering the present geometry, the small angle detector bank must be fully covered by the ^{3}He analyzer.

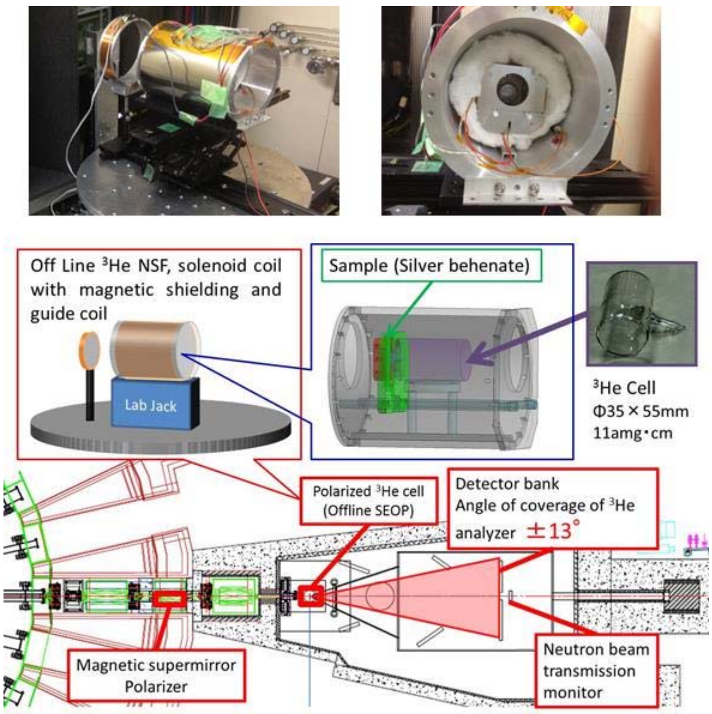

Fig.1 Schematic drawing of experimental setup.

The ^{3}He gas was polarized by using spin-exchange optical pumping (SEOP) station and then brought into the beamline. The nuclei polarization of the gaseous ^{3}He at the start of the experiment was 59.5% and the observed relaxation time at BL15 was 96.6 hours. The magnetic environment device for polarized ^{3}He cell included the adiabatic fast passage (AFP) NMR, which was a technique to measure the polarization of the ^{3}He nuclei and reverse the direction of the ^{3}He nuclear spin with respect to a static magnetic field. So we could detect a spin

1. Experimental method and results (continued)

Figure 2 shows the two dimensional SANS patterns on the small angle detector bank measured with neutrons of λ=3.0 Å. It took two hours to collect each pattern. The polarization of the ^{3}He nuclei was decreased to 54 % at the end of the experiments. During these measurements, we did not change the polarity of the ^{3}He nuclear spin. Three Debye-Scherrer rings from silver behenate were observed in the non-spin-flip (+, +) scattering pattern and relatively higher background was observed in the spin-flip (-, +) scattering pattern. It was confirmed that all the small angle detector banks were covered by the polarized ^{3}He gas analyzer.

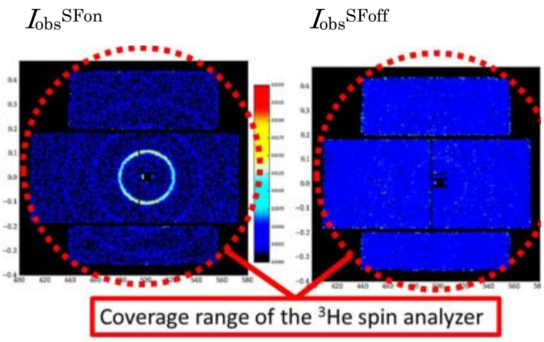

Fig.2 2D SANS intensities measured with the spin flipper on and off.

Figure 3 shows the one dimensional SANS profile. Because of the imperfect polarizing performance of the supermirror polarizer and the polarized ^{3}He spin analyzer, these observed intensities include four components written as follows:

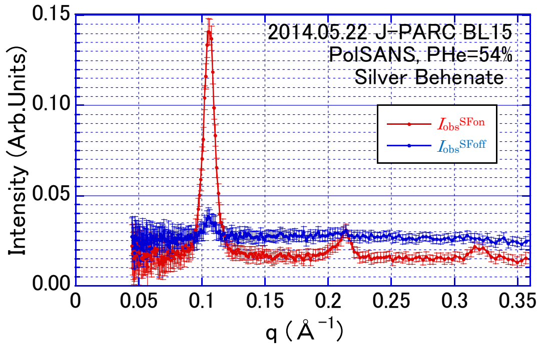

Fig.3 1D SANS intensities with the spin flipper on and off.

$$I_{obs}^{SFon} = N_+ I_{(++)} T_{++} + N_+ I_{(-+)} T_{-+} + N_- I_{(-+)} T_{++} + N_- I_{(++)} T_{-+},$$
$$I_{obs}^{SFoff} = N_- I_{(++)} T_{-+} + N_- I_{(-+)} T_{++} + N_+ I_{(++)} T_{++} + N_+ I_{(-+)} T_{-+},$$

where I_{obs}^{SFon} and I_{obs}^{SFoff} are the observed intensities with the spin flipper on and off, $I_{(+,+)}$ and $I_{(-,+)}$ are the intensity of the spin non-flip and spin flip components, N_+ and N_- are injected neutron with up and down spin, T_{++} and T_{-+} are transmission of the polarized ^{3}He analyzer of the neutron with spin being parallel and antiparallel to the ^{3}He nuclear spin. The $I_{(+,+)}$ and the $I_{(-,+)}$ can be written by

$$I_{(+,+)} = I_{coh} + 1/3 I_{inc}$$
$$I_{(-,+)} = 2/3 I_{inc}$$

where I_{coh} and I_{inc} are the coherent and incoherent scattering components of the silver behenate, respectively. Figure 4 shows the $I_{(+,+)}$ and $I_{(-,+)}$ components calculated according with these equation. We succeeded in separating the coherent and incoherent scattering components by using the polarized ^{3}He gas as a spin analyzer.

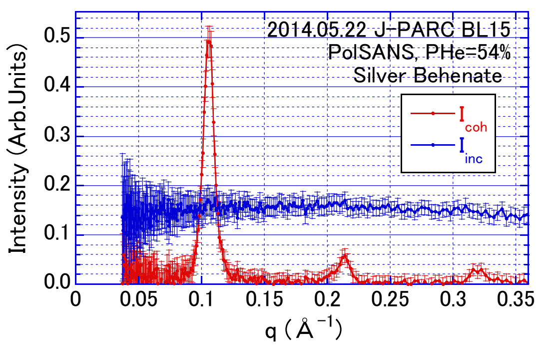

Fig.4 Choherent and incoherent scattering components of silver behenate.

In conclusion, we performed polarized small-angle neutron scattering demonstration experiments on silver behenate with using the polarized ^{3}He gas as a spin analyzer and succeeded in separating the coherent and incoherent scattering components. It was confirmed that the relaxation time of the polarized ^{3}He gas at BL15 was long enough. Because the beam time of the BL15 is very tight and most of the experiments performed within a few days, the offline SEOP based polarized ^{3}He analyzer is effective and realistic option for BL15.

Please use A4-size paper for further reporting, if necessary.