Experimental report

31/05/2016

Proposal: DIR-133 **Council:** 10/2014

Title: Neutron Attenuation in Thick Mica and Glue Films

Research area: Chemistry

This proposal is a new proposal

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Samples: Mica supported on silicon substrate

Instrument	Requested days	Allocated days	From	To
D17	1	1	02/07/2015	03/07/2015

Abstract:

DIR 133- Neutron Attenuation in Thick Mica and Glue Films

Motivation

A method for performing neutron reflection from the mica/liquid interface has been developed by the Clarke research group, as recently published[1,2]. This method circumvents some of the problems which have been historically associated with neutron reflection from mica substrates by adhering a layer of mica to a neutron grade flatness/roughness silicon wafer using a UV activated glue. Nevertheless, this approach encounters its own problems. The glue and mica layers adhered to the substrate are thicker than those typically encountered during a reflection measurement and cause significant attenuation of the neutron beam on its passage through the layer.

The attenuation of the beam by these thick layers has previously been assumed to be the sum of the coherent, incoherent and absorption cross sections of the materials, as shown in Eq 1.

$$N\sigma_{tot} = \frac{N\sigma_{abs\ (1.798\ \text{Å})}}{1.798}\lambda + N\sigma_{coh} + N\sigma_{incoh} \quad \textbf{Eq 1}$$

Where N is the number density of atoms, σ_{tot} is the total attenuation cross section, σ_{coh} is the coherent scattering cross section, σ_{incoh} is the incoherent scattering cross section, σ_{abs} is the absorption cross section and λ is the neutron wavelength.

Existing reflectivity data exhibits features consistent with different behaviour from that suggested above. During this direct access experiment, the attenuation of the beam by these thick layers was measured.

Neutron Transmission through Thick Glue and Mica Layers

Transmission of the neutron beam through a material measured as a function of wavelength can be used to access the attenuation cross section. The intensity is expected to follow a Beer-Lambert relation as in Eq 2 where I is the transmitted intensity, I_0 is the incident intensity, $N\sigma_{tot}(\lambda)$ is the wavelength dependent attenuation cross section and d is the layer thickness[3].

$$\mathrm{I} = \mathrm{I_0}\exp[-\mathrm{N}\sigma_{\mathrm{tot}}(\lambda)\mathrm{d}] \quad \textbf{Eq 2}$$

Eq 2 is rearranged to give Eq 3 which demonstrates that plotting $\frac{\ln\left[\frac{I}{I_0}\right]}{d}$ as a function of wavelength and fitting of the data enables $N\sigma_{tot}(\lambda)$ to be determined, assuming that d is well known.

$$-N\sigma_{tot}(\lambda) = \frac{\ln\left[\frac{I}{I_0}\right]}{d} \qquad \textbf{Eq 3}$$

The neutron transmission through mica and glue samples was measured as a function of wavelength using the D17 reflectometer.

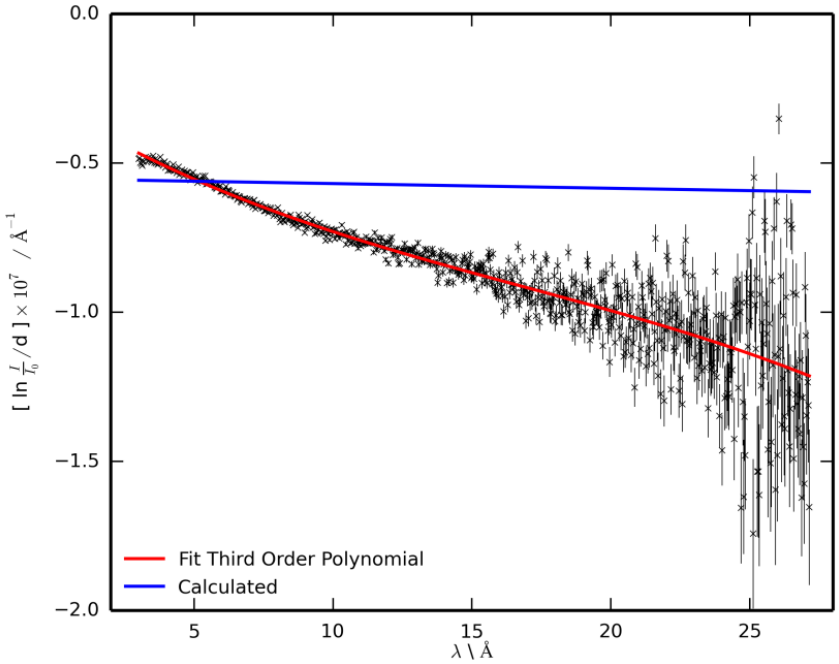

Figure 1: Plot to determine the wavelength dependent attenuation cross section of Loctite 3301 glue. The red line is a polynomial fitted to the transmission data and the blue line is the variation with wavelength expected from tabulated values and Eq 1.

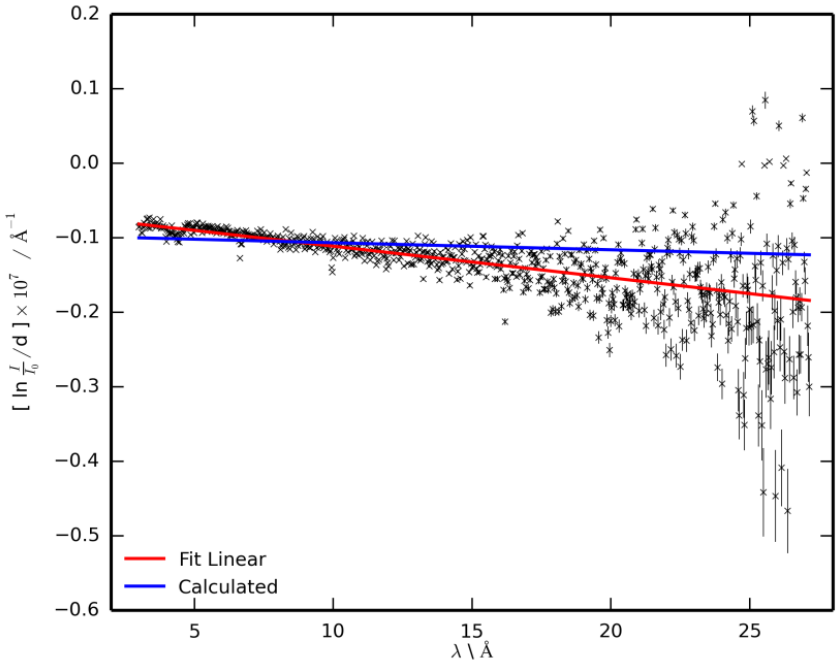

Figure 2: Plot to determine the wavelength dependent attenuation cross section of muscovite mica. The red line is a straight line fitted to the transmission data and the blue line is the variation with wavelength expected from tabulated values and Eq 1.

Figure 1 and Figure 2 show the manipulated transmission data collected for the glue and mica samples respectively. The wavelength dependent attenuation cross section has been fitted to the data is each case, as shown by a solid red line. The attenuation cross section showed distinctly different wavelength dependence (especially the glue layer) from that predicted from Eq 1 and the known composition of the materials. The predicted behaviour is shown as a solid blue line on both figures.

Significance of Findings

The attenuation cross sections are key parameters in fitting reflectivity data recorded from the mica/liquid interface (much like the SLD of specific components). The wavelength parametrisations extracted from this experiment have made full and quantitative analysis of existing reflectivity measurements possible. It is expected that the fully interpreted reflectivity data will result in further publications.

Bibliography

(1) Griffin, L. R.; Browning, K. L.; Truscott, C. L.; Clifton, L. A.; Clarke, S. M. Complete Bilayer Adsorption of C16TAB on the Surface of Mica Using Neutron Reflection. *J. Phys. Chem. B* **2015**, *119*, 6457−6461.

(2) Browning, K. L.; Griffin, L. R.; Gutfreund, P.; Barker, R. D.; Clifton, L. A.; Hughes, A.; Clarke, S. M. Specular Neutron Reflection at the Mica Water Interface. *J. Appl. Crystallogr.* **2014**, *47*, 1638–1646.

(3) Atkins, P.; Paula, J. de. *Atkins' Physical Chemistry*; OUP Oxford, 2014.