Experimental report

09/02/2016

Proposal: **7-05-439**

Council: 10/2014

Title: Diffusion of deuterated pentacene molecules on exfoliated graphite inthe sub-monolayer regime studied with NSE

Research area: Other...

This proposal is a new proposal

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Samples: C22D14/C

Instrument	Requested days	Allocated days	From	To
IN11	16	14	16/07/2015	30/07/2015

Abstract:

Organic thin films such as pentacene ($C_{22}H_{14}$) films are promising systems for the development of novel electronic devices. However, the electrical properties of the resulting devices are limited by the quality of the films, which strongly depends on the growth process. Diffusion favours layer-by-layer growth since dissipative motion with frictional forces is an effective mechanism leading to the nucleation of stable islands. However the number of studies on pentacene diffusion on different technologically relevant substrates is very small if compared to structural studies. We propose to fill this gap with comprehensive measurements of the dynamics of (deuterated) pentacene on exfoliated graphite substrates in the sub-monolayer regime. The goal is to identify the physical mechanisms, which drive the first layer formation in a weakly physisorbed phase.

Diffusion of deuterated pentacene molecules on exfoliated graphite in the sub-monolayer regime studied with NSE

Organic thin films such as pentacene ($C_{22}H_{14}$) films are promising systems for the development of novel electronic devices. However, the electrical properties of the resulting devices are limited by the quality of the films, which strongly depends on the growth process. Diffusion favours layer-by-layer growth since dissipative motion with frictional forces is an effective mechanism leading to the nucleation of stable islands. However the number of studies on pentacene diffusion on different technologically relevant substrates is very small if compared to structural studies. *In order to fill this gap we have carried out comprehensive measurements of the dynamics of deuterated pentacene* ($C_{22}D_{14}$) *on exfoliated graphite substrates in the sub-monolayer regime. We have measured the dynamics of pentacene on exfoliated graphite substrates, as a function of temperature in the sub-monolayer regime (0.5 ML and 0.9 ML).*

Measurements and experimental set-up:

We have performed the measurements using the two samples,(0.5 ML and 0.9 ML of deuterated pentacene, $C_{22}D_{14}$) which we had already prepared for the experiment in D20 (see report of experiment 5-21-1088 for further details).

The measurements have been performed with the cryofurnace set-up which allows us to cover a wide thermal range from 10 K up to 550 K. We measured at 5 K (resolution function), 100 K, 250 K, 350 K and 450 K and we spent 24 hours per temperature.

We used the IN11C instrumental set-up with an incoming wavelength of 5.5 Å. In addition, we measured for each sample and each temperature with the two available orientations: $2\theta = 20$ degrees and 50 degrees, which in total corresponds to a momentum transfer range spanning from 0.15 $Å^{-1}$ to 1.2 $Å^{-1}$.

Experimental Results

We observe a consistency between the structural results obtained in the D20 diffractometer and the coherent dynamics observed with IN11. The low momentum transfer range (0.15 $Å^{-1}$ - 0.6 $Å^{-1}$) contains the diffraction peaks of the pentacene adsorbed layer. Therefore the mobility of the molecules is strongly reduced, since the length scale matches the lattice parameter of the ordered layer. This gives rise to the De Gennes narrowing of the quasi-elastic spectrum or equivalently, to the non-decay of the intermediate scattering function with time that we observe (see top panel of Fig. 1). In the high momentum transfer range, we observe a shallow decay of 20 % of the signal for temperatures above the desorption temperature (450 K and 500 K). However the coverage decreases in this thermal range due to desorption. Therefore we expect an increment of the mobility of the molecules on the surface. Unfortunately the low statistics of the signal in this instrumental configuration makes the analysis of the signal very difficult. Finally, we observe little dependence of the intermediate scattering function with coverage (see bottom panel of Fig. 1), which indicates the tendency of the pentacene molecules to get trapped into islands on the surface which are probably pinned to defects of the substrate.

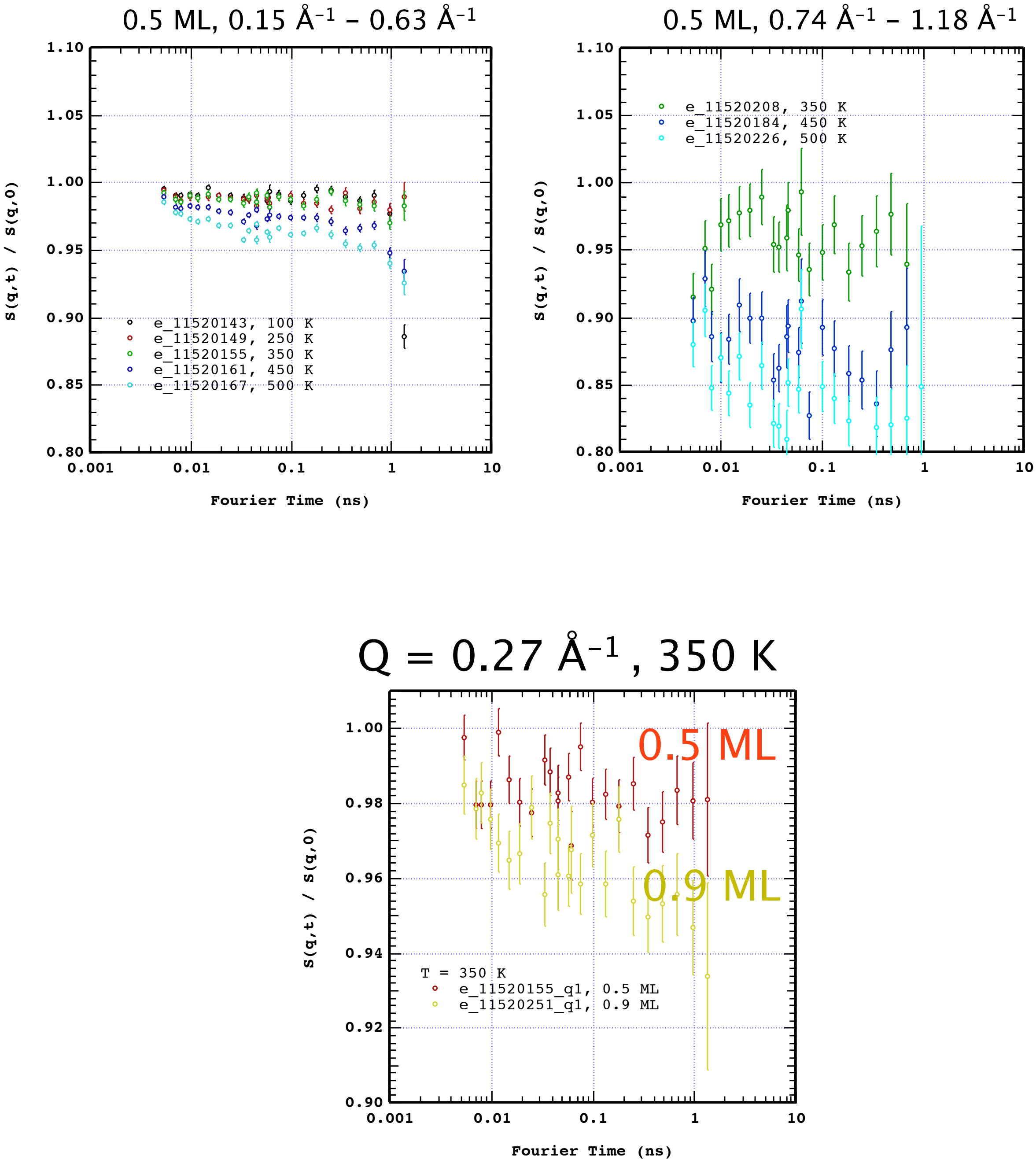

Figure 1: Top panel: Intermediate scattering functions for 0.5 ML in a thermal range between 100 K and 500 K where the signal has been integrated over the momentum transfer. Bottom panel: Comparison between the intermediate scattering functions for 0.5 ML and 0.9 ML at 350 K for a momentum tranfer of 0.27 Å^{-1} .