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Alternating barium stearate and copper stearate LB thin films

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Alternating layers based on copper and barium stearate have been prepared. The interlayer distance for both type of stearates have been determined by X-ray diffraction. It was found that the interlayer distance for an alternating assembly depends on the actual type of the stearate layer. Thus we demonstrated the possibility to control the inter-layer distance by choosing an appropriate sequency of layers. It is suggested that such layers may serve as high precision thickness standard at the ångström level.

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The nanotechnology uses the phenomenon of self-organization for making controlled assembly of molecules and atoms with specific functionalities [1]. Polymers are usually used for nanostructures, especially as thin films, due to their easy processing [2]. Langmuir-Blodgett films have numerous applications as field effect transistors [3], transducers, in electron-beam lithography [4], electronic displays, photovoltaic cells [5]. Controlled film thickness and refractive index make these films useful in integrated optics, in conventional optics and in optical data storage, as well as in magnetic data storage [6].

Recently Langmuir-Blodgett layers for vapour sensing have been deposited in an alternate layer LB trough [7].

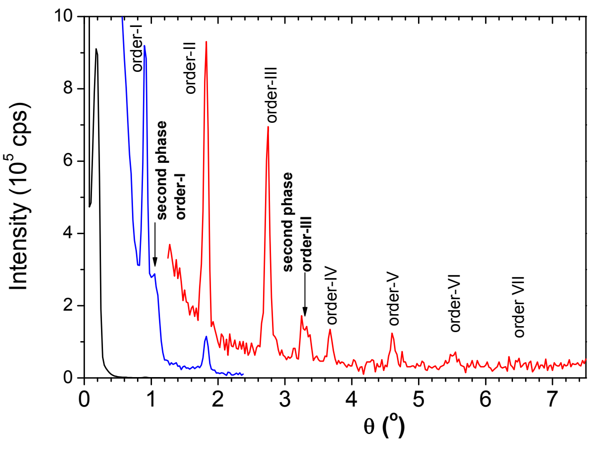


Fig. 1 The X-ray diffraction pattern of the barium stearate LB multilayer made up of 5 simple layers. The arrows show the position of a second phase inclined toward the substrate. 7 diffraction maxima are visible, corresponding to 7 diffraction orders.

Langmuir-Blodgett films based on barium stearate and copper stearate have been prepared using a KSV-5000 trough and balance. Firstly the glass substrates for layer transfer have been processed for good cleaning and making them hydrophobic. They were cleaned in distilled water and ethanol, followed by cleaning in a mixture of potassium di-chromate and sulphuric acid, and then washed again in ethanol and distilled water.

Using the classical LB method two samples with 5 layers each of barium stearate and copper stearate have been deposited, followed by one sample of 11 layers of alternated deposition of barium stearate and copper stearate. The periodicity of the alternated layers for the prepared multilayers are given in Tables 1-3.

The resulting multilayered samples have been investigated by X-ray diffraction. Fig. 1 and 2 show the results for the first two samples of barium stearate and copper stearate.

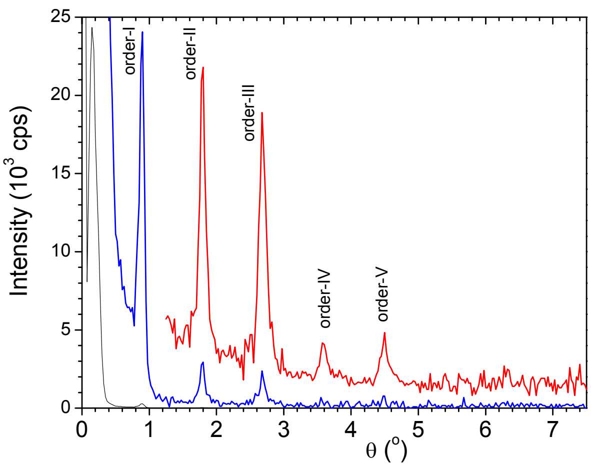


Fig. 2 X-ray diffraction pattern of the copper stearate LB multilayer with 5 simple layers.

Table 1 and Table 2 show the periodicity of the deposited layers for both types of fatty acid molecules. From the previously determined compression isotherm we set the transfer pressure: 28 mN/m in the case of barium stearate and 40 mN/m in the case of copper stearate molecules.

Table 1. Periodicity of the barium stearate multilayers, determined form the positions of the peaks of the X-ray diagram.

n	θ (deg)	d(Å)	d*n (Å)	D_{mean} (Å)
1	0.912	48.39	48.39 (I)	48.13 (Phase I)
1	1.075	41.06	***41.06 (I)***	
2	1.822	24.23	48.45 (II)	
3	2.74	16.11	48.34 (III)	
3	3.297	13.40	***40.19 (III)***	***40.62*** (Phase II)
4	3.672	12.03	48.11 (IV)	
5	4.611	9.58	47.91 (V)	
6	5.529	7.99	47.97 (VI)	
7	6.482	6.82	47.76 (VII)	

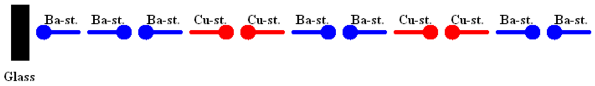
Table 2 Periodicity of the copper stearate multilayers determined form the positions of the X-ray diffraction peaks in the diagram.

n	θ (deg)	d(Å)	d*n (Å)	D_{mean} (Å)
1	0.893	49.42	49.42 (I)	49.28
2	1.790	24.60	49.32 (II)	
3	2.684	16.45	49.35 (III)	
4	3.587	12.31	49.25 (IV)	
5	4.500	9.82	49.09 (V)	

For the barium stearate multilayer packing the mean value of the packing inter-layer distance is 48.13 Å. For the copper stearate the same distance is 49.28 Å.

In the next step we have prepared alternate layers of barium and copper stearates using the special double Langmuir trough of the KSV-5000 device.

The sequence at the deposition of alternated layers, starting from the bottom of the sample was the following:



The transfer pressure was intermediate between that of barium- and of copper stearate films, and was carefully controlled during sequential deposition.

The structure of the complex layers thus obtained has been evaluated by X-ray diffraction. Figure 3 shows the result. From the position of the X-ray peaks for various diffraction orders it was concluded that a good packing of the layers has been obtained and, practically an equal inter-layer distance was formed. This inter-layer (mean) distance is 48.45 Å. This value is somewhat intermediary between the inter-layer distance obtained for the LB packing of barium stearate and that of copper stearate. Table 3 shows the inter-layer distance values calculated from the position of each peak.

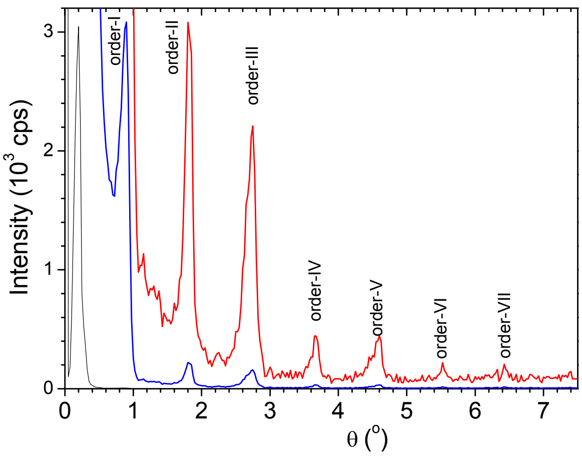


Fig. 3 XRD pattern of a complex multilayer formed by alternate layers of barium stearate (7 layers) and copper stearate (4 layers).

Table 3. Inter-layer distance for the complex alternating multilayer (barium stearate- copper stearate)

n	θ (deg)	d(Å)	d*n (Å)	D_{mean} (Å)
1	0.890	49.59	49.59 (I)	48.45
2	1.819	24.27	48.53 (II)	
3	2.733	16.15	48.46 (III)	
4	3.674	12.02	48.08 (IV)	
5	4.576	9.66	48.27 (V)	
6	5.524	8.00	48.01 (VI)	
7	6.425	6.88	48.18 (VII)	

Finally we have drawn the plot of the inter-layer distances, as a function of the layer composition for the three cases we investigated (Fig. 4). One observes an intermediate value of the lattice constant for the case of complex alternating multilayer. The theoretical mean value for the sample with alternating layers, is higher than the experimental value. This surprising fact cannot be interpreted reasonably.

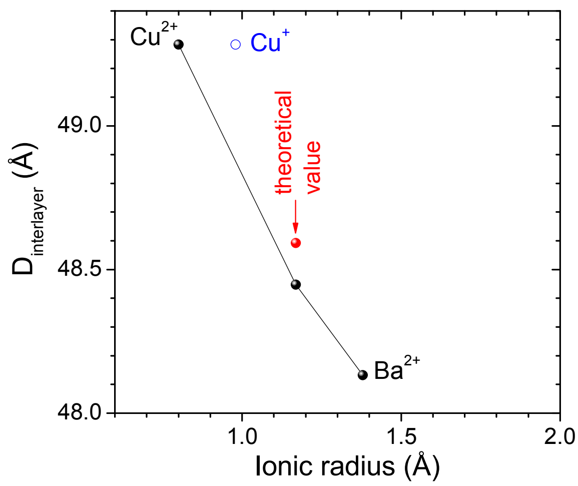


Fig. 4. Variation of the interlayer distance vs. molecule type used to make the films.

The result is important both for fundamental and practical points of view.

An application suggested by this work is the production of controlled thickness standards using the combination of two types of molecules in the Langmuir-Blodgett stacks as well as the design of new chemical vapour sensors.

Acknowledgement

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