NOVEL MATERIALS FOR MOLECULAR ELECTRONICS AND THEIR CHARACTERIZATION

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Summary Defect-free diacetylene (DA) Langmuir-Blodgett films polymerized on a air/water interface have various applications in biosensors, membrane physics or low-dimensional physics. Polymerization of DA monolayers is in general way characterized by optical spectroscopy. In this study for evaluation of photopolymerization process for the first time the Maxwell displacement current (MDC) measuring technique was used. In experiment MDC flows through the metal electrode/air gap/Langmuir monolayer/water surface structure. The effect of polymerization as well as the phase transition of polymerized DA was observed. Moreover PDA domain creation and homogenization was registered.

1. INTRODUCTION

The study of 3-dimensional crystalline polymers of diacetylene (DA) had already made substantial progress even before the attention was turned to Langmuir-Blodgett films formed of these materials. The polymers of diacetylene derivatives have some interesting properties such as non-linear optical properties, anisotropic electric conductivity [1]. Also the patterning of polymerized diacetylene (PDA) monolayers is a feasible approach for various components, where functional molecules can be integrated into a membrane with well-defined spatial arrangement [2] for preparing a biosensor with molecular recognition [3]. It was found that the Langmuir technique, in which dissolved monomers are spread onto a water surface, subsequently compressed, and then polymerized prior to deposition onto a substrate (LB film), are extremely effective in producing well-controlled and highly organized ultrathin PDA films [4].

A lot of studies have been reported on the photochemical reactions of diacetylene monolayers and LB films of DA, mostly focused on the colour change observed by optical spectroscopy [5]. The

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where G is the geometrical factor of the experimental arrangement. The measured displacement currents as well as the calculated dipole moment projections are presented in Fig. 5.



Fig. 5: (up) MDC signals obtained on monomeric DA and polymeric DA monolayers. (down) Calculations of the dipole moment projections of DA molecules before and after photopolymerization.

Because the dipole moment projection μ_z is a product of the dipole moment orientation and its magnitude, MDC technique can provide different profits. The dipole moment projection - area isotherm for monomers characterizes the orientational changes of the molecules, i.e. we assume a constant value of the dipole moment. However, after photopolymerization of diacetylene monolayer the molecular tilt is conserved and the MDC signal is generated by the change of the dipole moment magnitude. Therefore, the dipole moment projection of polymerized DA reflects blue to red phase transition.

The signals for as measured first three compressions in series after UV polymerization are shown in Fig. 6. The amplitude of the signal was changed, however the total induced charge (the area under the current-time, or current-area isotherm for constant compression rate) is conserved. Stabilization of the signal, formation of the monolayer, therefore caused is by the homogenization of material distribution, not by a destructive process. This result is in accordance with spontaneous domain creation in PDA [7].



Fig 6: (up) MDC signals obtained on polymerized DA monolayer in course of first three compressions.
(down) Calculations of the dipole moment projections of polymerized DA monolayer.

4. CONCLUSION

The MDC method was used for studying monolayer polymerization for the first time. It was shown, that its application is highly effective and significantly complement optical measurements (absorption spectroscopy). The experiment performed on the DA monomolecular film situated on the water surface revealed the effect of polymerization on the π -A as well as I – A isotherms and, thus, the changes of the molecular dipole moment could be calculated in the course of polymerization. Moreover, the experiment is sensitive to domain creation and their spatial distribution.

Further systematic measurements of the polymerization process in diacetylene monolayers are in progress.

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