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Features of the Self-organization of Films Based on Triglycine under the Influence of Vapors of Organic Compounds

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Abstract—The self-assembly of triglycine on the surface of highly oriented pyrolytic graphite and mica is studied by atomic force microscopy. The possibility of the formation of crystalline structures based on triglycine as a result of the action of vapors of organic compounds or water on its amorphous film is demonstrated. It is shown that organic compounds capable of forming hydrogen bonds affect the surface of films deposited onto these substrates. Organic compounds incapable of hydrogen bonding change the morphology of films deposited only onto the surface of pyrographite.

Keywords: atomic force microscopy, surface morphology, self-assembly, short-chain oligopeptides, triglycine, organic films, organic crystals

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INTRODUCTION

Organic crystals are of great interest for modern nanotechnologies [1]. They are used in designing optical storage devices, color displays, optical-communication systems [2], organic field-effect transistors [3], development of new dosage forms for pharmaceuticals [4]. Methods for the preparation of micro- and nanocrystals whose chemical-physical properties are determined to a considerable degree by their surface morphology are being actively developed [5]. The most applied method for the preparation of organic crystals is their growth from liquid solutions [6]; nevertheless, this method has some shortcomings associated with its sensitivity to very minute changes in the external conditions [7]. Among these shortcomings, we can cite the duration of the process and the lack of guarantee of obtaining crystals with the desired morphology, shape, and size. In addition, it is necessary to take into account the fact that organic compounds are capable of forming various polymorphic modifications [8]. Another method consists in the formation of crystals and nanostructures on the surface of amorphous films deposited onto various substrates subjected to vapors of organic compounds. Being metastable from the viewpoint of thermodynamics, the amorphous state of matter has an excess energy and can be transformed to the ordered state (nanostructures, crystals) due to the impact of external factors [9]. This transition can be initiated due to interaction between the film and vaporous compound. Varying organic vapors or the substrate types, one can obtain various organic structures [10–14]. At the same time, to date, the control of the self-assembly of molecules in thin films and the prediction of the possible morphology of the film surfaces with crystals grown on them remains a complicated task [15].

Rather widely applied objects for such investigations are short-chain peptides (oligopeptides), since the micro- and nanostructures based on them are now used in various domains [16], for instance, in optics and energetics [3, 17], medicine [18], and materials science [19]. The peculiarity of oligopeptides on account of which they are of interest is their capacity of self-assembly with the formation of different structures: nanoparticles, nanofibers, nanorods, nanowires, nanotubes, and nanospheres [20, 21]. The simplest oligopeptide from the diverse range of these structures is glycylglycine dipeptide formed from the residues of the simplest amino acid (glycine). Being part of many proteins and biologically active compounds, glycine has a high biological activity [22]; therefore, the structure and properties of its crystals are rather well investigated [23, 24]. At the same time, diglycine and triglycine are also of great interest, because they can be used to produce biologically active medical products [25]. It is known that in the process of the crystallization of diglycine from its solution under normal conditions, three polymorphs can