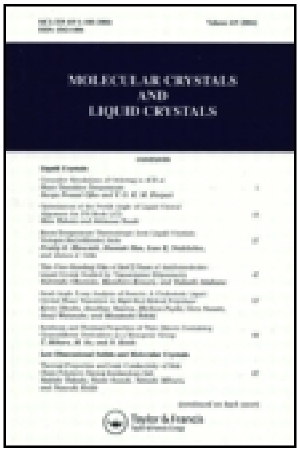

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Structure of Aerosil in Liquid Crystal Polymer

A. Hauser [a] , H. Kresse [a] & O. Yaroshchuk [b]

[a] Martin-Luther-Universitaet Halle-Wittenberg, FB Chemie, Institut fuer Physikalische Chemie, Muehlpforte 1, D-06108, Halle, Germany

[b] Institute of Physics, National Acad. Sci., prosp. Nauki 46, 252650, Kyiv, Ukraine

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Structure of Aerosil in Liquid Crystal Polymer

A. HAUSER[1], H. KRESSE[1*], O.YAROSHCHUK[2].
[1] Martin-Luther-Universitaet Halle-Wittenberg, FB Chemie, Institut fuer Physikalische Chemie, Muehlpforte 1, D-06108 Halle, Germany
[2] Institute of Physics, National Acad. Sci., prosp. Nauki 46, 252650 Kyiv, Ukraine

The structure of aerosil in a glassy state of liquid crystalline polymer was investigated using the method of atomic force microscopy. Rod-like agglomerates of aerosil were found. Average agglomerate size, anisotropy rate and inter-agglomerate distance were estimated.

Keywords: filled LC, memory effect, aerosil, structure.

INTRODUCTION

Filled liquid crystals (LCs) are suspensions of solid particles in a LC matrix. Aerosil is commonly used as solid component [1]. Such mixtures are turbid in initial state because of the orientation defects generated with aerosil particles. Application of the electric field to the layer of the suspension leads to the orientation of LC and so to the drastic increase of transparency. Such transparent state can be stable after the electric field is removed. In this meaning one can say about memory of filled LCs. In contrast to another heterogeneous LC media the memory efficiency in filled LC can be very high.

* To whom correspondence should be addressed. E-mail: fkoel@mlucom.urz.uni-halle.de

Due to this property filled LCs are promising media for bistable LC displays [2-4].

Explanation of the memory effect is based on the structure of aerosil in LC. There are two models of such structure. The first one assumes the network-like structure of the aerosil particles [2]. The second one supposes agglomerate structure of aerosil [5]. The arguments for the agglomerate model were results of the acoustic measurement [6]. Average size of agglomerate and inter-agglomerate distance was evaluated. The order of its magnitude was 100 nm.

The disadvantage of acoustic method is that sound wave can destroy an aerosil structure. To reduce the probability of this effect the more "softer" method for the study of aerosil structure was used. Atom force microscopy (AFM) method was chosen. We believe AFM strongly influences the structure of samples because, in contrast to other methods of scanning, it is non-contact one. Another advantage of this method is that its results should give obvious proof of the structure.

EXPERIMENTS AND DISCUSSION

The mixture of aerosil 300 (DEGUSSA) in cholesteric liquid crystalline polysiloxane C4754L (Wacker Chemie) was used for the investigation. Diameter of aerosil particles was about 10 nm. Glass transition temperature for C4754L was 55°C (G 55° N* 216° I). So, polymer was in the glass state at room temperature. It was important because AFM scan can be done in a solid samples only. High glass transition point of LC polymer allows us to carry out AFM measurements at room temperature.

Mixtures of 5 and 18 weight % aerosil 300 in C4754L were solved in dichlormethane. The solution was thoroughly agitated. After that a Si-wafers were dipped in the solution and dried for three days at room temperature. In this way layers of the polymer-aerosil mixture with a thickness of about 1μm were produced.

The AFM scans of the surface of prepared layers were performed using the TMX 2000 Explorer and Discoverer Scanning Probe Microscope of TOPOMETRIX. The measurements were carried out at room temperature and ambient conditions.

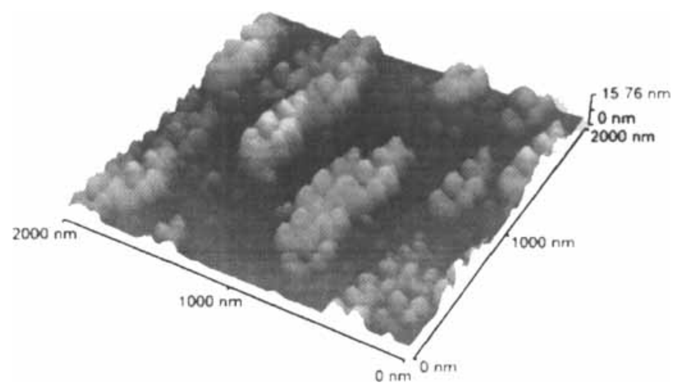

FIGURE 1. AFM-image of a mixture of 18 weight % aerosil in the polymer LC C4754L (Wacker Chemie) on a Si-wafer

Figure 1 shows the 3D-image of our sample. Separated rod-like agglomerates can be clearly detected here.

To confirm the nature of the building units of the agglomerates the central part of the image was magnified (Fig. 2). This image confirms that nearly spherical particles form the agglomerates. The number of particles in agglomerate was about 30. The average size of these particles was 60 nm. Therefore, we were sure that measured image corresponded to the aerosil agglomerate

The line measurement (Figure 3) is convenient for estimation of long *D* and short *d* diameters of agglomerates and inter-agglomerate distance *L*. The average values of these parameters were *D*=900 nm, *d*=250 nm, *L*=400 nm. Agglomerate anisotropy was D/d=3.6.

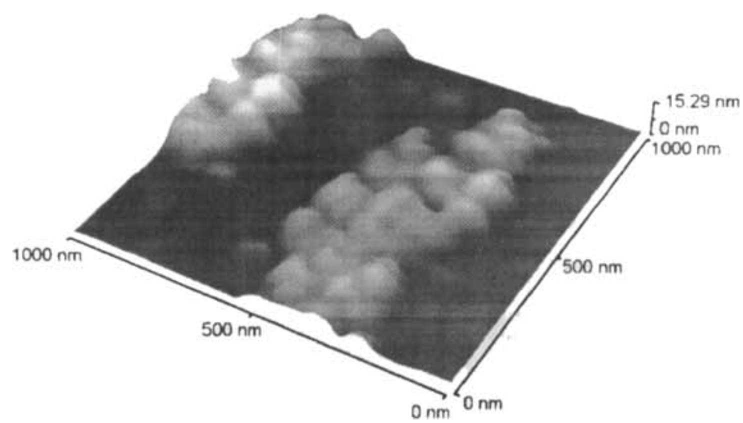

FIGURE 2. AFM image of the centre part of Fig. 1

Keeping the samples with aerosil concentration of 18 weight % above T_g=55^{0}C during 1 h does not essentially change the structure. However, for the samples with a low concentration of aerosil (5 weight %) the increase of aggregation rate after heating above T_g was observed. The reason is that viscosity decrease in the mesomorphic N^* state facilitates the process of agglomeration.

** Spherical particles we see on AFM scan are aerosil aggregates appearing during aerosil production process. They consist of 5-7 primary aerosil particles chemically linked between each other. The size of primary particles is about 10 nm [7].

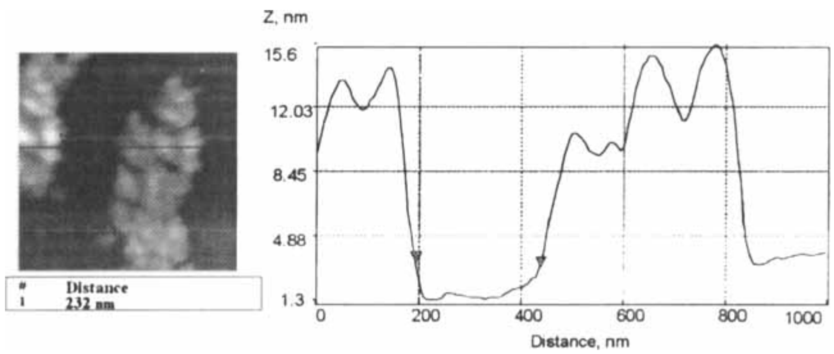

FIGURE 3. Line measurement of the AFM image in Fig. 2

CONCLUSION

In conclusion we must say that the model of separated agglomerates was directly proved. The rod-like shape of the agglomerates may be the result of the anisotropic LC surrounding. It was observed that aggregation rate of aerosil particles depended on the temperature and aerosil concentration.

The results of AFM measurements seem to be also important for the polymer science. Indeed, aerosil is common stuffing for the polymers. It improves mechanical, adhesion and other polymer characteristics [8]. AFM could be a good instrument for the study of aerosil structure in different polymer matrices.

Acknowledgements

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