Magnetic field effect on crystallization of glucose from aqueous solution

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Motivation

The structure of crystallite films, obtained by epitaxy from the water solution of glucose, was studied using “Intergra” nano-laboratory. The magnetic field applied to the solution was found to increase the rate at which crystals grow. A proposed mechanism of crystallization assumes the cluster structure of the solution. We believe the magnetic field breaks down the clusters in the solution, thus increasing the rate of crystallization. The experimental support for this hypothesis was found by analyzing light scattering, the kinetics of evaporation, and the temperature dependence of density of the water solution of glucose with and without the applied magnetic field.

Materials

Based on the rationale outlined in the introduction, for the objectives of this research to be met, concentrated solutions and weak magnetic fields should be used. Accordingly, we used a 40% glucose in water solution. The magnetic field applied to the solution was 0.43 mT, as the magnitudes of field that affect biological systems have values of at least 0.4-0.5 mT . Helmholtz coils were used to create the magnetic field.

Experimental results

1. The structure of the surface of the films obtained by epitaxy from the solution exposed to the magnetic field

In this experiment, we used glass plates of thickness 1 – 1.2 mm (Microscope slides CAT.NO.7101). The glucose solution, placed on the slide was then exposed to the magnetic field of magnitude 0.43 T for 1.0 hour. The control sample, the glucose solution not exposed to the magnetic field, was also kept on its slide for an hour before further proceeding. Probe nano-laboratory «Integra» was used to obtain images of the films' surface structure (Figure 1, Figure 2). As suggested by Figure1 and Figure2, the sizes of the crystallites obtained by epitaxy from the solution that was exposed to the magnetic field are generally larger.

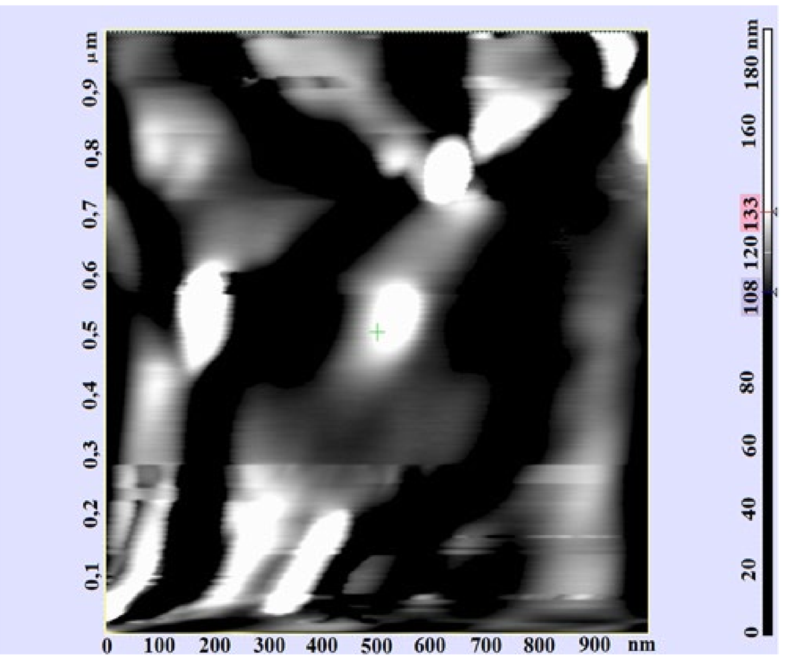

Figure1. Surface structure of the film obtained from the solution not exposed to the magnetic field

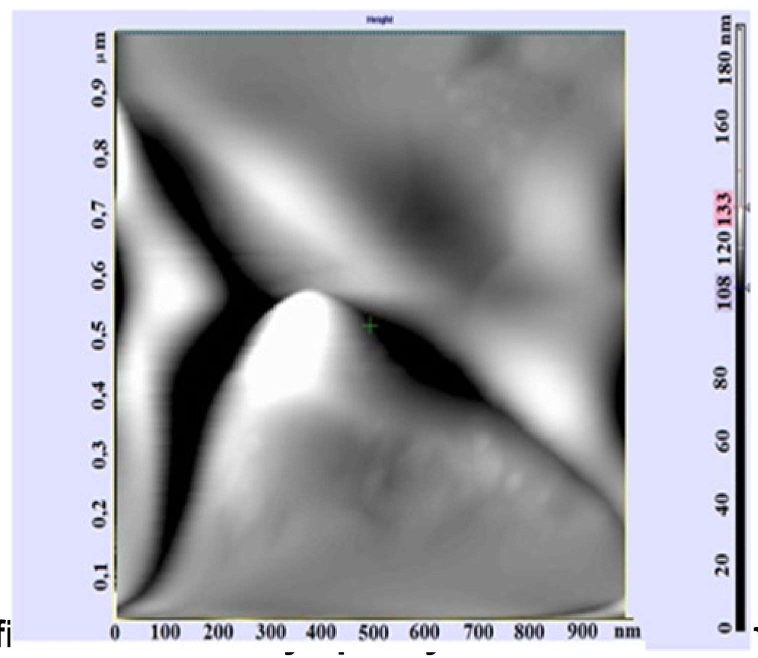

Figure 2 Surface structure of the film obtained from the solution exposed to the magnetic field

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In this experiment, we used glass plates of thickness 1 – 1.2 mm (Microscope slides CAT.NO.7101). The glucose solution, placed on the slide was then exposed to the magnetic field of magnitude 0.43 T for 1.0 hour. The control sample, the glucose solution not exposed to the magnetic field, was also kept on its slide for an ho... proceeding.

Probe nano-laboratory «Integra» was used to obtain images of the films' surface structure (Figure 1a, Figure 2a) and the histograms of height distribution for this surface (Figure 1b, Figure 2b).

As suggested by Figure1 and Figure2, the sizes of the crystallites obtained by epitaxy from the solution that was exposed to the magnetic field are generally larger.

2. Light scattering in the solution exposed to the magnetic field

A visual nephelometer, modified by an apparatus producing the magnetic field, was used to measure the intensity of the light scattering in the solution exposed to the magnetic field. We recorded the variation of the intensity of the scattered light I with time t. The uncertainty of the intensity measurements in the experiment was 5%. As the biological effects of the electromagnetic simulation REMFS in the presence of the magnetic field are known to be observed when the sample is exposed for at least 15 to 30 minutes, the sample was kept in the nephelometer for 30 minutes before the measurements were taken. The light scattering in the absence of the magnetic field was then observed for the next 30 minutes, after which the magnetic field was turned on. The measurements continued in the presence of the magnetic field for a further 90 minutes. The data collected is shown in Figure 3.

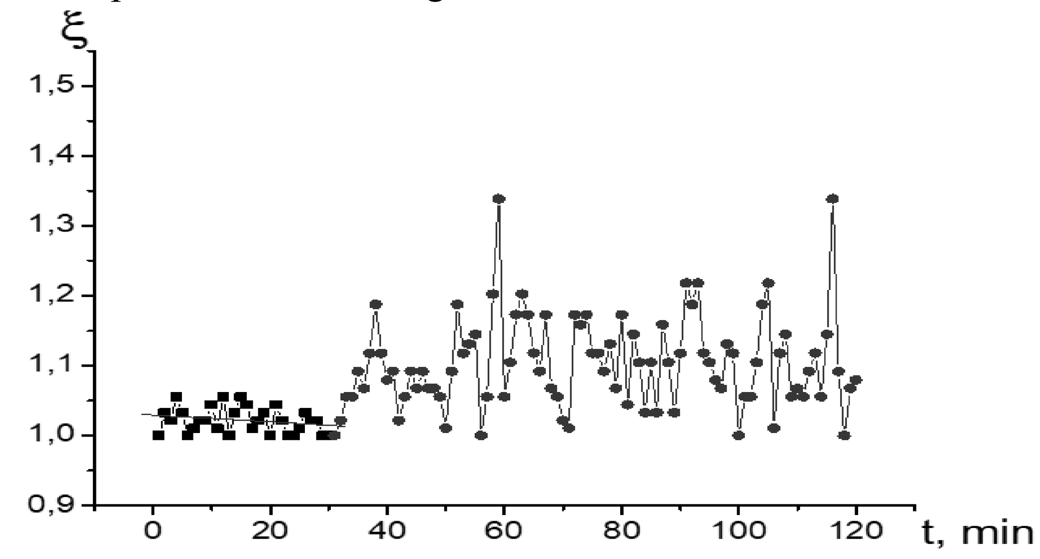

Figure 3. Temporal dependence of the relative intensity of light scattering

The relative intensity of light scattering appears to increase once the magnetic field is turned on. Additionally, its fluctuations appear to increase significantly as well.

3. Magnetic field and the kinetics of the water evaporation during the film formation

The glucose solution was exposed to the magnetic field for 1.0 hour. After that, the AND MX-50 Moister Analyzer was used to record the mass m of the sample (the slide with the solution on it) as a function of time t at 50 ^{o}C. The results are shown in Figure 4

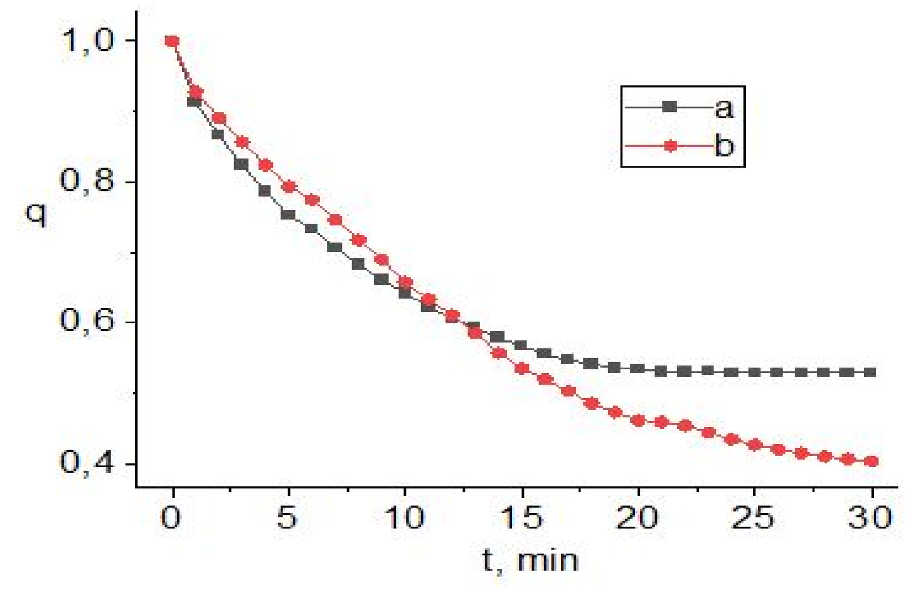

Figure 4 Temporal dependencies of the mass ratio of the samples (a) not exposed to the magnetic field and (b) exposed to the magnetic field

4. The density of the solution exposed to the magnetic field

A 40% glucose solution was exposed to the magnetic field for 1.0 hour. Afterward, the DMA4500 density meter was used to determine the density r of the solution in the temperature range from 10 to 80 ^{o}C. The uncertainty of the density measurements in the experiment was ±0.00005 g·cm^{-3}. The data collected is summarized in Figure 5.

As Figure 5 suggests, the density of the glucose solution exposed to the magnetic field is lower than that of the control solution.

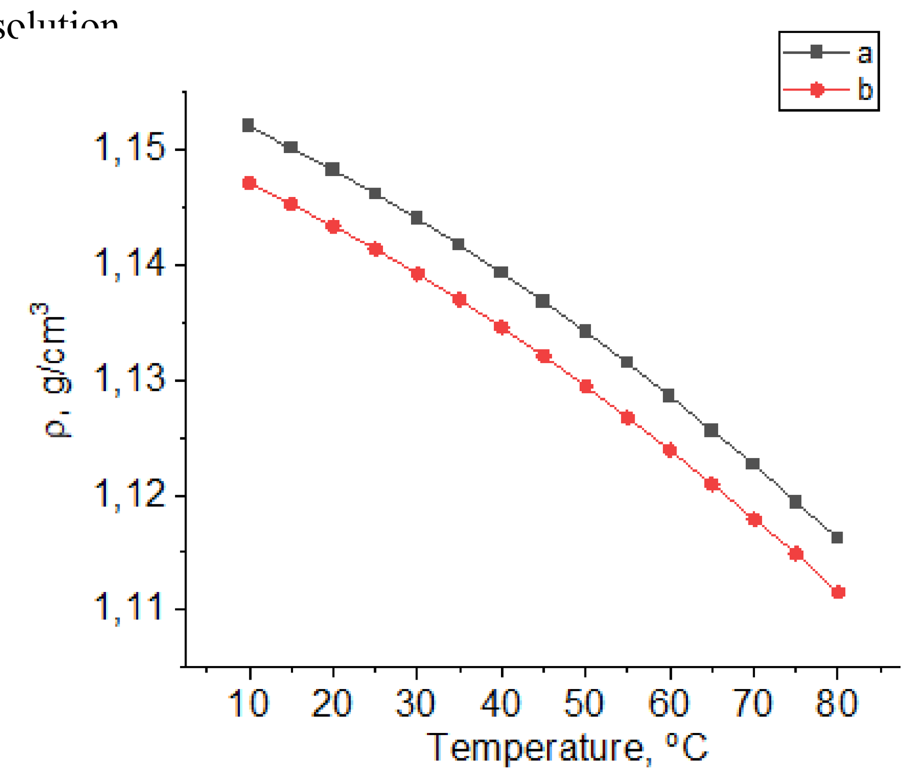

Figure 5. Temperature dependencies of the density of the glucose solution (a) not exposed to the magnetic field and (b) exposed to the magnetic field

Conclusions

The presence of a constant magnetic field speeds up the epitaxy of the glucose from its water solution. The mechanism allowing this to take place includes three processes:

(1) Turbulence transition of the solution under the magnetic field;

(2) The subsequent breakdown of clusters, present in the solution;

(3) Once the clusters begin to break, the rate of crystallization from the solution increases.

A necessary precondition for such processes to take place is the diamagnetic anisotropy of clusters. The latter factor indicates that this mechanism may also take place in other solutions whose clusters exhibit diamagnetic anisotropy.