

Light-controlled mass formation of aggregates of molecules in organic compounds

Tariel D. Ebralidze*, Nadia A. Ebralidze, Giorgi A. Mumladze, and Enriko S. Kitsmarishvili

Institute of Cybernetics, Georgian Academy of Sciences, Sandro Euli 5, Tbilisi 0186, Georgia

*E-mail: tarebra@yahoo.com

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During the mass formation of aggregates of molecules in a gelatin film dyed with the mixture of chrysophenine and acridine yellow dyes, photo-reorientation, photo-disorientation, and photo-orientation of the molecules are observed. Based on these observations, the photo-induction of granular anisotropy may be realized.

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The letter is dedicated to the questions of image formation during the anisotropy photo-induction in organic compounds^[1–7]. According to the existing views, an image during the anisotropy photo-induction in organic compounds is formed as a result of the molecule photo-orientation gained through the optical Kerr effect or cis-trans photoisomerization effect^[6,7]. At this time, a birefringence value is modulated in the material and generally, the image is nonlinearly recorded. An image in organic compounds may also be recorded as a result of the light-controlled mass aggregation. In this case, the image is formed in a similar way as that in silver emulsions, with the grain distribution and as a result, the linear recording of the image is possible. During the light-controlled mass aggregation of molecules, the anisotropy induction may be gained directly by provoking the textured aggregation of molecules or aggregate photo-texturing after spontaneous aggregation of molecules. Both cases were experimentally observed for azo-dye chrysophenine^[8–10].

It is known that the molecule aggregation in solutions is influenced by mixing of different dyes^[11]. In this connection, we give the observation results of the light-controlled mass aggregation of molecules for the mixture of dyes chrysophenine and acridine yellow^[12]. Three-percent water solution of gelatin was dyed with chrysophenine and acridine yellow dyes^[12] separately until saturated. The concentrations of chrysophenine and acridine yellow in each solution were approximately 0.46×10^{-3} and 1.05×10^{-3} mol/L, respectively. Figures 1(a) and (b) show the structural formulae of these dyes. Then, the equal amounts of solutions were mixed and poured on the microscope slide. After the glass was dried under room conditions, we received a thin gelatin film with the thickness of approximately 200 μm oversaturated with the dyes. Spontaneous aggregation of molecules took place in the film. The aggregations of molecules are anisotropic micro-particles. The optical axes of aggregates in the film are positioned chaotically. The aggregates may be observed with a polarizing microscope. Aggregates are particles of an elongated form. When turning the microscope table with the microscope slide on it, the integral picture does not change. It is true that at this moment the aggregates, which are observed

at the beginning, disappear, but other aggregates appear instead of them.

We irradiated the film containing the aggregates placed on the microscope-fluorometer table with the linearly polarized light of 100w/2 mercury lamp. The irradiation took place from the spectral line containing 440-nm wavelength. The time of exposition was 10 min. Figure 2 shows the image of the film containing mass aggregation of molecules with its central part irradiated with linearly polarized light along the area of a circular shape, which was observed with a polarizing microscope in terms

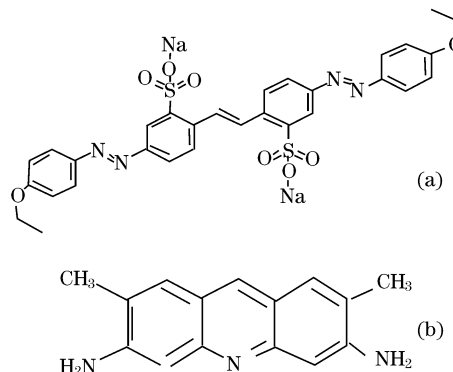


Fig. 1. Chemical structures of (a) chrysophenine and (b) acridine yellow.

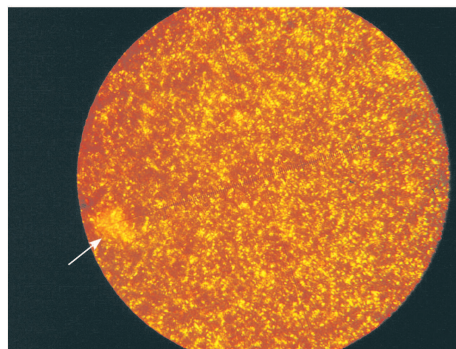


Fig. 2. Mass aggregation of molecules of the mixture of chrysophenine and acridine yellow in a gelatin film observed in terms of crossed polarizers.

of crossed polarizers at magnifying the image for 250 folds. As a result of irradiation, the optical axes reorientation took place in the aggregates of molecules. Unlike a non-irradiated area, every aggregate of the irradiated area now has equally oriented optical axes. This is evidenced by Fig. 3. It was taken after the microscope table when the film was turned at a definite angle from the position fixed in Fig. 2. The turning of the table is evidenced by the changed location of anisotropic formation (marked with arrow) against the ocular scale with divisions in Figs. 2 and 3. As can be seen, at the final location of the film, the irradiated area is fully darkened. This demonstrates that the optical axes of the aggregates are parallel to the optical axes of an analyzer or polarizer. It means that they have the optical axes of similar orientation. At the beginning, in the ensemble of spontaneously induced aggregates, we had the aggregates with the optical axes of every orientation and their optical axes had the same orientation as a result of irradiation. So it is clear that under the influence of light, the reorientation of the optical axes in the aggregates takes place.

Then we influenced another area of the same film by the same active but non-polarized light. The result was that the irradiated area in the crossed polarizers went dark. The darkened area remains dark when turning the microscope table with the film on it at any angle, i.e., the area irradiated with the light becomes isotropic. It is clear that this is the result of decomposition of the aggregates or disorientation of the molecules in the aggregates.

Afterwards, we influenced the central part of this

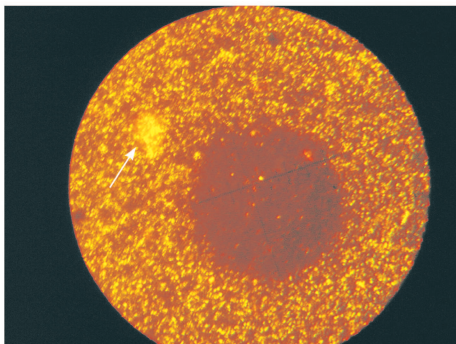


Fig. 3. Photo taken by turning the film at a definite angle from the position indicated in Fig. 2.

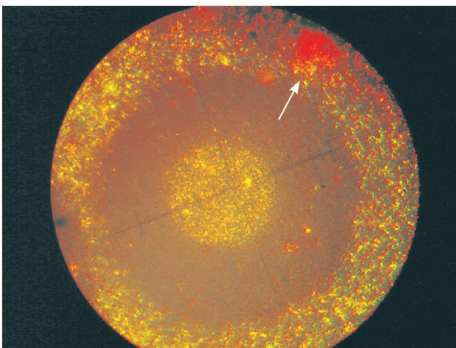


Fig. 4. Decomposition of the aggregates of molecules with non-polarized light and induction of aggregates of molecules caused by linearly polarized light in the center.

darkened area of the film by linearly polarized active light. As a result, the induction of anisotropic aggregates took place in this area of the film. The ensemble of the aggregates of the molecules in the central circle of Fig. 4 differs from the part in the outer circle since the optical axes of the aggregates here have the same orientation. Figure 5 shows the photo evidencing that the area with the photo-induced anisotropy is fully darkened. It was taken after turning the film from the position indicated in Fig. 4 at a certain angle. The turning is evidenced by different positions of the anisotropic formation (also marked with arrow) on the film in Figs. 4 and 5 against the ocular scale with divisions.

The measurements have ascertained that in such a case, the effective value of the proper "path difference" of photo-induced anisotropy is 30 nm in the film.

The spectral properties of the given material were studied. Figure 6 shows the light transmission spectra for gelatin films dyed separately with the dye chrysophenine, acridine yellow, and their mixture, denoted by *F*, *G*, and *H*, respectively. As can be seen, the violation of the additivity takes place in the spectrum of the mixture of dyes^[11]. Spectrum *H* of the light transmission of the mixture dyes has a form significantly different from the transmission spectra *F* and *G* of separate dyes. The transmission of the film made of the mixture dyes in the short wavelength region is more than the transmission of the films made of separate dyes, and contrarily, in the

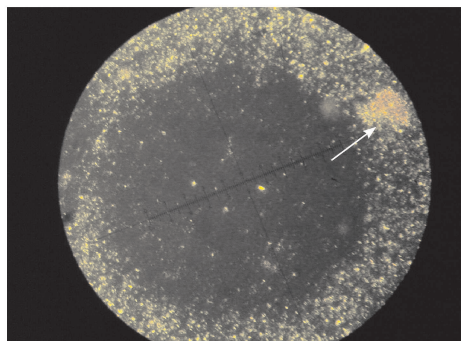


Fig. 5. Photo taken by turning the film at a definite angle from the position indicated in Fig. 4.

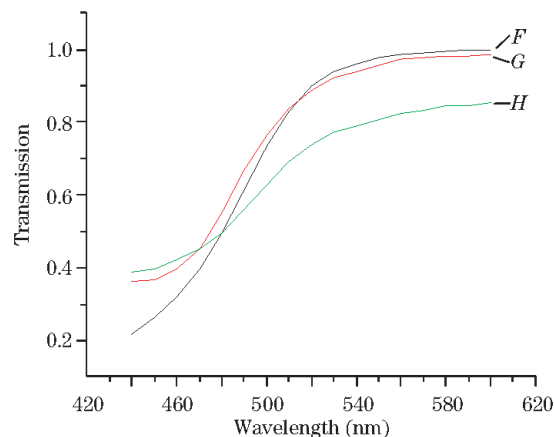


Fig. 6. Light transmission spectra for gelatin films dyed separately with the dye chrysophenine, acridine yellow, and their mixture denoted by *F*, *G*, and *H*, respectively.

long wavelength region, it is less than that of the films made of separate dyes. Therefore, we assume that when mixing the dyes, binary associates are formed, which are perhaps made of the molecules of both dyes^[11].

In conclusion, after pouring the three-percent gelatin water solution saturated with the mixture of chrysophenine and acridine yellow on the glass and drying it under room conditions, the mass formation of aggregates of molecules takes place. By the light effect of 100w/2 mercury lamp from the spectral line containing 440-nm wavelength on the film with the mass aggregation of molecules, the reorientation, disorientation, and orientation of the dye molecules are observed. Based on the observed phenomena, the photo-induction of granular anisotropy may be realized.

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