Reports of the Academy of Sciences of the USSR

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1958

SovietRxiv

Abstract

Full Text

Reports of the Academy of Sciences of the USSR

1958. Vol. 123, No. 5

PHYSICAL CHEMISTRY

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PRESERVATION OF THE LATENT IMAGE

AND SENSITIVITY IN NUCLEAR PHOTOGRAPHIC EMULSIONS

SENSITIZED WITH TRIETHANOLAMINE

(Presented by Academician A. P. Vinogradov, 17 VII 1958)

As was shown in ([1]-[3]), treatment of nuclear photographic emulsions with triethanolamine (TEA) increases their sensitivity to all particles, including relativistic ones. Our study ([4]) of the mechanism of the sensitizing action of TEA led to the conclusion that, in the reaction of TEA with AgHal in emulsion crystals, Ag subcenters are formed at the sensitivity centers, the same as under the action, for example, of pulse exposures. The conversion of subcenters into development centers under the subsequent action of particles occurs with considerably greater efficiency than the formation of such centers in the absence of subcenters. It could therefore be expected that there would be a decrease in regression of the latent image, i.e., greater stability with time of those centers that are formed after sensitization with TEA. Further, since the subcenters themselves also possess a certain stability, it could be expected that the increase in emulsion sensitivity after sensitization with TEA would be retained for some time, thereby reducing the drop in sensitivity (usually quite appreciable for nuclear emulsions) during storage without exposure. Finally, the ability of subcenters, known from the literature ([5]), to supplement one another to some extent during storage, forming development centers, might lead to an undesirable increase in fog. Experimental verification of these effects, quite apart from its practical usefulness, would be important for confirming the conclusion that subcenters are formed during sensitization with TEA. The corresponding experimental results are given below, together with the results of experiments aimed at elucidating particular details of the mechanism of sensitization by TEA.

The experiments were carried out on several batches of type P emulsion (NIKFI), irradiated with relativistic electrons, while they were stored in a refrigerator (temperature 5-6°, relative humidity 50%). Some samples of each emulsion batch, after sensitization with TEA, were first irradiated and then stored for various periods (to study regression of the latent image); another part was first stored for various periods and then irradiated (to study preservation of sensitivity); in addition, for comparison, all experiments included samples of the same emulsion not sensitized with TEA, stored and irradiated for the same periods and under the same conditions. Development of all emulsions was standard.

Table 1 gives data on regression and preservation for two emulsion batches, for one of them at two TEA concentrations. In agreement with our previous data ([1], [2]), increasing the TEA concentration does not give any substantial increase in track density, but does increase fog. Of note is a certain (10%) increase in track density during storage, the same for irradiation

before and after storage; it should be attributed to a regrouping of subcenters, as well as to a gradual, though not very considerable, increase in fog. The data on track density in specimens not sensitized with TEA are approximate, since during storage the regression of tracks and sensitivity is expressed not only in a decrease in track density, but also in their number and length; therefore, finding tracks of sufficient length is not always possible, and the data presented in this and the following tables refer to the preserved portions of tracks. A practically important conclusion from Table 1 is the complete preservation of sensitivity and of the latent image in emulsions sensitized with TEA, within the storage times studied and the accuracy of the measurements. This property of TEA is as essential as its sensitizing action.

Table 1

Track density (number of grains per 100 μ) and fog (number of grains per 1000 μ^3)

Emulsion no.	TEA concentration, %	0 days, variants 1 and 2: density	0 days, variants 1 and 2: fog	10 (or 18) days*: variant 1 density	10 (or 18) days*: variant 1 fog	10 (or 18) days*: variant 2 density	10 (or 18) days*: variant 2 fog	30 days: variant 1 density	30 days: variant 1 fog	30 days: variant 2 density	30 days: variant 2 fog	90 days: variant 2 density	90 days: variant 2 fog
3642	0	32±2	1.27	(31)	1.4	(32)	1.6	(27)	1.9	(29)	1.7	No tracks	2.9
3642	2	61±2	2.0	64±2	1.5	65±2	1.8	67±[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* The storage time of 10 days refers to emulsion 3642; the time of 18 days—to emulsion 3724.
** Variant 1—storage after irradiation; variant 2—irradiation after storage.

Table 2

Track density (number of grains per 100 μ) and fog (number of grains per 1000 μ^3)

Type of treatment	0 days, variants 1 and 2: density	0 days, variants 1 and 2: fog	30 days: variant 1 density	30 days: variant 1 fog	30 days: variant 2 density	30 days: variant 2 fog	90 days: variant 2 density	90 days: variant 2 fog
Without treatment	32±2 | 1.7 [illegible] after washing	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] | 67±2 | 2.5 | 68±2 | 2.0 || *Same, withsu*

Table 2 gives data confirming the conclusion made earlier (4), that the sensitizing action of TEA is not connected with its presence in the emulsion during irradiation and, in particular, is not connected with the acceptor action of the halide released during the radiolysis of AgHal, contrary to the opinion of Demers (6). The considerable increase in sensitivity, the absence of regression

and good keeping quality, as can be seen, do not change when TEA is washed out of the emulsion before irradiation; on the contrary, the introduction into the emulsion of $NaNO_2$, known as a good halide acceptor, did not increase the sensitivity and keeping quality and did not decrease regression. The small effect of washing out TEA on the growth of fog during storage shows that, from the moment subcenters are formed, the presence of TEA in the emulsion is not of essential importance, and the subsequent change in the properties of the emulsion with time is determined precisely by the presence of subcenters in its crystals.

Table 3

Track density (number per 100 μ of grains) and fog (number of grains per 1000 μ^3)

<table>
<tr><th>Type of sensitization</th><th>0 days, variants 1 and 2: density</th><th>0 days, variants 1 and 2: fog</th><th>18 days, variant 1: density</th><th>18 days, variant 1: fog</th><th>18 days, variant 2: density</th><th>18 days, variant 2: fog</th><th>30 days, variant 1: density</th><th>30 days, variant 1: fog</th><th>30 days, variant 2: density</th><th>30 days, variant 2: fog</th></tr>
<tr><td>Without sensitization</td><td>31$±2|2.1 6(33)|1.5|(33)|2.0|(30)|2.0|(30)|1.5||Bathingin2±2|4.0|69±4|4.4|65±3|2.7|69±2|4.4|67±3|3.2||B… |13.3|47±3|4.4|* |12.9|38±$3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

* Tracks are present, but are distinguishable with difficulty against the fog background.

The data of Table 3 show that decreasing the alkalinity of TEA (by adding acids that do not react with AgHal) reduces its sensitizing action, as was noted earlier ([4]), but still ensures good keeping quality of the latent image and of the sensitivity. This means that at lower pH values the result of the action of TEA is likewise the formation predominantly of subcenters, while the smaller increase in sensitivity should be attributed mainly to a decrease in the number of crystals in which the reaction with TEA has led to the formation of subcenters. The insignificance of regression in the emulsion treated with NaOH (having the same pH as TEA, but not being, unlike TEA, a reducer of AgHal) makes it necessary to suppose that in this case, too, subcenters are formed as the result of successive transformations

$$AgHal \rightarrow AgOH \rightarrow Ag_2O \rightarrow Ag.$$

In any case, NaOH, like TEA, does not affect the processes occurring during irradiation and development of the emulsion, since the result of the action of NaOH does not change when it is washed out of the emulsion before irradiation ([4]).

On the basis of the conclusion drawn earlier ([2]) about the fundamental similarity of the sensitizing action of TEA for all kinds of radiation, we carried out an experiment to investigate regression for exposure to light of low intensity for 45 sec. The experiment was performed on the same emulsion and according to the same scheme as in Table 3. For storage periods up to 30 days the regression was so insignificant that it could not be reliably established even in the control (untreated) sample; this is quite typical for exposure of long duration ([7]). After 75 days of storage, a considerable decrease in photosensitivity was noted (approximately twofold by the blackening density 1.0) in the control sample exposed before storage, complete abs–

of such a drop in the sample sensitized with TEA at pH 9, and a certain drop (∼ 20–40%) in samples sensitized with neutralized TEA or NaOH. These differences, in less distinct form, can also be seen in Table 3. In the samples that were stored before exposure, the decrease in photosensitivity was smaller and was clearly manifested (∼ 25%) only for the control sample.

Thus, the experiments described show that TEA has not only a sensitizing but also a stabilizing action, in full agreement with the concept of the mechanism of its interaction with the crystals of the photographic emulsion.

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Received
12 VII 1958

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Note: Figure translations are in progress. See original paper for figures.