Physical Chemistry

A. P. Zhdanov, A. L. Kartuzhanskii, I. V. Ryzhkova, and L. I. Shur

1958

SovietRxiv

Abstract

Full Text

Physical Chemistry

A. P. Zhdanov, A. L. Kartuzhanskii, I. V. Ryzhkova, and L. I. Shur

The Action of Triethanolamine on Photographic Emulsions

(Presented by Academician A. P. Vinogradov, 13 VII 1957)

Over the last ten years, reports have appeared ([1–3]) on the use of triethanolamine (TEA) to increase the sensitivity of nuclear photographic emulsions to ionizing particles. The mechanism of this action, as far as we know, has not been investigated. Nor are there data on how TEA affects the sensitivity of photographic emulsions to light. It therefore seemed advisable to us to investigate the influence of TEA on light sensitivity under different illumination conditions and to use the results obtained to elucidate the mechanism of the sensitizing action of TEA by analogy with other types of sensitization. Since there is a well-known analogy between the photographic action of light (in particular of high intensity) and that of ionizing particles, the action of particles on the same emulsions was investigated in parallel.

The behavior of seven different emulsions was studied: two "light" emulsions —motion-picture negative type A and high-sensitivity aerophotographic AC-1— and five nuclear emulsions: a particularly fine-grained type II-9 ([4]) and four fine-grained experimental emulsions synthesized in our laboratory ($\bar{d} = 0.25\,\mu$), with sensitivity to protons up to 15 MeV. Exposure to light was carried out from a pulsed source with a flash duration of $1.2 \cdot 10^{-6}$ sec and from a low-voltage incandescent lamp at exposure times from 5 to 45 sec, through a neutral-gray step wedge with a constant of 0.17. Exposure to alpha and beta rays was carried out so as to obtain a gradation of blackenings, respectively, with the aid of a Po^{210} alpha-particle source or a beta-radioactive sensitometer ([5]). In addition, exposure was carried out with recoil protons from a Ra + Be neutron source. Before exposure, the emulsions were bathed in an aqueous TEA solution, the concentration of which was varied from 1 to 5%, and in a number of cases up to 20% by weight; the bathing time was 3 min for light-sensitive emulsions and 10 min for nuclear emulsions (thickness 50 μ). Development was carried out under conditions standard for each type of emulsion. The blackenings were measured on an MF-2 photoelectric microphotometer.

Figure 1 shows the dependence of the sensitivity (estimated from the blackening density 0.5 above fog, with the sensitivity of the emulsion not treated with TEA taken as unity) on TEA concentration for all the emulsions studied, under

Fig. 1

Figure 1: Fig. 1

exposure to light with an exposure time of 5–45 sec. As is seen from the curves, an increase in sensitivity occurs for all emulsions, and the smaller the initial light sensitivity of the emulsion, the greater it is; for certain low-sensitivity emulsions this increase reaches 1.5 orders of magnitude. The characteristic curves of the emulsions (not reproduced here) show that the action of TEA is always somewhat greater for the initial portion, i.e., for the larger emulsion crystals. This, in fact, should explain certain differences in the action of TEA on individual nuclear emulsions. It is interesting to note that the optimal for

for the increase in photosensitivity, the concentration is on the order of 1–2%. A further increase in concentration, without increasing the sensitivity, leads to an increase in fog.

Special experiments showed that bathing in TEA after exposure gives no increase in sensitivity and that, consequently, the action of TEA is not connected with the development process.

Fig. 1. Dependence of photosensitivity, for prolonged treatment, on the concentration of TEA.
1 –f.-g.* No. 110, 2 –f.-g.* No. 122, 3 –f.-g.* No. 125, 4 –f.-g.* No. 123, 5 –a special fine-grained emulsion P-9, 6 –a cine-negative emulsion of type A, 7 –an aerial-photographic emulsion AS-1

* f.-g. –fine-grained emulsion

Figure 2 gives the dependence of the sensitivity of one of the nuclear emulsions to various kinds of radiation on the concentration of TEA. Here, for alpha and beta radiation, the sensitivity was likewise estimated from the exposure required to obtain a blackening density of $0.5 + D_0$, and for protons–from the track density. The regularities of Fig. 2 are typical also for the other emulsions investigated. In particular, for prolonged flashing the increase in sensitivity is always considerably greater than for a short pulse, which recalls the hypersensitizing action of a preliminary brief flashing. Another important feature of the curves in Fig. 2 is that the optimum concentration for all kinds of radiation lies within the same limits–from 1 to 2%.

The similarity between the sensitizing action of TEA and that of a preliminary brief flashing permits the supposition that the role of TEA is reduced to the formation of highly effective centers for the trapping of conduction electrons arising in the emulsion crystals under the action of radiation. It cannot be said in advance whether these centers are the result of the growth of already existing centers, or whether they arise by a direct reaction between TEA and silver halide. From this point of view, experiments on the study of the action of TEA on emulsion crystals from which the surface sensitivity centers had been removed

Fig. 2. Dependence of the sensitivity of fine-grained emulsion No. 123 to various radiations on the concentration of TEA.

Figure 2: Fig. 2. Dependence of the sensitivity of fine-grained emulsion No. 123 to various radiations on the concentration of TEA.

are of interest. For this purpose the emulsions were treated with a relatively concentrated (5%) solution of chromic acid, H_2CrO_4. For such emulsions the following regularities were established:

1) Desensitization, as the time of bathing in H_2CrO_4 is increased, passes through a maximum at 3–5 min of bathing for all the emulsions investigated, with layer thicknesses of 10–15 μ. The decrease in desensitization during prolonged treatment with H_2CrO_4 should evidently be attributed to the exposure of internal sensitivity centers as a result of destruction of the surface layer of the crystals.

2) The action of TEA on emulsions treated with H_2CrO_4 is, in general, considerably smaller than on untreated emulsions. This is very strongly expressed in highly sensitive emulsions (in particular, in "light" emulsions), where there are large sensitivity centers on the surface of the crystals, and is considerably less strongly expressed in low-sensitivity emulsions, where the surface centers are small.

3) The restoration of sensitivity by bathing in TEA of emulsions previously desensitized by H_2CrO_4 is considerably greater for emulsions subjected to prolonged bathing in H_2CrO_4 than for those subjected to short-

···to prolonged bathing. This feature is due to the fact that, under the short-term action of H_2CrO_4, the surface centers are already destroyed to a considerable extent, whereas the internal centers have not yet been exposed. Only with the exposure of the internal centers does the sensitizing action of TEA become significant, and in some cases (for example, upon irradiation of low-sensitivity emulsions with electrons) it completely compensates for, or even exceeds, the desensitizing action of H_2CrO_4.

Fig. 2. Dependence of the sensitivity of fine-grained emulsion No. 123 to various radiations on the concentration of TEA.
1 –β-radiation of C^{14}; 2 –prolonged exposure at low illumination ($t = 45$ sec.); 3 –short-term exposure at high illumination ($t = 1.2 \cdot 10^{-6}$ sec.); 4 –α-radiation of Po^{210}; 5 –recoil protons from a Ra + Be neutron source.

4) The dependence of the sensitizing action of TEA on its concentration for emulsions preliminarily desensitized with H_2CrO_4 also passes through a maximum at 1-2%, as it does for emulsions not subjected to the action of H_2CrO_4.

The regularities listed above clearly show that, for the action of TEA, the presence of sensitivity centers is necessary and that the role of TEA consists in increasing their size. This is also evidenced by the rapid growth of fog that we observed when the concentration of TEA was increased above the optimum, or when the bathing time in TEA was significantly prolonged.

Received
11 VII 1957

REFERENCES

1. P. Demers, *Canad. J. Res.*, **A25**, 223 (1947).
2. A. P. Zhdanov, L. I. Shur, V. V. Volina, *Tr. RIAN*, **7**, issue 1, 276 (1956).
3. N. A. Perfilov, E. I. Prokof' eva, N. R. Novikova, *Tr. RIAN*, **8** (1958).
4. N. A. Perfilov, E. I. Prokof' eva, N. R. Novikova, *Tr. RIAN*, **7**, issue 1, 257, 261 (1956).
5. A. L. Kartuzhanskii, B. P. Soltitskii, *Zhurn. nauch. i prikl. fotogr. i kinematogr.*, **2**, 167 (1957).

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