

Table 2

Method	Nucleon distribution model	$r_0, F$	Reference
$\pi^0$ -meson photoproduction on nuclei	uniform	$1.22 \pm 0.03$	[5]
	trapezoidal	$1.15 \pm 0.03$	
$\pi^0$ -meson photoproduction on nuclei	uniform	$1.23_{-0.03}^{+0.04}$	[6]
$\rho$ -meson photoproduction on nuclei	Woods-Saxon	$1.12 \pm 0.02$	[7]
$\pi^0$ -meson photoproduction on nuclei	uniform	$1.20_{-0.01}^{+0.02}$	Present work
	Woods-Saxon	$1.26_{-0.01}^{+0.02}$	

The results of the experimental data are given in Table 1. We see from the table that both models agree equally well with the experimental data.

Writing down the radius of the nucleus in the form  $R = r_0 A^{1/3}$ , we can compare the results of this paper with the results of other experiments in which the radius of the strong interaction of the nuclei was measured (Table 2).

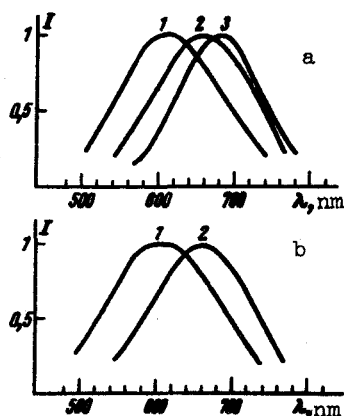
The obtained values of  $\lambda$  are in qualitative agreement with the values calculated from the total  $\pi N$ -scattering cross sections [8, 9].

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#### LUMINESCENCE OF SOLID ORGANIC DYES BOMBARDED BY THERMAL HYDROGEN ATOMS

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In [1] we have observed glow of solid aromatic substances bombarded by H atoms (H-luminescence or HL). This glow was attributed to chemoluminescence resulting from the reaction of the joining of the hydrogen atom to the aromatic molecule



a - HL Spectra, b - PL spectra, curve 1 - auramine OO, 2 - thioflavine, 3 - acridine yellow.

We report here investigation of HL of solid organic dyes at room temperature. The measurements were made with a setup which made it possible to register the HL spectra and the photoluminescence (PL) spectra [1]. To increase the sensitivity, we used a high-transmission spectrometer of the SSR type [2] and an FEU-79 photomultiplier with a multi-alkali photocathode. Substances of the grade "dyes for microscopy" were used.

HL was observed in acridine yellow, auramine OO, tartrazine, titanium yellow, thioflavine, and primulin. No HL was observed (the yield of HL was smaller than  $10^{-12}$  quanta per collision of the H atom with the surface) in the visible region of the spectrum in acridine orange, coryphosphine, fluorescein, proflavine, pyronine "B", acid fuchsin, and phenosafranine.

Figure a shows the HL spectra of certain of the investigated dyes (the spectra were corrected for the spectral sensitivity of the apparatus).

The main properties of HL of the investigated organic dyes can be formulated as follows: 1) the HL in the visible region is produced by dyes having no absorption bands in the region  $\lambda > 550$  nm; 2) when the absorption spectrum of the dye is shifted, the HL spectrum is shifted to the same direction; 3) the HL spectrum consists of a broad band; for dyes capable of PL (quantum yield greater than  $10^{-7}$ ), the spectra of the HL and PL practically coincide (see the figure).

The foregoing properties differ significantly from the corresponding characteristics of HL of simple aromatic substances (the presence of HL in all the investigated aromatic substances, a spectrum in the form of a broad band at  $\lambda \sim 600$  nm with little change from substance to substance [1]). Whereas in aromatic compounds the radiating centers are apparently the electron-excited radicals produced in accordance with the reaction (1), in the dyes the source of the radiation are molecules of the main substance or impurity centers (this is evidenced by the coincidence of the HL and PL bands). In order to accept the mechanism of excitation by chemical reaction (1) for dyes, it is necessary to assume the existence of an effective energy transfer from the excited radical to the matrix. The excitation energy of the radical can be estimated at  $E^* \sim 2 - 2.5$  eV [1]. Transfer of energy from the radical to the matrix is possible if the latter has electron levels  $E < E^*$ . For the investigated dyes,  $E_s \approx 2.9 - 2$  eV and  $E_T \approx 2.5$  eV [3]. Thus, transfer of excitation from the radical to the matrix is possible.

Lowering of the excited levels of the dye should lead to a shift of the HL spectrum into the infrared region. This explains the absence of HL in the visible region for dyes whose powders are dark-red, blue, and green.

One can assume also another mechanism of HL of dyes, analogous to the mechanism of radical recombination luminescence (RRL) of inorganic crystal phosphors [4]. RRL, as is well known [4], is due to chemisorption with formation of a charged form and to heterogeneous recombination of the atoms on the surface of the solid. Such a mechanism, however, is not very likely for dyes and

aromatic substances, if account is taken of the high activity of these substances with respect to the reaction wherein an H atom is joined to an aromatic ring (the activation energy of the process is approximately 3 kcal/mole).

The results of the present communication and of [1] allow us to propose the following mechanism of H-luminescence of solid compounds with aromatic rings interacting with H atoms. The energy in the combination reaction (1) on the produced free radical is released in the form of electron excitation. If the excitation levels of the matrix lie above the excitation level of the radical, then the HL centers are the radicals. In this case, luminescence in the visible region corresponds to radiation close to resonant. In the case of a matrix whose molecules have low-lying excitation levels, energy is transferred to the matrix and radiation is observed in the photoluminescence band of the substance. Accordingly, the HL spectrum changes little when the PL is shifted if the PL spectrum lies in the region  $\lambda_{PL} < 600$  nm, and coincides with the PL spectrum if  $\lambda_{PL} > 600$  nm.

We note in conclusion that HL in dyes can be induced not only by a reaction of the type (1), but also by secondary reactions in which MH radicals take place:  $H + MH \rightarrow M\dot{H}$ .

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#### IONIZATION INSTABILITY AND MOTION OF GLOWING SPOTS IN $Na_2ZnGeO_4:Mn$ CRYSTALS

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$Na_2ZnGeO_4:Mn$  crystals were excited, just as in [1], by a dc voltage  $V$  at  $50^\circ C$ . It was observed that at  $V \approx 1$  kV (crystal length 5 - 6 mm) a bright green spot with dimension  $\sim 0.5$  mm is produced at the cathode; this spot moves to the anode at a velocity  $\sim 4 \times 10^{-2}$  cm/sec. The current in this case is  $\sim 10$   $\mu A$  and becomes unstable. With increasing  $V$ , several such spots are produced, and then entire glowing regions of quaint appearance become visible. The observed phenomenon obviously pertains to one of the forms of electric instabilities. The slowness of the motion of the glowing spot shows that deep levels take part in this process. Levels equal to  $\sim 1$  eV were found in these crystals by means of the photoconductivity spectrum. The sign of the thermoelectric power showed that the crystals were the n-type. The donor in them was Mn substituted for Na, which produced additional photoluminescence bands [2]. An estimate of the donor concentration  $N_d$  based on the relative brightness of these bands yields  $N_d \approx 10^{18}$   $cm^{-3}$ . The acceptor may be the aluminum present in the crystals, if it is substituted for Ge. Then  $N_a$  is of the same order.

The recombination and temperature-electric instabilities are connected with recombination via the deep levels. However, they do not explain the observed phenomenon, since their occurrence requires continuous generation of free carriers of both signs. Thermal generation is completely excluded here,