

$\epsilon \approx 1.12$  eV. Assuming  $a \approx 3 \times 10^{-8}$  cm,  $\sigma \approx 3 \times 10^{-19}$  cm<sup>2</sup>,  $\nu(T_0) \approx \nu'_R$ ,  $1/C \approx 300^\circ\text{K}$  [3], and  $c\rho \sim c_c\rho_c$ , and recognizing that for fused quartz  $\lambda \sim 10^{-3}$  cal-cm<sup>-1</sup>sec<sup>-1</sup>deg<sup>-1</sup>, we obtain  $I_{\text{thr}} \sim 10^{11}$  W/cm<sup>2</sup>. This agrees with the experimental data [1]. We note that here  $\nu'_R \approx 2\sigma I_{\text{thr}}/\epsilon \sim 10^{11}$  sec<sup>-1</sup>, and consequently the value  $\nu(T_0) \approx \nu'_R \sim 10^{11}$  sec<sup>-1</sup> is perfectly reasonable. We call attention to the fact that  $I_{\text{thr}}$  does not depend on the concentration of the impurity centers.

Thus, the proposed model of the initial stage of the process of optical destruction of transparent dielectrics explains the threshold character of this phenomenon on the basis of the occurrence of a thermal explosion.

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#### USE OF LASERS FOR SELECTIVE BREAKING OF CHEMICAL BONDS

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We propose the use of two-step excitation for selective breaking of previously chosen chemical bonds of molecules.

The development of powerful cw lasers in the infrared band uncovers a possibility of controlled action on molecular processes, such as initiation and acceleration of chemical reactions, selective excitation and breaking of chemical bonds. These questions have already been the subject of a number of papers [1 - 6].

A serious obstacle to the solution of the problem of selective breaking of bonds with the aid of laser radiation is the anharmonicity of the molecule vibrations. For most molecules, the processes of vibrational-translational relaxation at the lower levels are much slower than exchange of quanta within the limits of one mode of vibration. This makes it possible to excite individual modes by resonant absorption of radiation from a lower level. However, owing to the harmonicity, vibrational-translational relaxation begins to predominate at higher levels, but still far from the dissociation limit [7, 8]. So long as the heating of the gas upon absorption of the radiation does not lead to a diffuse propagation of the excitation over these levels, the dissociation of the molecules will have a very low probability. In the case of polyatomic molecules, predissociation, not accompanied by heating of the gas, is possible as was observed experimentally in [1]. In both cases, the same bond is broken.

For selective breaking of bonds chosen beforehand, one can use the two-step photoexcitation proposed in this paper. To this end the molecules, resonantly absorbing the radiation from a laser in the infrared band, are simultaneously irradiated with light from another laser in the visible or in the near ultraviolet. The wavelength of the second laser is chosen such as to permit photodissociation from those energy levels of the electronic ground state, which

are populated by absorption of the IR-laser radiation and exchange of quanta in collisions, but whose vibrational relaxation is still not significantly affected by the anharmonicity of the oscillations. It is possible here to use lasers having a quantum energy insufficient for photodissociation from the lower vibrational level<sup>1)</sup>.

Let us estimate the necessary laser parameters. We start from the following equations

$$\frac{dx}{dr} = -x + \frac{w_1}{(1+x)^2} - w_2 \frac{m-x}{1+x} \left(\frac{x}{1+x}\right)^m \quad (1)$$

$$\frac{dc}{dr} = -w_2 \left(\frac{x}{1+x}\right)^m \frac{c}{1+x}$$

Here  $c = \sum_n f_n$ ,  $x = (1/c) \sum_n n f_n$  ( $f_n$  are the level population probabilities normalized such that  $c + f_g = 1$ , where  $f_g$  is the probability of dissociation of the molecule);  $\tau = t/t_k$ ,  $t_k$  - time of vibrational-translational relaxation;  $w_{1,2} = \sigma_{1,2} I_{1,2} t_k / h\nu_{1,2}$ ,  $\sigma_1$  is the cross section for resonant absorption of an IR quantum,  $\sigma_2$  is the photodissociation cross section, and  $h\nu_{1,2}$  and  $I_{1,2}$  are the quantum energy and the power flux density of the IR laser and of the laser in the visible band. It is assumed that the photodissociation takes place upon transition from the  $m$ -th vibrational level to a repulsion term or to an unstable section of an excited term. Equations (1) were obtained from the system of equations for the populations of a harmonic oscillator under the condition that the distribution of the molecules over the levels is quasistationary and is determined by the average number  $x$  of quanta per molecule, and  $w_{1,2} \ll t_k/t_0$ , where  $t_0$  is the quantum-exchange time. The latter limitation need not be imposed if one determines the distribution function of the molecules over the levels in the diffusion approximation. However, estimates show that to violate this condition it is necessary to have flux densities that are difficult to realize in the continuous regime in a considerable volume of gas at a pressure above 10 Torr.

The solution of Eqs. (1) is not complicated, but is difficult to visualize. The necessary estimates can be performed directly. We shall assume henceforth that  $m = 10$ . If  $w_2 x^m (1+x)^{-m-1} \geq 1$ , then an appreciable fraction of the molecules dissociates even before the vibrational relaxation becomes significant. In this case the quantity  $x$  assumes a steady value within a time  $\tau_y \approx 1/w_2$ , after which it varies slowly in comparison with  $\tau_y$  and is determined by excitation and photodissociation. If  $x \approx 3$ , then to realize this regime it is necessary to have  $w_2 \geq 70$  and  $w_1 \geq 110$ . If  $w_2 \approx 1$ , the steady-state value of  $x$  is assumed within a time  $\tau \approx 1$ , and the value of  $x$  is determined by the excitation and vibrational relaxation. If  $w_1 \approx 50$ , then  $x \approx 3$  and an appreciable fraction of the molecules decays within a time  $\tau \approx 70/w_2$ .

We present numerical examples. At a pressure  $p = 10$  Torr we have for many molecules  $t_k \approx 10^{-3}$  sec, for allowed transitions  $\sigma_1 = 10^{-16} - 10^{-17}$  cm<sup>2</sup>, and

<sup>1)</sup>Two-step photodissociation of a diatomic molecule (HCl) by pulsed application of neodymium-laser radiation and its harmonics was obtained recently by R.V. Ambartsumyan and V.S. Letokhov (Conference on Laser Applications, Washington, July 1971).

both quantities decrease like  $\sim 1/p$ . At  $h\nu_1 = 2 \times 10^{-13}$  erg, we have  $w_1 \approx 1$  if  $I_1 \approx 0.2 - 2$  W/cm<sup>2</sup>. If  $\sigma_2 = 10^{-19}$  cm<sup>2</sup> and  $h\nu_2 = 4 \times 10^{-12}$  erg, then  $w_2 \approx 1$  and  $I_2 \approx 4 \times 10^3$  W/cm<sup>2</sup>. At the presently available radiation intensities, two-step dissociation can be realized, in particular, and is faster than the time of vibrational relaxation.

From the point of view of two-step dissociation, interest attaches to excitation of the molecules CF<sub>3</sub>I ( $\nu_1 = 1073$  cm<sup>-1</sup>) by a CO<sub>2</sub> laser. The continuous absorption spectrum of these molecules from the lower vibrational level begins with 35,500 cm<sup>-1</sup>, and it is possible that excitation of about ten vibrational levels will suffice for dissociation of this molecule by radiation of the second harmonic of a neodymium laser ( $\sim 20,000$  cm<sup>-1</sup>).

We note in conclusion that resonant photoexcitation of molecule vibrations can greatly increase the rate of photodissociation from broad band sources of visible light by increasing the number of photodissociation channels.

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#### SCATTERING OF $\gamma$ QUANTA BY NUCLEONS IN THE QUARK MODEL

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In connection with the appearance of experimental data on the total cross sections of  $\gamma N$  interactions at high energies [1], it is of interest to extend the quark model to the processes  $\gamma + N \rightarrow \gamma + N$ .

The amplitudes of  $\gamma N$  scattering (above the threshold of V-meson photoproduction) can be connected in the quark model with the amplitudes of elastic scattering of mesons by nucleons:

$$\frac{8}{a} \frac{\gamma_p^2}{4\pi} F(\gamma N - \gamma N) = \left(1 + \frac{\gamma_p^2}{\gamma^2} - \frac{\gamma_p}{\gamma \phi}\right) [(\pi^- p) + (\pi^+ p)] + \frac{\gamma_p^2}{\gamma \phi^2} [(K^+ p) + (K^- p) + (K^0 p) + (\bar{K}^0 p)] \pm 2 \frac{\gamma_p}{\gamma_\omega} [(K^+ p) + (K^- p) - (K^0 p) - (\bar{K}^0 p)], \quad (1)$$

where  $(\pi p)$  and  $(Kp)$  are the amplitudes of elastic  $\pi p$  and  $Kp$  scattering,  $\gamma_V$  are standard constants of the  $\gamma V$  interaction; the signs  $(\pm)$  correspond to scattering of  $\gamma$  quanta by protons and neutrons.