

On the beam axis ($\tau = 0$) at $I_0 = \text{const}$ we have

$$r = r_0 - \frac{I_0 T_d}{W_c} \ln\left(1 + \frac{t}{T_d}\right) \quad (12)$$

Obviously, the duration of that part of the pulse which clears the channel effectively is equal to the diffusion time T_d . In the case of turbulent diffusion we have $T_d \approx 1$ sec for a beam with $a = 1$ m. With decreasing cross section of the high-power beam, the role of diffusion blurring of the channel increases ($T_d/T_w \approx av/D$).

6. Using the foregoing formulas it is possible to trace also the passage of the laser beam itself (Fig. 2b). In this case there is an analogy with the passage of a laser beam through a self-bleaching medium with inertial absorption mechanism. We note also that after clearing the cloud can act on the beam like a thermal lens and make it nonlinearly divergent [7, 8].

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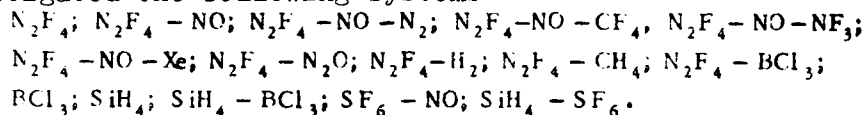
STIMULATION OF CHEMICAL PROCESSES BY INFRARED LASER RADIATION

N.G. Basov, E.P. Markin, A.N. Oraevskii, A.V. Pankratov, and A.N. Skachkov
 P.N. Lebedev Physics Institute, USSR Academy of Sciences
 Submitted 21 July 1971
ZhETF Pis. Red. **14**, No. 4, 251 - 253 (20 August 1971)

In [1] we have observed the photochemical action of infrared radiation, wherein the vibrationally-excited molecules take direct part in a chemical reaction. The conclusion that vibrationally-excited molecules take part in the reaction follows also from the results of [2].

We have investigated the behavior of several inorganic chemical nonreacting systems under the influence of IR radiation of a CO₂ laser. The radiation intensity ranged from 20 to 50 W in a beam of approximate diameter 9 mm. The irradiation time was shorter than 0.5 sec. The reactions were produced in cells 20 mm in diameter and 100 mm long, with windows of AgCl. The substances absorbing the IR radiation of 10.6 μ wavelength were N₂F₄ (valent vibrations of the N-F bond $\nu_2 = 934$ cm⁻¹ and $\nu_8 = 958$ cm⁻¹), BCl₃ (valent vibrations $\nu_3 = 958$ cm⁻¹), SF₆ (deformation vibration $\nu_3 = 943$ cm⁻¹), SiH₄ (deformation vibration range 910 - 1000 cm⁻¹, frequency 914 cm⁻¹), and PF₅ (valent vibration 948 cm⁻¹).

We investigated the following systems:

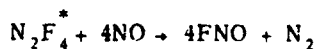


The experimental conditions and the reactions are listed in the table. Laser-chemical reactions occur at explosive rates and are accompanied by the emission of light.

The emission spectrum of the products of the reaction of N_2F_4 with NO revealed two regions - infrared and visible. The visible spectrum is interpreted as the emission of the molecule FNO, produced in the reaction $F + NO = FNO^*$.

Reagents, partial pressures, Torr	Irradiation cond., intensity (W), number of irradiations (n), final pressure (P_f), Torr.	Reaction products, process
N_2F_4 100 NO 100	40 W glow $P_f = 262$	FNO, N_2 , F_2
N_2F_4 100 NO 200 N_2 460	70 W glow	NO_2 , N_2O , N_2
N_2F_4 100 NO 100 CF_4 200	30 W	NF_3 , NO, CO_2 (10%) CF_4 , N_2
N_2F_4 300 N_2O 150	40 W weak glow $n = 3$ $P_f = 512$	NO_2 (49%), NF_3 (38%) N_2O (5%), FNO, N_2
N_2F_4 50 H_2 100	50 W glow	N_2 , HF $N_2F_4 + 2H_2 = 4HF + N_2$
N_2F_4 228 CH_4 114	50 W glow $P_f = 534$	CF_4 (22%), HF, N_2 $N_2F_4 + CH_4 = CF_4 + 4HF + N_2$ CF_4 and C produced in excess CH_4
N_2F_4 114 BCl_3 114	50 W $n = 3$ glow at $n = 1$ $P_f = 289$	BF_3 , chlorine fluorides N_2
SiH_4 228	50 W $n = 3$ glow at $n = 1, 2$ $P_f = 284$	Si, H_2 (34%) $SiH_4 = Si + 2H_2$, convers. 22%
SiH_4 112 BCl_3 112	40 W $n = 3$ glow at $n = 1, 2, 3$ $P_f = 234$	BCl_2H , SiH_3Cl $SiH_4 + BCl_3 = BCl_2H + SiH_3Cl$ B_2H_6
SiH_4 300 SF_6 100	40 W glow $P_f = 698$	SiF_4 , H_2 , S $SiH_4 + 2/3SF_6 = SiF_4 + 2H_2 + 2/3S$

The reaction between N_2F_4 and NO is initiated by the interaction of the vibrationally-excited molecules of N_2F_4 with NO:



($\Delta H_p = -149.2$ kcal/mole for N_2F_4 in the ground state). The reaction takes place in the irradiated zone of the cell. The flash covers the entire volume of the reactor.

Excited products are produced during the course of the chemical reactions. The presence of intense luminescence gives ground for carrying out experiments aimed at detecting inverted populations of the products in laser-chemical reactions and at observing lasing effects.

Irradiation of N_2F_4 , BCl_3 , SF_6 , PF_5 , and SiH_4 has shown that all substances with the exception of silane do not dissociate at intensities lower than ~ 40 W and pressures lower than 200 Torr. This gives grounds for assuming that the investigated reactions (with the possible exception of reactions with silanes) begin not with a stage of dissociation of the vibrationally-excited molecules, but with an exothermal-reaction stage (for example, the reaction for the system $N_2F_4 - NO$).

A comparison has revealed an appreciable difference between laser-chemical and thermal reactions. Thus, when mixtures of N_2F_4 with NO and of N_2F_4 with N_2O are heated, only decomposition of N_2F_4 takes place, viz., $3N_2F_4 = 4NF_3 + N_2$, and there is no reaction with NO or N_2O . This can be attributed to the fact that the vibrationally-excited molecules produced upon absorption of the IR radiation have chemical properties different from those of the molecules in the ground state.

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BIEXCITON IN Cu_2O CRYSTAL

O.I. L'vov and P.P. Pavinskii

Leningrad State University

Submitted 21 June 1971

ZhETF Pis. Red. 14, No. 2, 253 - 256 (20 August 1971)

An anomalous hydrogen-like series, converging not to the short-wave region of the spectrum, as usual, but to the long-wave region, was recently observed [1] in the luminescence spectrum of the crystal Cu_2O . The series was interpreted as the emission spectrum of a biexciton that becomes converted into an exciton of the green series (see the review [2]). The anomalous sequence of lines in the new series is due to the fact that the initial level in the emission of the quantum is the electronic excited state of the lattice (biexciton) with an excitation energy 33720 cm^{-1} , which is approximately double the excitation energy of the main electrons of the yellow or green series.

A variant of the biexciton structure is also proposed in [1]. On the basis of the presented experimental information, the authors conclude that the biexciton in Cu_2O consists of two identical excitons of the green series with the frequency sum exceeding the level indicated above by 150 cm^{-1} . The latter quantity is interpreted as the binding energy of the biexciton relative to its dissociation.