

ULTRAVIOLET LASERS USING ORGANIC-SCINTILLATOR MOLECULES

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Submitted 24 October 1968

ZhETF Pis. Red. 9, No. 1, 15 - 18 (5 January 1969)

We have obtained powerful laser emission in a new class of medium, namely organic scintillators.

A large number of scintillators have a high extinction coefficient in the absorption region, and a large luminescence quantum yield. The fluorescence of solutions of many of them is quenched relatively little by molecular oxygen.

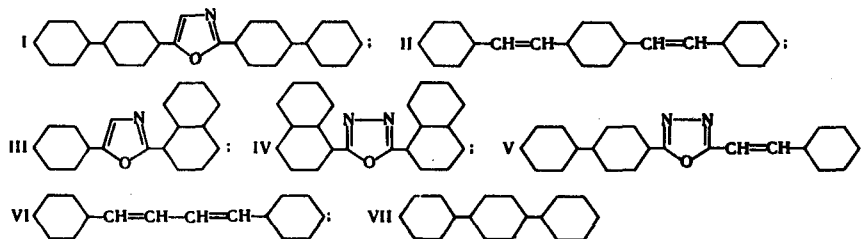
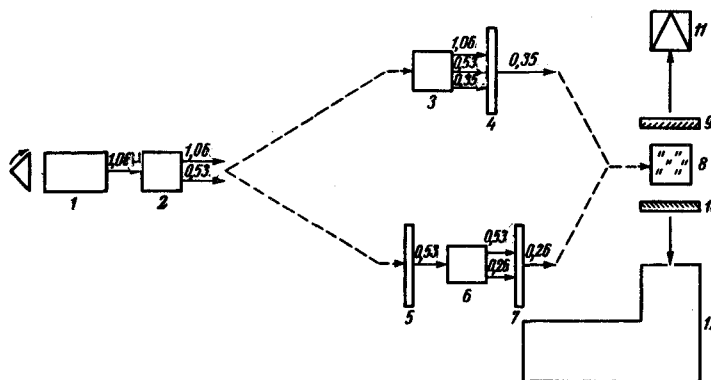


Fig. 1. Investigated compounds: I - 2,5-di(biphenyl)-1,4-oxazole; II - 1,4-distyryl-benzene; III - 2-phenyl-5-anaphthyl-1,4-oxazole; IV - 2,5-di(α -naphthyl)-1,3,4-oxadiazole; V - 2-biphenyl-5-styryl-1,3,4-oxadiazole; VI - diphenylbutadiene; VII - para-terphenyl.

We chose for the investigations a number of representatives of aromatic hydrocarbons, aryl-oxazoles, aryloxadiazoles, arylethylenes, and diphenylpolyenes (see Fig. 1). The molecules of these compounds have sufficiently intense absorption in the region of emission of the third and fourth harmonics of the neodymium laser (353 and 265 nm, respectively), which were used for pumping, and fluoresce in the ultraviolet region of the spectrum.

A block diagram of the experimental setup is shown in Fig. 2. The emission of a neodymium laser (Q-switched with a rotating prism, power 300 - 400 MW) was transformed into the second harmonic ($P = 20 - 30$ MW), and the either into the third ($P = 7 - 8$ MW) or fourth ($P = 0.5 - 0.6$ MW). The unsealed cell with the solution at room temperature was placed in the resonator, the optical axis of which was perpendicular to the pumping beam (transverse variant). The purpose of the experiment was to obtain lasing. No attempt was made to obtain the optimal

Fig. 2. Block diagram of experimental setup: 1 - neodymium laser, 2, 3, 6 - KDP crystals, 4, 5, 7 - filters, 9, 10 - mirrors, 8 - cell with solution, 11 - calorimeter, 12 - ISP-30 spectrograph



Compound (Fig. 1)	λ_{pump} , nm	Solvent	Concentration 10^{-3} mole/l	λ_{gen} , nm	$\Delta\lambda_{\text{gen}}$, Å	P_{pump} , MW	Conversion coeff., %	Gen. thresh. %	$R_1 \times R_2^1$
I	353	Toluene	2,6	409	60	8	4	-	0,31×0,71
		Toluene	0,7	409	60	8	-	-	0,31×0,71
II	353	Toluene	1,6	411	40	8	7,5	50	0,30×0,71
		Toluene		417	40				0,45×0,66
III	353	Toluene	3,7	399,5	70	8	6,5	-	0,37×0,84
IV	353	Toluene	3,1	391	50	8	6,5	100	0,78×0,85
		Benzene	3,1	391	50	7	4,5	-	0,78×0,85
V	353	Toluene	3,1	390,5	70	8	2,5	-	0,78×0,85
		Benzene	3,1	391,5	50	7,5	3,5	-	0,78×0,85
VI	353	Toluene	2,9	383	20	8	1,5	900	0,66×0,92
VII	265	Cyclohexane	1,3	341	60	0,6	1,3	300	0,83×0,94

1) R_1, R_2 - reflection coefficients of mirrors 9 and 10 (Fig.3) at the generator wavelength.

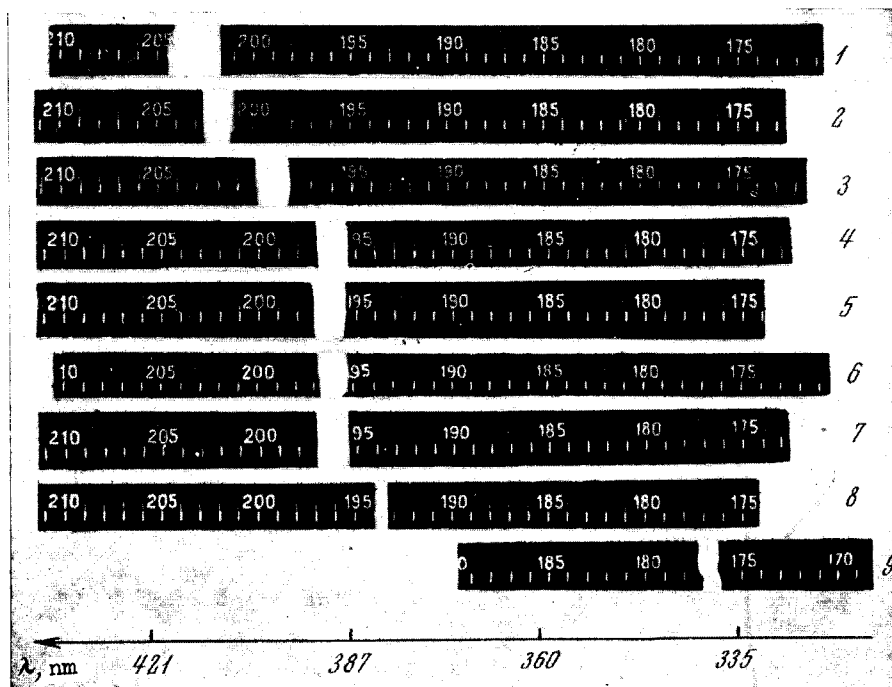


Fig. 3. Laser emission spectrograms: 1 - 1,4-distyrylbenzene in toluene, 2 - 2,5-di(biphenyl)-1,4-oxazole in toluene, 3 - 2-phenyl-5- α -naphthyl-1,4-oxazole in toluene, 4 - 2,5-di(α -naphthyl)-1,3,4-oxadiazole in toluene, 5 - 2,5-di(α -naphthyl)-1,3,4-oxadiazole in benzene, 6 - 2-biphenyl-5-styryl-1,3,4-oxadiazole in toluene, 7 - 2-biphenyl-5-styryl-1,3,4-oxadiazole in benzene, 8 - diphenylbutadiene in toluene, 9 - paraterphenyl in cyclohexane.

system parameters and maximum output power. The results of the experiments are shown in the table and in Fig. 3. In addition, the beam divergence of the para-terphenyl laser was measured and found to be $4 - 5'$. It is interesting to note that even molecules of simple electronic structure, such as para-terphenyl or diphenylbutadiene, are capable of emitting radiation. Lasers using these molecules operate in accordance with the usual scheme of two singlet levels, broadening as a result of the system of vibrational and rotational sub-levels [1]. The experimental results indicate that lasing on the basis of the indicated mechanism can be effected not only in dyes, but in many organic compounds of other classes.

We have thus obtained for the first time uv generation from solutions of organic scintillators. Such lasers can find use in various investigations, particularly photochemical ones, when it is necessary to have a sufficiently strong monochromatic radiation in the 400 - 200 nm range. Heretofore, only several sources of emission lines were available in this range, namely at 353 (third harmonic of endodymium laser), 347 (second harmonic of ruby laser); 337 (molecular-nitrogen gas laser), and 265 nm (fourth harmonic of neodymium laser).

There is no doubt that the number of scintillators capable of lasing in the uv region can be increased manyfold, so that at least the spectral region from 300 to 400 nm will be fully covered by generation lines. It should be noted that even under non-optimal conditions the lasing threshold turned out to be low. This gives grounds for assuming that generation of uv radiation can be obtained from such compounds pumped with flash lamps. It is also important that many of the compounds of the types listed above, unlike the dyes used to obtain laser emission in the visible range, are much more stable against the action of ultraviolet radiation, oxidation, and other factors. Another advantage of these compounds is that they can be readily incorporated in plastic matrices, and therefore can be used as active elements of solid-state lasers.

We note also that these compounds are good energy acceptors, and can therefore be used for lasers in which the population inversion of the active levels is the result of energy transfer from other excited molecules (energy donors).

The authors are grateful to R. N. Nurmukhametov for supplying a number of compounds and for interest in the work.

[1] B.I. Stepanov, A. I. Rubinov, *Usp. Fiz. Nauk* 95, 45 (1968) [*Sov. Phys.-Usp.* 11, (1969)].

MICROWAVE-ABSORPTION FLUCTUATIONS AT PHASE TRANSITION IN BARIUM TITANATE

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Submitted 25 October 1968
ZhETF Pis. Red. 9, No. 1, 19 - 23 (5 January 1969)

The notion that regions with anomalously high free-carrier concentration (on the order of 10^{20} cm^{-3}) are located near the end faces of ferroelectric domains was advanced in [1 - 3]. To check on this notion, investigations were made of the light emission accompanying each act of BaTiO_3 depolarization [4] and microwave absorption in barium titanate [5]. The experiments agree with the concept of screening of the spontaneous induction in ferroelectrics with