Optica Applicata, Vol. XIV, No. 2, 1984

Eighteen new laser dyes generating in the visible spectral range

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The paper presents lasing properties of four series of recently synthetised highly fluorescent organic dyes. All the investigated dyes are listed in the Table. Dyes of series A being photostable were synthetised photochemically [1] by an irradiation of 1-phenyl-2-(2-arylethenyl)-3, 3-dimethyl-3H-indolium perchlorate by a medium pressure mercury lamp. Dyes of series B, C and D were obtained by non-photochemical methods.

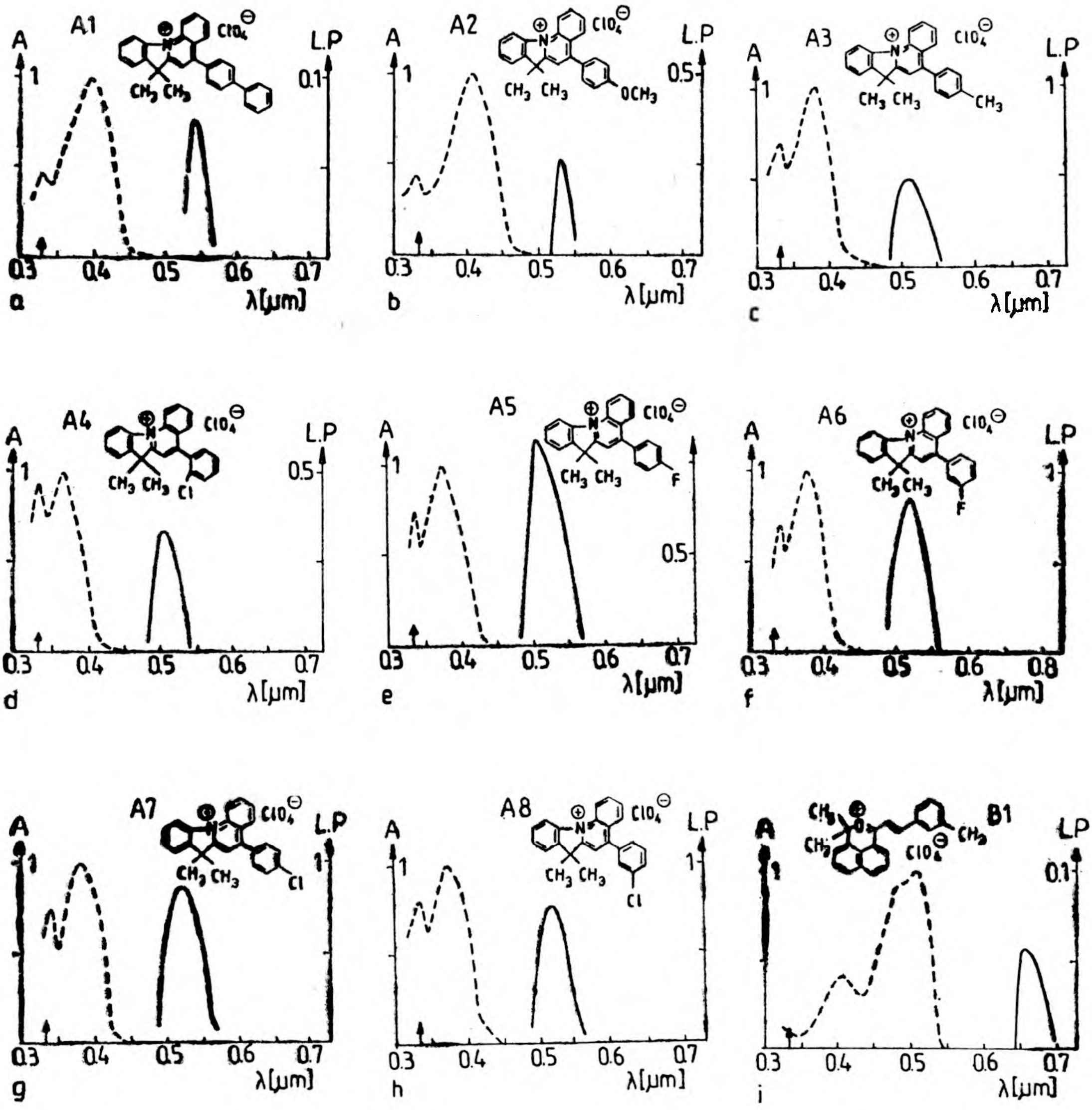
Lasing properties of all the dyes have been investigated in a standard arrangement [2] of a dye laser pumped by a nitrogen laser with 0.25 MW pulses of 6 ns FWHM time and 55 Hz repetition rate. The laser dye solution was flowing transversely in a compact cell [3]. Since majority of organic glues are not resistant to the solvents used, our dye cell was sealed with specially developed inorganic glue [4]. A high dispersion rutile prism [5] served as a tuning element. The laser resonator outcoupling was 10 %. The output power was measured by a sampling oscilloscope (UNITRA OS-1500) with a fast photodiode corrected for spectrally flat response. Lasing wavelength was measured by a prismatic spectroscope. Solvents for the dyes were chosen to maximize their fluorescence. Concentrations of solutions were adjusted to optimize the laser output power. The optimal concentrations of dyes were measured in optical density units (i.e., extinction of 1 cm absorption path of the dye solution) at the pump laser wavelength (337.1 nm). Optical densities given in Table were extrapolated from the data for the dye solutions diluted to fall within measuring range of spectrophotometer used (SPECORD UV-VIS). Dyes A1–A8 and B1–B7 were dissolved in dichloromethane, dyes C1, C2, D1, D2 — in xylene.

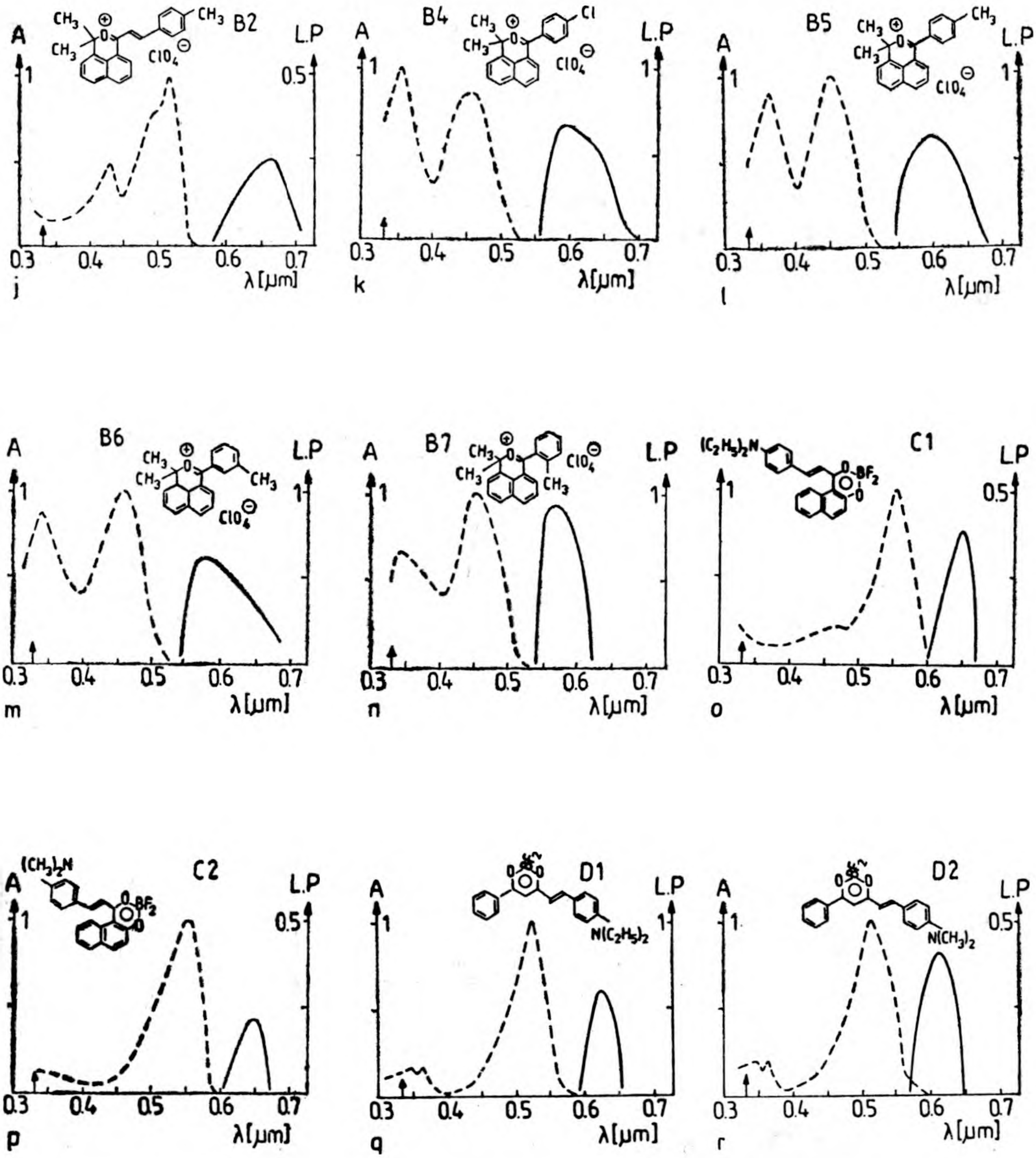
Figures a–r show absorption and lasing spectra of the dyes. The laser output power was measured in arbitrary units with 1.0 corresponding to the maximum output power obtained for Rhodamine 6G in methanol in the same laser configuration. In the Table for each group a general chemical name and for every dye the radicals R are given. Fluorescence quantum yields of the dyes of the group A, measured by means of an HITACHI HFP-4 spectrofluori-

Dye		Optical density 337 [nm]	Lasing		Maximal power	Fluorescence quantum yield	Summary formula	Melting point [°C]	Remarks
Code	Radical (R)		range [nm]	max [nm]					
			5-R-7, 7-dimethyl-7H-indolo [1,2-a] quinolinum perchlorate						
A1	4-diphenyl	46.5	527–566	542	0.078	0.881	$C_{30}H_{24}ClNO_4$	300–301	
A2	4-methoxyphenyl	38.0	516–558	528	0.264	0.976	$C_{25}H_{22}ClON_5$	271–273	
A3	4-methylophenyl	17.5	483–557	508	0.500	0.668	$C_{25}H_{22}ClNO_4$	234–235	
A4	2-chlorophenyl	21.5	480–549	503	0.333	0.568	$C_{24}H_{19}Cl_2NO_4$	241–242	
A5	4-fluorophenyl	41.0	482–567	520	1.130	0.612	$C_{24}H_{19}ClFNO_4$	254–255	
A6	3-fluorophenyl	10.0	484–558	512	0.848	0.581	$C_{24}H_{19}ClFNO_4$	294–295	
A7	4-chlorophenyl	27.5	485–575	540	0.863	0.581	$C_{24}H_{19}Cl_2NO_4$	240–243	
A8	3-chlorophenyl	16.5	485–555	513	0.776	0.546	$C_{24}H_{19}Cl_2NO_4$	239–241	
			1-R-3, 3-dimethyl-3H-naphto [1,8-cd] pyrylium perchlorate						
B1	3-methylostyryl	38.5	655–700	645	0.058	–	$C_{23}H_{21}O_5Cl$	187–190	unstable
B2	4-methylostyryl	18.0	585–705	648	0.254	–	$C_{23}H_{21}O_5Cl$	188–190	
B3	styryl	9.0	–	670	–	–	$C_{22}H_{19}O_5Cl$	201–202	highly unstable
B4	4-chlorophenyl	2.7	555–702	628	0.712	–	$C_{20}H_{16}O_5Cl_2$	178–178	unstable
B5	4-methylophenyl	6.0	542–675	595	0.670	–	$C_{21}H_{19}O_5Cl$	194–195	unstable
B6	3-methylophenyl	5.7	545–680	623	0.631	–	$C_{21}H_{19}O_5Cl$	186–187	
B7	2-methylophenyl	3.1	535–640	585	0.945	–	$C_{21}H_{19}O_5Cl$	209–210	
			1-R-2,4-dioxa-3-difluorobora-phenanthrene						
C1	4-diethylaminostyryl	9.0	605–670	650	0.390	–	$C_{23}H_{22}BF_2NO_2$	183–185	
C2	4-dimethylaminostyryl	8.0	602–670	640	0.212	–	$C_{21}H_{18}BF_2NO_2$	205–206	
			4-phenyl-6-R-1,3-dioxa-2-difluorobora-benzene						
D1	4-diethylaminostyryl	8.0	580–660	630	0.596	–	$C_{21}H_{22}BF_2NO_2$	163–164	
D2	4-dimethylaminostyryl	3.0	565–645	615	0.410	–	$C_{19}H_{18}BF_2NO_2$	245–246	ref. [8], 231–232

meter and quinine in 0.1 n H_2SO_4 [6] as the standard are quoted according to SOROKA [7]. The melting points of the dyes which serve as a simple evaluation of their purity are also given.

As it is seen from the presented results the output power of some of the investigated dyes (e.g. A5, A6, A7) is comparable with Rhodamine 6G. Tuning ranges of all presented dyes are relatively wide. For the dyes B4, B5, B6 and B7 this range exceeds 100 nm. Unfortunately, some of the dyes of the B group are unstable; for B3 the lasing range could not be even determined. The decomposition of this dye was manifested by significant changes in the absorption spectrum.





Spectral properties of investigated dyes. Dotted line – absorption (A), solid line – laser output power (LP) in arbitrary units normalized to maximum power of Rh 6G in methanol. The arrow shows pump wavelength (337.1 nm)

Acknowledgements – We would like to thank Dr. K. B. Soroka and Dr. J. Bogdańska from the Institute of Fundamental Chemistry of Technical University of Szczecin for providing us with the dyes of group A [9–11] and B [12], respectively. The dyes of groups C and D were synthetised by one of the authors (J.A.S.).

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Received September 16, 1983