レーザー資料

色素レーザー用有機化合物総覧 Ⅲ

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Index of Organic Compounds for Dye Lasers Ⅲ

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前々号 (レーザー研究, 8巻4号p.694~712), 前号 (8巻5号p. 803~825) に引きつづき, これまでに報告のあった色素レーザー用有機化合物の発振特性の一覧表を示す。今回はスチルベン系を中心とする芳香族化合物の残部と, クマリン系化合物を取りあげる。表の詳しい説明や全般的な略号については前々号を参照されたい。参考文献は今回新しく出た 177) 以降を巻末に示した。総合索引は最終回に掲載する予定である。

Ⅱ. Ⅱ. オリゴフェニレン (Origophenylene)

ベンゼン環を直線状に並べた化合物を一般に *p*-Origophenylene とよぶ。ベンゼン環の数が 3 個の *p*-Terphenyl 系 (#M206-#M208) と, 4 個の *p*-Quaterphenyl 系 (#M209-#M212) の化合物は, 波長 400nm 以下の紫外部で最も重要な材料である。化学的にも比較的安定である。これまでに最も短い波長で発振しているのは, BM-Terphenyl (#M208) で 311nm までである。²⁴³⁾

それより少し波長は長くなるが, *p*-Terphenyl

(#M206) は最短波長域で最も効率の良い材料である。*p*-Quaterphenyl の誘導体である Polyphenyl1 (#M212) は最も短い波長で CW 発振し, UV イオンレーザーの励起によって, 362nm までの同調域が得られている²⁴²⁾。

なお, 300nm 以下の波長域での色素レーザー発振の可能性については, Wood ら¹⁸⁷⁾ や Abakumov ら²⁴⁰⁾ による考察がある。

Ⅱ. Ⅲ. 共役ジエン化合物 (Conjugated diene compounds)

これはエチレン, ブタジエンなどの直鎖状不飽和炭化水素にベンゼン環が付いたものである。最も重要なのは, Fig. 4 に示した Stilbene および Distryl benzene (Bistilbene) の誘導体である。これらの化合物の発振波長域はおおよそ 400~500nm にわたっている。化学的には安定であるが, レーザー発振特性はクマリン系より劣っていることが多い。したがってクマリンが発振困難となる 430nm 以下の波長で重要である。Bistilbene 誘導体である Stilbene 3 (#M260) は, 紫外イオンレーザーの励起により, 403-493nm の波長域で CW 発振をする¹⁹⁹⁾。一

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Table XIV. Laser characteristics of Origophenylenes and their chemical structures.

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
#M206 p-Terphenyl ; PTP ; U. V. 1.					
Cyclohexane	1.3mM	341nm (BB)	Glass-FH (0.5—0.6MW)	E=1.3%	177)
Cyclohexane	1mM	330—360nm (Grating)	Glass-FH	Thr=100kW	178)
DMF	0.8mM	341nm (BB)	F1 (20J, 50nsRT)	40kW (ASE), Thr=6.6J,	137)
Dioxane	0.2—0.4mM	342.5—355.5nm (BB, Concentration)		Thr=4.2J	
Cyclohexane	9mM	340nm (BB)	CO ₂ -laser-produced plasma (5.6J)	0.1mJ (25ns)	115)
Cyclohexane	2mM	342.6nm (BB)	F1 (81.5J, 80nsRT)	25.2mJ, 0.42MW	179)
Dioxane	10mM	335—346nm (Grating)	KrF (1mJ, 25ns)	25μJ, 3kW	180)
Cyclohexane	1—5mM	323—364nm (Grating)	KrF (6mJ, 5ns, 100Hz)	E=28%	181)
Cyclohexane	0.08mM	321.8—365.3nm (Grating)	KrF (8MW, 15ns)	1MW, 11mJ, E=10%	59)
Cyclohexane	2mM	340.3nm (BB)	XeCl (60mJ, 35ns)	E=20.7%	95)
Cyclohexane	5mM	334—362nm	KrF XeBr	80kW, E=30% E=20%	182)
		340nm (BB)	Mode-locked Glass-FH (4mJ, 7ps, single pulse)	75μJ, E=5% (ps pulse)	93)
Cyclohexane	2mM	333—348nm (Grating) (Osc+Amp)	YAG-FH (5mJ, 5ns, 10Hz)	E=6%	183)
Cyclohexane	4mM	334—347nm (Grating) (Osc+Amp)	KrF, XeCl (150—250mJ, 10—20ns)	E=14%	26)
#M207 4, 4'-N, N, N', N'-Tetraethylamino-p-terphenyl.					
DMF		417—427nm (BB)	F1 (200nsRT)	Thr=26J	184)
#M208 BM-2, 2'-Dimethyl-p-terphenyl ; BM-Terphenyl.					
Cyclohexane	0.96mM	311.2—360nm (Grating)	KrF (70mJ, 14ns)	9mJ	243)
Cyclohexane	0.9mM	311—350nm (Grating) (Osc+Amp)	KrF (250mJ, 10—20ns)	E=8%	26)
#M209 p-Quaterphenyl.					
Toluene		362—390 (Grating)	N ₂ (100kW, 10ns)		185)
DMF	7mM	374nm (BB)	F1 (20J, 50nsRT)	Thr=6J	137)
DMF	Satur.	370nm (BB)	N ₂ (530kW, 3.5ns)	E=11%	139)
DMF	0.075mM	375nm (BB)	F1 (100J, 150nsRT)	12mJ	186)
Cyclohexane	1mM	365nm (BB)	CO ₂ -laser-produced plasma (10J)	0.2mJ	187)
Vapor, SF ₆ (10atm)	280°C	350nm (BB)	Nd-FH (5—20mJ, 15ns)	E=1%	188)
#M210 4, 4'''-Bis-butyloctyloxy-p- quaterphenyl ; BBQ ; BBOQ ; P386 ; U. V. 3 ; BiBuQ.					
Buthanol		381—389nm (BB)	F1 (200nsRT)	Thr=13J	184)
Hexane emulsified in glycerin+water	1mM	(BB)	N ₂ (50kW)		191)
Dioxane		380.3nm (Grating+Prism)	KrF (20mJ, 10ns, 7Hz)	30kW	189)
Dioxane or cyclohexane	2.6mM	386nm (BB)	KrF (160mJ, 0.2Wav.)	11mJ (10—12ns)	190)
Dioxane	0.5mM	383.4nm (BB)	XeCl (60mJ, 35ns)	E=25.1%	95)
			N ₂ (3.5mJ, 15ns)	E=18.8%	
Ethanol +Toluene (1:1)	2mM	380—410nm (Etalon)	Mode-locked YAG-TH (1GW, 30ps/pulse)	a few MW (25ps) (Synchronous pumping)	192)
Cyclohexane	2.5mM	373—391nm (Grating) (Osc+Amp)	YAG-FH (5mJ, 5ns, 10Hz)	E=3.8%	183)

Table XIV. (continued).

Solvent	Concentration	Laser wave length (tuning)	Excitation	Output	Ref.
Cyclohexane		360—395nm (Grating) (Osc+Amp)	XeCl (55mJ, 10Hz)	9mJ, E=16%	242)
Toluene +ethanol (1:1)	2.5mM	373—399nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	0.85mJ	97)
Cyclohexane	0.36mM	359—405nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=17%	26)
DMF	0.08 mM	370—410nm (Grating)	F1 (150nsRT, 1Hz)		87)
#M211 3, 3', 2'', 3''-Tetramethyl-p-quaterphenyl; TMQ.					
Cyclohexane	2mM	338—361nm (Grating) (Osc+Amp)	YAG-FH (5mJ, 5ns, 10Hz)	E=1.2%	183)
Cyclohexane	2mM	338—360nm (Grating) (Osc+Amp)	KrF or XeCl (150—250mJ, 10—20ns)	E=6%	26)
#M212 Polyphenyl 1.					
EG	0.2—0.6mM	360—410nm (Grating) (Osc+Amp)	XeCl (55mJ, 10Hz)	10.2mJ, E=18.5%	242)
EG	2.5mM	362—412nm (BF filter)	Ar (UV all lines, 3.3W)	80mW, Thr=1W	
EG	0.56mM	360—408nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=18%	26)
EG	2.5mM	360—415nm (Grating) (Osc+Amp)	N ₂ (1.5MW, 4ns)	E=14%	
#M213 p-Quinquephenyl.					
Dioxane	Satur.	420nm (BB)	N ₂ (530kW, 3.5ns)	E=15.5%	139)
#M214 p-Phenylene-4, 4'-bistetraphenylimidazole-2-dium dichloride.					
Ethanol	Satur.	426nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M215 p-Terphenylene-4, 4'-bis (tetraphenylimidazole-2-dium) dichloride.					
Ethanol	Satur.	415nm (BB)	N ₂ (1MW, 2.5ns)		155)

Fig. 4. Structures of (a) stilbene and (b) distyryl benzene (bistilbene).

般にこの種の Stilbene 系化合物には、蛍光増白剤として研究開発されているものも多く、Majewski と Krasinski によって多数の蛍光増白剤のレーザー発振が報告されている。¹⁹⁸⁾

II. IV. その他の芳香族化合物 (Other aromatic compounds)

その他の芳香族化合物を Table XVI に示した。

III. 複素環化合物 (Heterocyclic compounds)

III. I. クマリン, アザクマリン誘導体 (Coumarin and Azacoumarin derivatives)

Fig. 5 (a) にその構造を示した Coumarin の誘

Table XV-1. Laser characteristics of Conjugated diene compounds. Their chemical structures are given in Table XV-2.

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
#M216 4-Phenyl stilbene ; PBE.					
Dioxane	2mM	380nm (BB)	N ₂ (530kW, 3.5ns)	E=0.8%	139)
Naphthalene (crystal)	2×10 ¹⁷ cm ⁻³	376nm (BB) 4.2K	Nd-THG (2MW, 30ns)		207)
#M217 4, 4'-Diphenyl stilbene ; 1, 2-Di-4-biphenyl-ethylene ; DPS ; BBE.					
Toluene		408nm (BB)	Glass-TH (1MW)		76)
Benzene	1mM	408.5nm (BB)	Ruby-SH (0.8MW, 12ns)		193)
Benzene	Satur. ×0.66	409nm (BB)	F1 (20J, 50nsRT)	Thr=3.8J	137)
		400—420nm (Grating)	N ₂ (120kW, 10ns, 100Hz)	E=23% (8ns)	130)
Xylene	Satur.	404.6—411.7nm (Grating)	N ₂ (100kW)		194)
Benzene	0.25mM	406nm (BB)	F1 (100J, 150nsRT)	10mJ	186)
		405nm (BB)	Mode-locked Glass-TH (1—3mJ, 6ps, Single pulse)	0.1mJ, E=5% (ps pulse)	93)
Dioxane	<1.2mM	401—404nm (BF filter)	Xe (364nm, 5kW, 200ns, 10Hz)	500W, E=10% (120ns)	195)
Dioxane	Satur.	405.5nm (BB)	XeCl (60mJ, 35ns)	E=27.3%	95)
Dioxane	Satur.	396—416nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	0.8mJ	97)
Dioxane	0.7mM	393—419nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=13%	26)
Biphenyl (crystal)		418nm (BB) 4.2K	Nd-THG (2MW, 30ns)		207)
#M218 Stilbene 1 ; Sulphonated diphenyl-stilbene.					
EG	1mM	390.4—448.5nm (BF filter)	Kr (UV all lines, 3.7W)	440mW, E=12%	196)
EG	0.67g/l	395—435 (BF filter)	Ar or Kr (UV all lines, 3W)	300mW, E=12%	86)
		405—428nm (Single axial mode)		58mW	
EG	1mM	398—435nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=16%	26)
EG	0.6mM	390—450nm (Grating) (Osc+Amp)	N ₂ (1.5MW, 4ns)	E=17%	
#M219 1-(4-biphenyl)-2-(1-naphthyl) ethylene ; α NBE.					
Cyclohexane	0.8mM	410.8 (BB)	Ruby (5MW, 20ns)	0.3MW	164)
Benzene		416.6nm (BB)			
#M220 1, 2-Di-(1-naphthyl) ethylene ; α NNE.					
Toluene		426nm (BB)	Glass-TH (1MW)		76)
#M221 1, 2-Di (2-naphthyl) ethylene ; β NNE.					
Naphthalene (crystal)	10 ¹⁸ cm ⁻³	397nm (BB) 4.2K	Nd-THG (2MW, 30ns)	E=25%	207)
#M222 1-(4-biphenyl)-2-(2-naphthyl) ethylene ; β NBE.					
Naphthalene (crystal)	10 ¹⁸ cm ⁻³	397nm (BB) 4.2K	Nd-THG (2MW, 30ns)	Thr=0.01J/cm ²	207)
#M223 1-(1-Naphthyl)-2-(2-naphthyl) ethylene.					
Naphthalene (crystal)		397nm (BB) 4.2K	Nd-THG (2MW, 30ns)		207)
#M224 1-(2-Naphthyl)-2-phenylethylene.					
Naphthalene (crystal)	10 ¹⁸ cm ⁻³	385nm (BB) 4.2K	Nd-THG (2MW, 30ns)	Thr=0.01J/cm ²	207)
#M225 4, 4'-Bis (4-phenyl-2H-triazol-2-yl)-2, 2'-stilbenedisulfonic acid dipotassium salt ; Triazinyl stilbene No. 10.					
Water+NP-10	1.5mM	420—454nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=3.6%	197)
Methanol	1.5mM	414—437.5nm (Grating)		E=3.6%	

Table XV-1 (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
#M226 Tinopal PCRP ; FBA 70.					
Benzene	1mM	430nm (BB)	N ₂ (1MW, 2.5ns)		155)
Dioxane		414—453nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M227 Tinopal RBS ; FBA 46.					
Methanol+Dioxane (1:9)		414—472nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M228 Tinopal GS ; FBA 47.					
Methanol		422—476nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M229 Blankophor R ; FBA 30.					
Methanol		396—447nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M230 Delft weiss BSW ; FBA 81.					
Methanol		411—464nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M231 Tinopal BV ; FBA 1.					
Methanol		405—459nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M232 Leukophor B ; FBA 32.					
Methanol		410—465nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M233 Uvitex CF ; FBA 134 ; Weissstener BV ; FBA 111.					
Methanol		410—462nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M234 4, 4'-Bis[(4-anilino-6-methoxy-1, 3, 5-triazin-2-yl)amino]-2, 2'-stilbenedisulfonic acid ; Triazinyl stilbene No. 1.					
Water+NP10	1.5mM	417.5—442.5nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=2.2%	197)
#M235 4, 4'-Bis[[4-anilino-6-(2-hydroxyethylamino)-1, 3, 5-triazin-2-yl]amino]-2, 2'-stilbenedisulfonic acid ; Triazinyl stilbene No. 2.					
Water+NP-10	1.5mM	420—438nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=2.5%	197)
#M236 4, 4'-Bis[[6-bis(2-hydroxypropyl)amino-4-(x-sulfoanilino)-1, 3, 5-triazin-2-yl]amino]-2, 2'-stilbenedisulfonic acid ; Tryazinyl stilbene No. 3.					
Water+NP-10	1.5mM	420—447nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=2.8%	197)
#M237 4, 4'-Bis[[6-bis(2-hydroxyethyl)amino-4-(x-sulfoanilino)-1, 3, 5-triazin-2-yl]amino]-2, 2'-stilbenedisulfonic acid ; Tryazinyl stilbene No. 4.					
Water+NP-10	1.6mM	425—459nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=3.2%	197)
Methanol	1.6mM	417.5—461nm (Grating)		E=3.2%	
EG +Methanol (9:1)	2mM	411—481nm (BF filter)	Ar (UV all lines, 3.5W)	350mW	199)
#M238 4, 4'-Bis[[6-(2-hydroxyethyl)methylamino-4-(x-sulfoanilino)-1, 3, 5-triazin-2-yl]amino]-2, 2'-stilbenedisulfonic acid ; Tryazinyl stilbene No. 5.					
Water+NP-10	1.5mM	420—445nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=2.6%	197)
#239 4, 4'-Bis[[4-(x, y-disulfoanilino)-6-morpholino-1, 3, 5-triazin-2-yl]amino]-stilbenedisulfonic acid ; Tryazinyl stilbene No. 6.					
Water+NP-10	1.5mM	418—448nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=2.95%	197)
#M240 4, 4'-Bis[[4-(x, y-disulfoanilino)-6-(2-hydroxyethyl)methylamino-1, 3, 5-triazin-2-yl]amino]-2, 2'-stilbenedisulfonic acid ; Tryazinyl stilbene No. 7.					
Water+NP-10	1.5mM	418—449nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=2.95%	197)
#M241 4, 4'-Bis[[4-(x, y-disulfoanilino)-6-ethylamino-1, 3, 5-triazin-2-yl]amino]-2, 2'-stilbenedisulfonic acid ; Tryazinyl stilbene No. 8.					
Water+NP-10	1.5mM	419—447.5nm (Grating)	N ₂ (100kW, 7ns, 75Hz)	E=3.2%	197)

Table XV-1 (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
#M242 1, 4-Distyryl benzene.					
Toluene		415nm (BB)	Glass-TH (1MW)		76)
Toluene	1.6mM	411, 417nm (BB)	Glass-TH (8MW)	E=7.5%	177)
Toluene	~1mM	412—435nm (Grating)	N ₂ (600kW, 5ns, 5—50Hz)	45kW	200)
#M243 1, 4-Bis (2-methylstyryl) benzene, Bis MSB.					
Ethanol	0.1mM	419nm (BB)	Ruby-SH (0.8MW, 12ns)		193)
Toluene	0.4mM	424nm (BB)	F1 (90J, 100nsRT)	12kW, Thr=44J	138)
Dioxane	3.5mM	423nm (BB, Short cavity)	Mode-locked YAG-TH (1mJ, 11ps, Single pulse)	(13.8ps)	201)
Dioxane	1mM	422nm (BB)	XeCl (60mJ, 35ns) N ₂ (3.5mJ, 15ns)	E=22.1% E=22.0%	95)
Dioxane	1mM	410—430nm (Etalon)	Mode-locked YAG-TH (1GW, 30ps/pulse)	a few MW (25ps) (Synchronous pumping)	192)
Dioxane	1.2mM	411—430nm (Grating) (Osc+Ampl)	N ₂ (1MW, 10ns, 50Hz)	0.6mJ	97)
#M244 2'-Chloro-1, 4-distyrylbenzene.					
Toluene		420nm (BB)	Glass-TH (1MW)		202)
#M245 4'-Chloro-1, 4-distyrylbenzene.					
Toluene		420nm (BB)	Glass-TH (1MW)		202)
#M246 4, 4''-Dichlor-1, 4-distyrylbenzene.					
Toluene		420nm (BB)	Glass-TH (1MW)		76)
#M247 2'-Methoxy-1, 4-distyrylbenzene.					
Toluene		425nm (BB)	Glass-TH (1MW)		202)
#M248 3'-Methoxy-1, 4-distyrylbenzene.					
Toluene		415nm (BB)	Glass-TH (1MW)		202)
#M249 4'-Methoxy-1, 4-distyrylbenzene.					
Toluene		425nm (BB)	Glass-TH (1MW)		202)
#M250 2, 2''-Dimethoxy-1, 4-distyrylbenzene.					
Toluene		430nm (BB)	Glass-TH (1MW)		76)
#M251 1-Styryl-4-[ω-vinyl-(n-biphenyl)] benzene*					
Toluene		432nm (BB)	Glass-TH (1MW)		76)
#M252 1-Styryl-4-[ω-(2-naphthyl)-vinyl] benzene.					
Toluene		425nm (BB)	Glass-TH (1MW)		202)
Naphthalene (crystal)	10 ¹⁷ cm ⁻³	415, 442nm (BB) 4.2K	*Nd-THG (2MW, 30ns)	Thr=0.07J/cm ²	207)
#M253 1, 4-Bis(2-naphthyl) styrylbenzene.					
Naphthalene (crystal)	10 ¹⁶ cm ⁻³	422, 449nm (BB) 4.2K	Nd-THG (2MW, 30ns)	Thr=5mJ/cm ²	207)
#M254 1, 4-Bis(x-sulfostyryl) benzene.					
Methanol	1—2mM	413—431nm	N ₂	E=1.7%	203)
Water	1—2mM	415—443nm	N ₂	E=1.35%	

* 1-Styryl-4-[ω -(n-biphenyl) vinyl] benzene の誤りではないとも考えられる。

Table XV-1 (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
#M255 1, 4-Bis(x-sulfostyryl)-2-chlorobenzene.					
Methanol	1—2mM	413—431nm	N ₂	E=2.8%	203)
#M256 1, 4-Bis(p-dimethylaminostyryl) benzene.					
PMMA	0.01—1mM	478nm (BB)	Glass-TH (0.04J, 40ns)		168)
#M257 1, 4-Bis(x, y-dicyanostyryl)-2-chlorobenzene.					
Dioxane	1—2mM	408—423nm	N ₂	E=1.9%	203)
#M258 4, 4'-Bis(x, y-dichlorostyryl) biphenyl.					
Dioxane	1—2mM	416—437nm	N ₂	E=1.9%	203)
#M259 4, 4'-Bis(x, y-dicyanostyryl) biphenyl.					
Dioxane	1—2mM	408-422nm	N ₂	E=1.95%	203)
#M260 4, 4'-Bis(2-sulfostyryl) biphenyl; Stilbene 420; Stilbene 3.					
Methanol	1.8mM	408—453nm	N ₂	E=3.6%	203)
Water	1.8mM	421—468nm		E=2.6%	
Water+NP-10	1.8mM	416—455nm		E=3.5%	
EG +Methanol (9:1)	2mM	403—493nm (BF filter)	Kr (UV all lines, 3.45W)	660mW, E=19%	199)
		420—472nm (BF filter+Etalon) (single axial mode, ring cavity)	Ar (351, 363nm, 2.5W)	210mW	84)
EG	1.5mM	420—470nm (Tuning wedge)	Mode-locked Ar (351nm, 141mW, 130ps) (UV all lines, 400mW, 300ps)	(Synchronous pumping) 204) 20mW (1ps) 60mW (3.3—4.6ps)	
EG	0.88g/l	406—480nm (BF filter) 415—460 (Single axial mode)	Ar or Kr (UV all lines, 3W) Ar or Kr (UV all lines, 2.2W)	500mW, E=18% 40mW	86)
Methanol +Ethanol (1:1)	1.5mM	415—435nm (Grating)	YAG-TH (6—8mJ, 8ns)		94)
		408—460nm (Grating) (Osc+Amp)	YAG-TH	E=22%	98)
Ethanol	1mM	405—467nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=15%	26)
EG	0.5mM	410—460nm (Grating) (Osc+Amp)	N ₂ (1.5MW, 4ns)	E=15%	
Water +Ammonyx LO	0.5mM	425—470nm (Grating) (Osc+Amp)	N ₂ (1.5MW, 4ns)		
#M261 4, 4'-Bis[[2-sulfo-4-(6, 8-disulfo-2H-naphtho[2, 1-d] triazol-2-yl)]styryl] benzene.					
Methanol	1mM	485nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M262 2-Styrylbenzothiazole; Uvitex RS; FBA 41.					
Methanol		413—434nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M263 Blankophor BP; FBA 116.					
Methanol		412—468nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M264 Tinopal RP; FBA 104.					
Methanol		417—472nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M265 Leukophor DC; FBA 69.					
Methanol		447—508nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M266 Uvitex SFC.					
Methanol		409—459nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)

Table XV-1 (continued).

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
#M267 Heliofor BDC.					
Methanol		408—461nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M268 Uvitex NSI ; FBA 65.					
Methanol		410—463nm (Prism)	N ₂ (200kW, 6ns, 30Hz)		198)
#M269 1, 4-Diphenylbutadiene.					
Toluene	2.9mM	383nm (BB)	Glass-TH (8MW)	E=1.5%	177)
Cyclohexane	5mM	354—360nm	KrF	E=10%	182)
#M270 1, 1, 4, 4,-Tetraphenylbutadiene.					
Cyclohexane	1mM	501nm (BB)	Ruby-SH (5MW, 20ns)	1MW	164)
Cumene	5mM	498nm (—80 to 20°C, BB) 423—438nm (—130 to —70°C, BB)	N ₂ (2ns)		204)

R₁-CH=CH-R₂
#M216; #M217; #M219-#M228

#M242- #M250; #M252- #M254; #M256; #M261

Table XV-2. Chemical structures of Conjugated diene compounds. The symbols (a)—(p) are shown in Table XV-3.

Dye No.	R ₁	R ₂
#M216	Ph	(a)
#M217	(a)	(a)
#M219	(a)	(b)
#M220	(b)	(b)
#M221	(c)	(c)
#M222	(a)	(c)
#M223	(b)	(c)
#M224	Ph	(c)
#M225	(d)	(d)
#M226	Ph	(e)X=Ph
#M227	Ph	(e)X=Na
#M228	(f)	(f)
#M229	(g)	(g)
#M230	(h)	(h)
#M231	(i)	(i)
#M232	(j)X=OH	(j)X=OH
#M233	(j)X=OCH ₃	(j)X=OCH ₃
#M234	R=OCH ₃	n=0
#M235	R=N(C ₂ H ₄ OH) ₂	n=0
#M236	R=N(CH ₂ CHOH) ₂ CH ₃	n=1
#M237	R=N(C ₂ H ₄ OH) ₂	n=1

Table XV-2 (continued).

#M238		n=1	CH ₃	#M247	Ph	(k)X=OCH ₃
				#M248	Ph	(l)X=OCH ₃
#M239		n=2		#M249	Ph	(m)X=OCH ₃
				#M250	(k)X=OCH ₃	(k)X=OCH ₃
#M240		n=2		#M252	Ph	(c)
				#M253	(c)	(c)
#M241	R=NHC ₂ H ₅	n=2		#M254	(n)X=SO ₃ H	(n)X=SO ₃ H
#M242	Ph	Ph		#M255	(n)X=SO ₃ H	(n)X=SO ₃ H
#M243	(k)X=Me	(k)X=Me		#M256	(m)X=N(CH ₃) ₂	(m)X=N(CH ₃) ₂
#M244	Ph	(k)X=Cl		#M257	(o)X=CN	(o)X=CN
#M245	Ph	(m)X=Cl		#M258	(o)X=Cl	(o)X=Cl
#M246	(m)X=Cl	(m)X=Cl		#M259	(o)X=CN	(o)X=CN
				#M260	(n)X=SO ₃ H	(n)X=SO ₃ H
				#M261	(p)	(p)

Table XV-3. Abbreviations used in Table XV-2.

(a)	(e)	(h)	(k)	(o)
(b)	(f)	(i)	(l)	(p)
(c)	(g)	(j)	(m)	
(d)			(n)	

Table XVI. Laser characteristics of other aromatic compounds and their chemical structures.

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
#M271 Sodium-salicylate.					
Ethanol	>1mM	395—418nm (Grating)	N ₂ (100kW, 10ns, 100Hz)		185)
Ethanol	Satur.	403nm (BB)	N ₂ (530kW, 3.5ns)	E=0.6%	139)
#M272 Aminobenzoic acid.					
Toluene		398—406nm (Grating)	N ₂ (100kW, 10ns, 100Hz)		185)
#M273 2-(4-Biphenyl) indene ; 4BPI.					
DMF		388—393nm (BB)	F1 (50J, 200nsRT)	Thr=40J	184)
DMF (deoxygenated)				Thr=30J	
#M274 Azulene.					
Naphthalene (crystal)		398nm (BB) 4.2K	Nd-THG (2MW, 30ns)	Thr=0.02J/cm ²	207)
#M275 Lachs.					
Glycerin		540nm (BB)	Ruby-SH		2)

Table XVI (continued).

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
#M276 Fluorol 7GA; FBA 75; Fluorol 555; Green 10.					
Methanol +HCl+COT	0.1g/l (pH=6)	530—608nm (Grating)	F1 (22J)	15mJ	206)
Water+HCl +COT+Ammonyx Lo	0.13g/l				
Methanol +Coumarin 6+COT (SA:DQOC) without SA	0.6mg/l	535—590nm (Etalon)	F1 (260J)	50mJ (5ps) (Mode-locked) 150mJ (1μs)	205)
Methanol	0.1mM	542—592nm (Grating)	F1 (150nsRT, 1Hz)		87)

導体は、レーザー材料の中で最も系統的かつ広範に開発され、そのレーザー発振特性がテストされている。その数は約100種（#M277- #M374）にもおよぶ。構造的に見れば、7-位置の置換基がその特性に大きな影響を与えるので、一覧表では7-位置置換基の種類によって分類配列した。

7-位置が水酸基である 7-Hydroxycoumarin は別名 Umbelliferone とよばれ (Fig. 5 (b) 参照), この種の誘導体は独特の性質を持っている。たとえば 4-MU (#M281) には酸性溶液中で 490 nm 付近を極大とする新しい蛍光帯が生じる。これは最初 H^+ との exciplex 状態によるものとされたが、その後の研究では pH の綿密な調節によって、5種類もの異なった状態が同定されていて、それらの蛍光帯を利用して、370~600nm の非常に広い波長域で増幅利得が得られている^{215,241)}。また #M291 や #M292 のような methyleneiminodiacetic 酸では、pH の他に溶かし込んだ金属イオンの種類によっても発振波長が制御できる。^{154, 219)}

Coumarin 誘導体の発振波長は置換基によって多少変化する。その結果、たとえば #M311, #M330, #M337, #M334 という組合せで、420-580nm が効率良くカバーできる。Coumarin

系化合物のレーザー効率は良好で、Xanthene 色素に匹敵する。特に短パルス励起に対してだけでなく、立上りの遅いフラッシュランプや CW 励起でも良い効率が得られている。CW 発振のしきい値は低い、比較的長波長のものを除けば、可視部ではなく UV イオンレーザーの励起が必要である。Coumarin 系化合物の一般的な欠点として、耐久性に乏しく劣化が速いことがあげられる。フラッシュランプに対する耐光性を高めるためにメチル置換基の水素をフッ素化した化合物も開発されている²¹⁷⁾。

Fig. 5 (c) に示した Azacoumarin の誘導体は同一構造の Coumarin にくらべ発振波長が多少短くなる。

なおこの他、コダック社のカタログにレーザー材料として Coumarin 138, Coumarin 338, Coumarin 339 が載せられているが、レーザー発振した記録が見出せなかったため表には含めなかった。

Fig. 5. Structures of (a) coumarin, (b) umbelliferone, and (c) azacoumarin.

Table XVII-1. Laser characteristics of Coumarin and Azacoumarin derivatives. Their chemical structures are given in Table XVII-2.

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
#M277 6-Acetyl-5-hydroxy-4-methylcoumarin.					
Ethanol+KOH		490nm (BB)	Ruby-SH (2MW, 40ns)	Thr=22mJ	213)
#M278 7-Hydroxycoumarin ; Umbelliferone.					
Water	1mM	457nm (BB)	F1 (1 μ F, 20kV, 700nsRT)		208)
Water (basic)	1mM	458nm (BB)	F1 (9J, 80nsRT)	Thr=1.9J	1)
Alcohol	40mg/l	405—429nm (BB) 450—471nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)
#M279 3-Cyanoumbelliferone.					
Ethanol+Water (7:3)		490—520nm (Grating)	F1 (85J)	5mJ	211)
#M280 3-Ethoxycarbonylumbelliferone ; Coumarin 15.					
Water		465nm (BB)	F1 (30J)	Thr=19J	165)
Ethanol+KOH		458nm (BB)	Ruby-SH (2MW, 40ns)	Thr=3.5mJ	213)
Ethanol		443nm (BB)			
PMMA (thin film)	240mM		N ₂ (140kW)	Gain=10cm ⁻¹ (ASE)	212)
Ethanol		410nm (Grating)	N ₂ (70kW)		211)
#M281 4-Methylumbelliferone ; 4-MU ; Coumarin 4.					
Water (pH>9)	4mM	454nm (BB)	F1 (100J)	10mJ (300ns)	214)
Ethanol+Water (6:4)		437—544nm (Grating)	N ₂ (100kW, 100Hz)		215)
Ethanol+HCl (1/400, 0.1M)		385—457nm (Grating)			
+HCl (1/30, 0.1M)		391—567nm (Grating)			
+HCl (1/10, 1M)		459—574nm (Grating)		48kW	
Water	1mM	430—485nm (Grating)	Ruby-SH (5MW, 15ns)	100kW	79)
Ethanol (acid)	18mM	477—546nm (Grating+Prism)	N ₂ (130kW)	5.7kW	13)
Water+NaOH	2mM	435—480nm (Prism)	Ar (351, 364nm, 3.3W)	Thr=482mW	216)
EG+Benzyl alcohol (9:1)	~3mM	440—480nm (BF filter)	Ar (351, 364nm, 1.5W)		35)
#M282 4-Trifluoromethylumbelliferone ; C7F.					
Ethanol +Water (1:1)	0.75mM	506nm (BB)	F1 (5J)	0.6kW	217)
#M283 3-Cyano-4-methylumbelliferone.					
Ethanol	2mM	399—475nm (Tuned)	N ₂ (200kW)		210)
Ethanol	2mM	440—510nm	N ₂ (200kW)		
+16% Water					
Ethanol	0.1mM	450—500nm	F1 (85J)	15mJ	
+35% Water					
Water (base)	1mM	466—504nm (Tuned)	Ruby-SH (4.6MW)	60kW	211)
Ethanol	1mM	405—451nm	Ruby-SH (2.5MW)	37kW	
#M284 3-Phenyl-4-methylumbelliferone.					
Ethanol+KOH		475nm (BB)	Ruby-SH (2MW, 40ns)	Thr=6mJ	213)
Alcohol		400—423nm (BB) 442—460nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)

Table XVII-1. (continued).

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
#M285 3-iso-Propyl-4-methylumbelliferone.					
Alcohol		426—447nm (BB) 452—471nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)
#M286 3-Ethyl-4-methylumbelliferone.					
Water+KOH		458nm (BB)	Ruby-SH (2MW, 40ns)	Thr=4mJ	213)
Methanol		410nm (BB)			
Ethanol		425nm (BB)			
Ethanol+H ₂ SO ₄		493nm (BB)			
#M287 3-n-Buthyl-4-methylumbelliferone.					
PMMA (thin film)	240mM		N ₂ (140kW)	Gain=10cm ⁻¹ (ASE)	212)
#M288 3-Benzyl-4-methylumbelliferone.					
Ethanol or Water (base)		463.5—468 (BB)	F1 (0.5μF, 20kV, 750nsRT)		78)
Ethanol +NaOH	50mg/l		F1 (200J, 800nsRT)		74)
#M289 3, 4-Cyclopentenoumbelliferone.					
Water (pH=9)	2mM	blue (BB)	F1 (0.3μF, 1μs)		218)
#M290 4, 8-Dimethylumbelliferone ; 4, 8-Dimethyl-7-hydroxycoumarin.					
Ethanol (base)	50mg/l	455—505nm (Grating)	F1 (0.3μF, 25kV, 500nsRT)		99)
#M291 7-Hydroxycoumarin-8-methyleneiminodiacetic acid ; Umbelliferone-methyleneiminodiacetic acid.					
Water (pH=3.1)	5mM	459nm (BB)	N ₂ (25kW, 10ns)		154)
Water (pH=10)		469nm (BB)			
+Ca ²⁺ (pH=10.7)		470nm (BB)			
+Sr ²⁺ (pH=11)		471nm (BB)			
+Ba ²⁺ (pH=7.5)		473nm (BB)			
+Al ³⁺ (pH=3)		445nm (BB)			
Water	0.25mM	453—464nm (BB)	F1 (380nsRT)		
#M292 Calcein blue ; 4-Methylumbelliferone methyleneiminodiacetic acid.					
Ethanol +NaOH	100mg/l	459—464nm (BB)	F1 (200J, 0.5μsRT)		74)
Water (pH=9)	1mM	425—478nm (Grating)	N ₂ (700kW, 2.5ns)		219)
Water+Al ³⁺ (pH=5)	1mM	400—435nm (Grating)			
(pH=9)		415—445nm (Grating)			
(pH=11)		430—450nm (Grating)			
Water+Ba ²⁺ (pH=12)	1mM	435—478nm (Grating)			
Water+Sr ²⁺ (pH=5)		446nm (BB)	N ₂ (700kW, 2.5ns)		219)
+Ca ²⁺ (pH=5)		446nm (BB)			
#M293 6-Methoxy umbelliferone.					
Water (pH=9)	2mM	blue (BB)	F1 (0.3μF, 1μs)		218)
#M294 Esculin ; 6-Glucosyloxyumbelliferone.					
Water			F1 (50J, 400ns)		102)

Table XVII-1. (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
Water (base)	1mM	469nm (BB)	F1 (9J, 80nsRT)	Thr=1.3J	1)
Water		440—490nm (Prism) (Ring cavity, single axial mode)	F1 (60J)	4kW	101)
Methanol +NaOH	0.4mM	450—505nm (Grating)	F1 (86J)	310mJ (240ns)	100)
Ethanol	0.1mM	460nm (BB)	F1 (100J, 150nsRT) F1 (625J, 800nsRT)	300mJ 2.5J, E=0.4%	186)
Alcohol		423nm—441nm (BB) 460—478nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)
#M295 5, 7-Dihydroxy-4-methylcoumarin.					
Ethanol+KOH		474nm (BB)	Ruby-SH (2MW, 40ns)	Thr=10mJ	213)
#M296 6, 7-Dihydroxy-4-methylcoumarin.					
Ethanol+KOH		471nm (BB)	Ruby-SH (2MW, 40ns)	Thr=48mJ	213)
Methanol		403nm (BB)			
Ethanol+H ₂ SO ₄		455nm (BB)			
#M297 3-Biphenyl-7-methoxycoumarin.					
Benzene	1mM	437nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M298 N-[4-(7-Methoxy-2H-2-oxo-1-benzopyran-3-yl)phenyl]-trimethylammonium methylsulfate.					
Water	1mM	457nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M299 1-(7-Methoxy-2H-2-oxo-1-benzopyran-3-yl)-3-methyl-1H-1, 2, 3-triazolium methylsulfate.					
Water	1mM	450, 458nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M300 7-Methoxy-3-carbethoxycoumarin.					
Ethanol+KOH		459nm (BB)	Ruby-SH (2MW, 40ns)	Thr=13mJ	213)
Ethanol		422nm (BB)			
#M301 7-Acetoxy-4-methylcoumarin.					
Ethanol (base)	50mg/l	441—486nm (Grating)	F1 (0.3μF, 25kV, 500nsRT)		99)
Ethanol+KOH		457nm (BB)	Ruby-SH (2MW, 40ns)	Thr=6mJ	213)
Alcohol		400—420nm (BB) 440—465nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)
#M302 7-Acetoxy-3-phenylcoumarin.					
Ethanol+KOH		483nm (BB)	Ruby-SH (2MW, 40ns)	Thr=45mJ	213)
#M303 7-Acetoxy-5-allyl-4, 8-dimethylcoumarin.					
Ethanol (base)	50mg/l	458—515nm (Grating)	F1 (0.3μF, 25kV, 500nsRT)		99)
#M304 7-Acetoxy-4-methyl-3-(α-naphthyl) coumarin.					
Ethanol+KOH		463nm (BB)	Ruby-SH (2MW, 40ns)	Thr=7mJ	213)
#M305 7-Acetoxy-6-allyl-4, 8-dimethylcoumarin.					
Ethanol	150mg/l		F1 (200J, 800nsRT)		74)
#M306 7-Acetoxy-3-phenylcoumarin.					
Alcohol		470—494nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)
#M307 7-Acetoxy-4-aryl-3-phenylcoumarin.					
Alcohol		465—503nm (BB, Electric current)	N ₂ (200kW, 5ns, 50Hz)		209)

Table XVII-1. (continued).

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
#M308 7-Butyryloxy-4-methylcoumarin.					
Water+Acetonitrile (9:1) (pH=9)	1mM	Blue (BB)	F1 (0.3 μ F, 1 μ s)		218)
#M309 7-Aminocoumarin; C3H.					
Ethanol	0.75mM	450nm (BB)	F1 (5J)	1kW	222)
#M310 7-Amino-3-phenylcoumarin; Coumarin 10.					
Water+DPA(4:1)+COT	1mM	470—500nm (Prism)	Ar (35l, 364nm, 3.3W)	Thr=380mW	216)
#M311 7-Amino-4-methylcoumarin; Coumarin 120; Coumarin 440; Blue 1.					
Methanol		440nm (BB)	F1		83)
Water	1mM	420—470nm (Prism)	Ar (35l, 364nm, 3.3W)	Thr=608mW	216)
+DPA (4:1)+COT					
Ethanol	2.5mM	419—472nm (Grating)	N ₂ (270kW)	75kW	220)
EG+Benzyl Alcohol (9:1)	~3mM	424—477nm (BF filter)	Ar (35l, 364nm, 1.5W)	120mW	35)
Methanol	0.2mM	425—470nm (Grating)	F1 (73J)	150mJ (240ns)	100)
Ethanol	0.7mM	441nm (Grating)	YAG-TH (10.5MW, 8ns, 20Hz)	220mWav.	221)
Ethanol	8.7mM	440nm (BB, Short cavity)	Mode-locked Glass-TH (1mJ, 11ps, single pulse)	(13.8ps)	201)
		430nm (BB)	Glass-TH (1—3mJ, 6ps)	0.2mJ, E=10% (ps pulse)	93)
Ethanol	4mM	436nm (BB)	XeCl (60mJ, 35ns)	E=41.1%	95)
Ethanol	5mM	420—475nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	0.8mJ	97)
#M312 7-Amino-4-trifluoromethylcoumarin; Coumarin 151; Coumarin 490; C3F; Green 1.					
Ethanol	0.75mM	484nm (BB)	F1 (5J)	5.0kW	217)
Ethanol	0.75mM	496nm (BB)	F1 (5J)	5.5kW	
+Water (1:1)					
Ethanol		490nm (BB)	F1 (30J, 1 μ s)	Thr=16J	223)
Methanol	0.2mM	470—508nm (Prism)	F1 (60J)		224)
Methanol	0.1mM	477—515nm (Grating)	F1 (150nsRT, 1Hz)		87)
+Ammonyx LO					
#M313 7-Amino-4-methoxycoumarin.					
Ethanol		417nm (BB)	F1 (50J, 200nsRT)	Thr=30J	184)
#M314 7-Amino-3-ethyl-4-methylcoumarin.					
Ethanol		438nm (BB)	Ruby-SH (2MW, 40ns)	Thr=7mJ	213)
#M315 7-Methylamino-4, 6-dimethylcoumarin; Coumarin 9.					
Ethanol		443nm (BB)	F1 (3.6 μ F, 10kV, 1.2 μ sRT)		225)
Ethanol (acid)		484nm (BB)			
Ethanol	1mM	420—480nm (Grating)	N ₂ (90kW, 10ns)	5kW (2—7ns)	226)
Ethanol+HCl	1.5mM	435—525nm (Grating)			
Water	1mM	450—480nm (Etalon)	F1 (15Hz, 450Wav., 1.5 μ sRT)	288mWav.	90)
+Ethanol (2:1)					
#M316 4-Methyl-7-sulfomethylaminocoumarin sodium salt; Coumarin 175.					
Water		457nm (BB)	F1 (30J)	Thr=14J	165)

Table XVII-1. (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Laser wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
#M317 3-Phenyl-7-sulfomethylaminocoumarin sodium salt; Coumarin 316.					
Water		494nm (BB)	F1 (30J)	Thr=16J	165)
#M318 7-(2-Hydroxyethylamino)-4-methylcoumarin; Coumarin 360.					
Water		470nm (BB)	F1 (30J)	Thr=14J	165)
#M319 7-Ethylamino-4-trifluoromethylcoumarin; Coumarin 500.					
Ethanol		500nm (BB)	N ₂		152)
Ethanol	1mM	500nm (BB)	KrF (0.2J, 20ns)	E=18%	120)
Ethanol	5mM	485—530nm (Grating)	YAG-TH (6—8mJ, 8ns)		94)
Ethanol	10mM	473—547nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	1.2mJ	97)
		483—570nm (Grating) (Osc+Amp)	YAG-TH	E=20%	98)
Methanol+Water		490—560nm (Grating)	F1 (10Hz)	0.3Wav. (1.4μs)	126)
#M320 7-Ethylamino-4, 6-dimethylcoumarin; Coumarin 2; Coumarin 450; Blue 2.					
Ethanol		446nm (BB)	F1 (3.6μF, 10kV, 1.2μsRT)		225)
Ethanol (acid)		487nm (BB)			
Water	2mM	430—480nm (Prism)	Ar (35l, 364nm, 3.3W)	Thr=269mW	216)
+DPA (4:1)					
EG+Benzyl alcohol (9:1)	~3mM	430—492nm (BF filter)	Ar (35l, 364nm, 1.8W)	168mW	35)
Methanol	0.2mM	430—485nm (Grating)	F1 (86J)	270mJ (240ns)	100)
Methanol	0.5mM	450nm (BB)	F1 (484J)	5J, E=1%	
Methanol	0.7mM	454nm (Grating)	YAG-TH (10.5MW, 8ns, 20Hz)	330mWav.	221)
Ethanol	1mM	435—463nm (Grating)	YAG-TH (6—8mJ, 8ns)		94)
EG	0.59g/l	438—480nm (BF filter)	Ar or Kr (UV All lines, 2W)	320mW, E=15%	86)
		432—480nm (Single axial mode)		36mW	
Ethanol	10mM	428—465nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	0.85mJ	97)
Ethanol	5mM	427—480nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=15%	26)
#M321 7-Ethylamino-6-methyl-4-trifluoromethylcoumarin; Coumarin 307; Coumarin 503; Green 3.					
Ethanol		502nm (BB)	F1 (30J, 1μs)	Thr=12J	223)
PMMA (thin film)	240mM	500nm (BB) 476.5nm (DFB)	N ₂ (140kW)	Gain=50cm ⁻¹ (ASE)	212)
Ethanol	7mM	476—542nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=14.2%	26)
Ethanol	5mM	473—547nm (Grating+) (Osc+Amp)	N ₂ (1.5MW, 4ns)		
Methanol + Ammonyx LO	0.1mM	481—540nm (Grating)	F1 (150nsRT, 1Hz)		87)
#M322 4-Methyl-7-(3-sulfopropyl) aminocoumarin sodium salt; Coumarin 378.					
Water		468nm (BB)	F1 (30J)	Thr=11J	165)
#M323 4-Methyl-7-(4-sulfobutyl) aminocoumarin sodium salt; Coumarin 380.					
Water		470nm (BB)	F1 (30J)	Thr=11J	165)
#M324 7-Dimethylaminocoumarin; C2H.					
Ethanol	0.75mM	465nm (BB)	F1 (5J)	7.5kW	222)
#M325 7-Dimethylamino-3-ethoxycarbonylcoumarin; Coumarin 14.					
Ethanol			F1 (30J, 1μs)		223)

Table XVII-1. (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
Ethanol	0.2mM	(prism)	F1 (750J)	3.8J, E=0.5%	125)
#M326 7-Dimethylamino-4-methylcoumarin ; Coumarin 311.					
Ethanol		453nm (BB)	F1 (50J, 200nsRT)	Thr=12J	184)
PMMA (thin film)		(BB)	N ₂ (140kW)	Gain=13cm ⁻¹ (ASE)	212)
#M327 7-Dimethylamino-4-trifluoromethylcoumarin ; Coumarin 152 ; Coumarin 485 ; C2F ; Green 6.					
Ethanol	0.75mM	519nm (BB)	F1 (5J)	2.0kW	217)
Dioxane	0.75mM	479nm (BB)	F1 (5J)	6.1kW	
Ethanol		520nm (BB)	F1 (30J, 1μs)	Thr=30J	223)
Ethanol	1.3—10mM	520nm (Grating+Etalon)	YAG-TH (120mJ, 5—6ns, 10Hz)	16mJ, E=19%	227)
Ethanol	10mM	490—562nm (Grating) (Osc+Amp)	N ₂ (1MW, 50Hz, 10ns)	1mJ	97)
		503—570nm (Grating) (Osc+Amp)	YAG-TH	E=16%	98)
Ethanol	7.7mA	490—570nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=5.5%	26)
#M328 7-Diethylamino-4-hydroxy-3-methylcoumarin.					
Ethanol		429—442nm (BB)	Nd-THG		228)
Water+1N HCl		451—466nm (BB)			
#M329 7-Diethylaminocoumarin ; LD 466 ; ClH ; Blue 4.					
Ethanol	0.75mM	466nm (BB)	F1 (5J)	8.0kW	222)
Ethanol	1mM	450—485nm (Grating)	YAG-TH (6—8mJ, 8ns)		94)
Methanol +Ammonyx LO	0.08mM	462—490nm (Grating)	F1 (150nsRT, 1Hz)		87)
#M330 7-Diethylamino-4-methylcoumarin ; DAMC ; 7D4MC ; Coumarin 1 ; Coumarin 460 ; Blue 3.					
Ethanol		460nm (BB)	F1		229)
Ethanol		460.7nm (Grating)	F1	300kW	230)
Ethanol	0.1mM	460nm (BB)	F1 (3.6μF, 20kV)	(Active mode-locking)	231)
		445—490nm (Grating)	N ₂ (120kW, 10ns, 100Hz)	E=27%	130)
Ethanol	1—10mM	438.5—482nm (BB, Concentration)	N ₂ (20—40kW)	E=20%	232)
Ethanol	2mM	445—475nm (Grating)	Ruby-SH (5MW, 15ns)	7kW	79)
	0.25mM	(BB)	F1 (600J, 400nsRT)	4.18J (600ns), E=0.7%	233)
EG+Benzyl alcohol (9:1)	~3mM	445—505nm (BF filter)	Ar (35l, 364nm, 1.35W)	166mW	35)
Ethanol	0.7mM	457nm (Grating)	YAG-TH (10.5MW, 8ns, 20Hz)	380mWav., E=22%	221)
Ethanol	7.1—59mM	450—465nm (Short cavity)	Mode-locked Glass-TH (11ps, 1mJ, single pulse)	40μJ, 13.8ps	201)
Ethanol	0.15—3mM	456—463nm (BF filter)	Xe (365nm, 5kW, 200ns, 10Hz)	1kW, E=20% (120ns)	195)
Ethanol	5mM	440—475nm (Grating)	YAG-TH (6—8mJ, 8ns)		94)
Ethanol	4mM	456nm (BB)	XeCl (60mJ, 35ns)	E=35.4%	95)
EG	1.8g/l	450—500nm (BF filter)	Ar or Kr (UV All lines, 2.5W)	370mW, E=15%	86)
		450—500nm (Single axial mode)	Ar or Kr (UV All lines, 2W)	32mW	
Ethanol	10mM	440—478nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	1mJ	97)
		443—490nm (Grating) (Osc+Amp)	YAG-TH	E=12%	98)

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>O</i>	<i>Output</i>	<i>Ref.</i>
#M331 7-Diethylamino-3-ethyl-4-methylcoumarin.						
Ethanol		463nm (BB)	Ruby-SH (2MW, 40ns)		Thr=2mJ	213)
#M332 2-(7-Diethylamino-2H-2-oxo-1-benzopyran-3-yl)-1, 3-dimethylbenzimidazolium chloride.						
Methanol	Satur.	508nm (BB)	N ₂ (1MW, 2.5ns)			155)
#M333 7-Diethylamino-4-trifluoromethylcoumarin; Coumarin 35; Coumarin 481; Pilot 481; C1F; Blue 7.						
Dioxane	0.75mM	481nm (BB)	F1 (5J, 20Hz)		3.8kW	234)
Dioxane	0.7mM	489nm (Grating)	YAG-TH (10.5MW, 8ns, 20Hz)		390mWav., E=23%	221)
Dioxane	5mM	465—510nm (Grating)	YAG-TH (6—8mJ, 8ns)			94)
Dioxane	10mM	465—516nm (Grating)	N ₂			236)
Ethanol	10mM	492—545nm (Grating)				
Dioxane	10mM	480—541nm (Grating)				
+Ethanol (2:1)						
Dioxane	3.6mM	481nm (BB)	KrF (160mJ, 0.2Wav.)		11.4mJ (10—12ns)	190)
or cyclohexane						
Dioxane	10mM	460—517nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)		1.2mJ	97)
Dioxane	0.15mM	475—490nm (Grating)	F1 (150nsRT, 1Hz)			87)
#M334 3-(2-Benzothiazolyl)-7-diethylaminocoumarin; Coumarin 6, Green 8.						
Methanol		540nm (BB)	F1			83)
Water	0.3mM	515—585nm (Prism)	Ar (488nm, 1.5W)		220mW, Thr=174mW	216)
+DPA (4:1)+Ammonyx LO+COT						
Benzyl alcohol	~3mM	516—567nm (BF filter)	Ar (488nm, 2.3W)		196mW	35)
Ethanol	0.1mM	540nm (BB)	F1 (100J, 150nsRT)		60mJ	186)
Methanol	0.2mM	520—560nm (Grating)	F1 (73J)		170mJ (240ns)	100)
Ethanol	10mM	507—529nm (Grating)	N ₂ ⁺ (478nm, 1mJ, 250kW, 10Hz)			235)
Ethanol	Satur.	528nm (BB)	XeCl (60mJ, 35ns)		E=20.4%	95)
		515—575nm (BF filter+Etalon) (Ring cavity, single axial mode)	Ar (6W, 488nm)		490mW	84)
Benzyl alcohol	0.68g/l	520—580nm (BF filter)	Ar (488nm, 3W)		370mW, E=13%	86)
+Glycerin (4:1)		520—570nm (Single axial mode)			90mW	
#M335 3-(5-Chloro-2-benzothiazolyl)-7-diethylaminocoumarin; Coumarin 34.						
Ethanol		540nm (BB)	F1		Thr=10.2J	143)
#M336 3-(2-Benzimidazolyl)-7-diethylaminocoumarin; Coumarin 7.						
Water	0.4mM	500—575nm (Prism)	Ar (477nm, 800mW)		80mW, Thr=148mW	216)
+DPA (4:1)+Ammonyx LO+COT						
Benzyl alcohol	~3mM	495—567nm (BF filter)	Ar (477nm, 1.2W)		117mW	35)
Ethanol		524nm (BB)	F1		Thr=9.9J	143)
#M337 7-Diethylamino-3-(1-methyl-2-benzimidazolyl)coumarin; Coumarin 30; Coumarin 515.						
Methanol		510nm (BB)	F1			83)
Water	1mM	495—515nm (Prism)	Ar (458nm, 370mW)		Thr=443mW	216)
+DPA (4:1)+COT						
Benzyl alcohol	~3mM	492—550nm (BF filter)	Ar (458nm, 0.8W)			35)

Table XVII-1. (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
Methanol	0.2mM	480—525nm (Grating)	F1 (73J)	100mJ (240ns)	100)
Ethanol	10mM	482—507nm (Grating)	N ₂ ⁺ (428nm, 1mJ, 250kW, 10Hz)		235)
EG	0.24g/l	480—545nm (BF filter) 480—540 nm (Single axial mode)	Kr (All violet lines, 2.5W)	290mW, E=13% 40mW	86)
#M338 4-Methyl-7-[N-methyl-N-(4-sulfobutyl)amino] coumarin sodium salt ; Coumarin 306.					
Water		478nm (BB)	F1 (30J)	Thr=43J	165)
#M339 4-Methyl-7-bis(3-sulfopropyl) aminocoumarin disodium salt ; Coumarin 379.					
Water		473nm (BB)	F1 (30J)	Thr=15J	165)
#M340 7-Bis(4-sulfobutyl)amino-4-methylcoumarin disodium salt ; Coumarin 381.					
Water		478nm (BB)	F1 (30J)	Thr=25J	165)
#M341 7-(3-Chloro-5-diethylamino-triazin-2-yl)amino-3-phenylcoumarin.					
Methanol	1mM	446nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M342 Piperidino [3, 2-g]coumarin ; C4H.					
Ethanol	0.75mM	477nm (BB)	F1 (5J)	5.0 kW	222)
#M343 N-Methylpiperidino[3, 2-g]coumarin ; C8H.					
Ethanol	0.75mM	475nm (BB)	F1 (5J)	7kW	222)
#M344 4-Trifluoromethyl-piperidino[3, 2-g] coumarin ; Coumarin 340 ; C4F.					
Ethanol	0.75mM	522nm (BB)	F1 (5J)	6.2kW	217)
Ethanol		513nm (BB)	F1 (30J, 1μs)	Thr=12J	223)
#M345 N-Methyl-4-trifluoromethyl-piperidino[3, 2-g] coumarin ; Coumarin 522 ; C8F ; Green 7.					
Ethanol	0.75mM	522nm (BB)	F1 (5J)	7.8kW	217)
Ethanol	5mM	505—550nm (Grating)	YAG-TH (6—8mJ, 8ns)		94)
Methanol	0.2mM	501—568nm (Grating)	F1 (150nsRT, 1Hz)		87)
+ Ammonyx LO					
#M346 N-Ethyl-4-trifluoromethyl-piperidino[3, 2-g] coumarin ; Coumarin 355.					
Ethanol		522nm (BB)	F1 (30J, 1μs)	Thr=11J	223)
#M347 4-Methyl-N-(3-sulfopropyl)-piperidino[3, 2-g] coumarin sodium salt ; Coumarin 386.					
Water		486nm (BB)	F1 (30J)	Thr=10J	165)
#M348 4-Methyl-N-(4-sulfobutyl)-piperidino[3, 2-g] coumarin sodium salt ; Coumarin 388.					
Water		489nm (BB)	F1 (30J)	Thr=10J	165)
#M349 4-Trifluoromethyl-piperidino[2, 3-h] coumarin ; C5F.					
Ethanol	0.75mM	521nm (BB)	F1 (5J)	1.3kW	217)
#M350 N-Methyl-4-trifluoromethyl-piperidino[2, 3-h] coumarin ; C9F.					
Ethanol	0.75mM	537nm (BB)	F1 (5J)	6.8kW	217)
#M351 1, 2, 4, 5-3H, 6H, 10H-Tetrahydro[1]benzopyrano[9, 9a, 1-g] quinolizin-10-one ; C6H ; LD 490 ; Green 2.					
Ethanol	0.75mM	490nm (BB)	F1 (5J)	7kW	222)
Methanol	0.2mM	459—525nm (Prism)	F1 (80J) Cavity dumping	350mJ (300ns) 300mJ (20ns)	224)
Methanol+Water		470—500nm (Grating)	F1 (10Hz)	0.8Wav., (1.4μs)	126)

Table XVII-1. (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
Methanol +Ammonyx LO	0.1mM	465—529nm (Grating)	F1 (150nsRT, 1Hz)		87)
#M352 2, 3, 5, 6-1H, 4H-Tetrahydro-8-methylquinolazino[9, 9a, 1-gh] coumarin ; Coumarin 102 ; Coumarin 480 ; Blue 6.					
Methanol		480nm (BB)	F1		83)
HFIP		510nm (BB)			
Water +DPA (4:1)	2mM	465—500nm (Prism)	Ar (351, 364nm, 3.3W)	Thr=323mW	216)
Ethanol	0.75mM	480nm (BB)	F1 (5J)	4.1kW	234)
EG+Benzyl alcohol (9:1)	~3mM	460—522nm (BF filter)	Ar (351, 364nm, 1.5W)	106mW	35)
Methanol	0.7mM	485nm (Grating)	YAG-TH (10.5MW, 8ns, 20Hz)	270mWav.	221)
Ethanol		480nm (BB)	F1 (30J, 1 μ s)	Thr=12J	223)
Methanol	0.2mM	460—525nm (Grating)	F1 (86J)	400mJ (240ns)	100)
Ethanol	10mM	453—510nm (Grating)	N ₂ ⁺ (428nm, 1mJ, 250kW, 10Hz)		235)
		470nm (BB)	Mode-locked Glass-TH (1—3mJ, 6ps, single pulse)	0.3mJ, E=15% (12ps)	93)
Methanol (SA: DOC)	0.22mM	475—490nm (Etalon)	F1	Mode-locked (10ps)	237)
Ethanol	4mM	474.5nm (BB)	XeCl (60mJ, 35ns)	E=39.8%	95)
Ethanol	10mM	453—495nm (Grating) (Osc+Amp)	N ₂ (1MW, 10ns, 50Hz)	0.9mJ	97)
		460—510nm (Grating) (Osc+Amp)	YAG-TH	E=13%	98)
Ethanol	6mM	456—503nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=18.5%	26)
#M353 2, 3, 5, 6-1H, 4H-Tetrahydro-8-trifluoromethylquinolizino[9, 9a, 1-gh] coumarin ; Coumarin 153 ; Coumarin 540A ; Pilot 495 ; C6F ; Green 9.					
Ethanol		543nm (BB)	F1	Thr=12.6J	143)
Ethanol	0.75mM	538nm (BB)	F1 (5J)	6kW	217)
Dioxane	10mM	507nm (Grating)	N ₂		236)
Ethanol		519—575nm (Grating+Etalon) (single axial mode)	N ₂ (50kW, 3ns, 30Hz)	8kW	238)
Ethanol	4mM	513—580nm (Grating) (Osc+Amp)	XeCl (150mJ, 10—20ns)	E=8.4%	26)
Ethanol	5mM	516—592nm (Grating) (Osc+Amp)	N ₂ (1.5MW, 4ns)		
Methanol	0.1mM	520—586nm (Grating)	F1 (150nsRT, 1Hz)		87)
#M354 2, 3, 6, 7, 10, 11-Hexahydro-1H, 5H, 9H-quinolizine[1, 9-gh] cyclopenta[c] coumarin ; Coumarin 106 ; Coumarin 478.					
Ethanol		478nm (BB)	F1 (30J, 1 μ s)	Thr=13J	223)
#M355 9-Acetyl-1, 2, 4, 5-3H, 6H, 10H-tetrahydro-1-benzopyrano[9, 9a, 1-gh]quinolizin-10-one ; Coumarin 334 ; Coumarin 521.					
Ethanol		521nm (BB)	F1 (30J, 1 μ s)	Thr=12J	223)
#M356 9-Cyano-1, 2, 4, 5-3H, 6H, 10H-tetrahydro-1-benzopyrano[9, 9a, 1-gh]quinolizin-10-one ; Coumarin 337 ; Coumarin 523.					
Ethanol		522nm (BB)	F1 (30J, 1 μ s)	Thr=12J	223)
#M357 9-Carboxy-1, 2, 4, 5-3H, 6H, 10H-tetrahydro-1-benzopyrano[9, 9a, 1-gh] quinolizin-10-one ; Coumarin 343 ; Coumarin 519 ; Green 5.					
Ethanol		519nm (BB)	F1 (30J, 1 μ s)	Thr=12J	223)

Table XVII-1. (continued).

<i>Solvent</i>	<i>Concentration</i>	<i>Lasing wavelength (tuning)</i>	<i>Excitation</i>	<i>Output</i>	<i>Ref.</i>
Water		518nm (BB)	F1 (30J)	Thr=8J	165)
Methanol	0.2mM	490—513nm (Grating)	F1 (150nsRT)		87)
#M358 1, 2, 4, 5-3H, 6H, 10H-Tetrahydro-9-carbethoxy-1-benzopyrano[9, 9a, 1-gh] quinolizin-10-one; Coumarin 314; Coumarin 504; Green 4.					
Ethanol		506nm (BB)	F1	Thr=10.9J	143)
Ethanol		504nm (BB)	F1 (30J, 1 μ s)	Thr=8J	223)
Glycerin+Water	0.25mM	520nm (Etalon)	F1 (500J)	3mJ (10ps)	239)
+Coumarin 6 (SA: PIC)				(Mode-locked)	
Methanol	0.1mM	484-537nm (Grating)	F1 (150nsRT, 1Hz)		87)
+Ammonyx LO					
Methanol+Water		489—520nm (Grating)	F1 (10Hz)	0.95Wav. (1.4 μ s)	126)
#M359 (1, 2, 4, 5-3H, 6H, 10H-Tetrahydro-10-oxo-[1]benzopyrano[9, 9a, 1-gh]quinolizin-8-yl)acetic acid; Coumarin 217.					
Water		514nm (BB)	F1 (30J)	Thr=9J	165)
#M360 3-Phenyl-7-(4-phenylpyrazol-1-yl) coumarin.					
Benzene	1mM	434nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M361 7-(4-Methyl-5-phenyl-2H-1, 2, 3-triazol-2-yl)-3-phenylcoumarin.					
Benzene	1mM	434nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M362 7-(4-Ethyl-5-methyl-2H-1, 2, 3-triazol-2-yl)-3-(1H-1, 2, 4-triazol-1-yl) coumarin.					
Benzene	1mM	414nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M363 7-(4-Methyl-5-phenyl-2H-1, 2, 3-triazol-2-yl)-3-(1H-1, 2, 4-triazol-1-yl) coumarin.					
Benzene	1mM	426nm (BB)	N ₂ (1MW, 2.5ns)		155)
Dichloromethane	1mM	430nm (BB)			
#M364 3-p-Tolyl-7-(1H-1, 2, 3-triazol-1-yl) coumarin.					
Benzene	1mM	421nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M365 3-p-Tolyl-7-(1H-1, 2, 4-triazol-1-yl) coumarin.					
Benzene	1mM	423nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M366 7-(3,5-Dimethyl-1H-1, 2, 4-triazol-1-yl)-3-(p-methoxyphenyl) coumarin.					
Benzene	1mM	438nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M367 1-[7-(4-Chloro-3-methyl-pyrazol-1-yl)-2H-2-oxo-1-benzopyran-3-yl]-4-methyl-1, 2, 4-triazolium methylsulfate.					
Methanol	1mM	458nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M368 5-n-Butoxy-6-methyl-2-[3-(4-chloropyrazol-1-yl)-2H-2-oxo-1-benzopyran-7-yl]benzotriazolium inner salt.					
Benzene	1mM	439nm	N ₂ (1MW, 2.5ns)		155)
#M369 3-[7-(5-Ethyl-4-methyl-2H-1, 2, 3-triazol-2-yl)-2H-2-oxo-1-benzopyran-3-yl]-1-methyl-3H-1, 3, 4-triazolium methylsulfate.					
Water	1mM	467nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M370 3-Methyl-1-(3-tolyl-2H-2-oxo-1-benzopyran-7-yl)-1H-1, 2, 3-triazolium methylsulfate.					
Methanol	1mM	502nm (BB)	N ₂ (1MW, 2.5ns)		155)
#M371 Coumarian 24.					
Methanol		510nm (BB)	F1		60)
#M372 Coumarin 445.					
Ethanol		445nm (BB)	F1		152)
EG		435—484nm	Ar (CW)		

Table XVII-1. (continued).

Solvent	Concentration	Lasing wavelength (tuning)	Excitation	Output	Ref.
Methanol+Water		420—460nm (Grating)	F1 (10Hz)	0.5Wav. (1.4 μ s)	126)
#M373 Coumarin 527.					
Ethanol		527nm (BB)	N ₂		152)
#M374 Coumarin 531.					
Ethanol		531nm (BB)	N ₂		152)
#M375 7-Hydroxy-4-methyl-8-azacoumarin.					
Ethanol		431nm (BB)	F1 (50J, 200nsRT)	Thr=18J	184)
#M376 7-Amino-3, 4-dimethyl-8-azacoumarin.					
Ethanol	5mM	(BB)	N ₂ (10ns, 20kW, 10Hz)		184)
#M377 7-Dimethylamino-4-methyl-8-azacoumarin.					
Ethanol		434nm (BB)	F1 (50J, 200nsRT) F1 (70J, 400—600nsRT)	Thr=20J Thr=65J	184)
#M378 7-Morpholino-4-methyl-8-azacoumarin ; LD 425 ; Violet 3.					
Ethanol		431nm (BB)	F1 (50J, 200nsRT)	Thr=18J	184)
Methanol	0.2mM	419—440nm (Grating)	F1 (150nsRT, 1Hz)		87)
Dioxane	7.5mM	404—425nm	N ₂		152)
Ethanol	3mM	408—448nm			
#M379 8-Aza- 4-trifluoromethyl (1, 4-dimethylpiperidino)[3, 2-g] coumarin ; AC2F.					
Ethanol	0.75mM	490nm (BB)	F1 (5J)	9.0kW	222)
#M380 8-Aza- 4-trifluoromethyl (1, 2, 4-trimethylpiperidino)[3, 2-g] coumarin ; AC3F ; Green 2.5.					
Methanol	0.2mM	465—511nm (Prism)	F1 (80J)		224)
Methanol	0.08mM	471—525nm (Grating)	F1 (150nsRT, 1Hz)		87)
+Ammonyx LO					

Table XVII-2. Chemical structures of Coumarin and Azacoumarin derivatives.
The numbers (1)—(19) are shown in Table XVII-3.

Dye No.	R ₃	R ₄	R ₅	R ₆	R ₇	R ₈
#M277	H	Me	OH	CH ₃ CO	H	H
#M278	H	H	H	H	OH	H
#M279	CN	H	H	H	OH	H
#M280	C ₂ H ₅ COO	H	H	H	OH	H
#M281	H	Me	H	H	OH	H
#M282	H	CF ₃	H	H	OH	H
#M283	CN	Me	H	H	OH	H
#M284	Ph	Me	H	H	OH	H
#M285	iso-propyl	Me	H	H	OH	H
#M286	Et	Me	H	H	OH	H
#M287	n-C ₄ H ₉	Me	H	H	OH	H

Table XVII-2 (continued).

#M288	CH ₂ -Ph	Me	H	H	OH	H
#M290	H	Me	H	H	OH	Me
#M291	H	H	H	H	OH	(1)
#M292	H	Me	H	H	OH	(1)
#M293	H	H	H	CH ₃ O	OH	H
#M294	H	H	H	(2)	OH	H
#M295	H	Me	OH	H	OH	H
#M296	H	Me	H	OH	OH	H
#M297	biphenyl	H	H	H	OMe	H
#M298	(3)	H	H	H	OMe	H
#M299	(4)	H	H	H	OMe	H
#M300	C ₂ H ₅ COO	H	H	H	OMe	H
#M301	H	Me	H	H	OCOMe	H
#M302	Ph	H	H	H	OCOMe	H
#M303	H	Me	allyl	H	OCOMe	Me
#M304	(5)	Me	H	H	OCOMe	H
#M305	H	Me	H	allyl	OCOMe	Me
#M306	Ph	H	H	H	OCOMe	H
#M307	Ph	amyl	H	H	OCOMe	H
#M315	H	Me	H	Me	NHMe	H
#M320	H	Me	H	Me	NHEt	H
#M321	H	CF ₃	H	Me	NHEt	H

Table XVII-2 (continued).

Dye No.	X	R ₃	R ₄	#M325	NMe ₂	C ₂ H ₅ COO	H
#M308	(6)	H	Me	#M326	NMe ₂	H	Me ₂
#M309	NH ₂	H	H	#M327	NMe ₂	H	CF ₃
#M310	NH ₂	Ph	H	#M328	NMe ₂	Me	OH
#M311	NH ₂	H	Me	#M329	NEt ₂	H	H
#M312	NH ₂	H	CF ₃	#M330	NEt ₂	H	Me
#M313	NH ₂	H	OMe	#M331	NEt ₂	Et	Me
#M314	NH ₂	Et	Me	#M332	NEt ₂	(7)	H
#M316	NHCH ₂ SO ₃ Na	H	Me	#M333	NEt ₂	H	CF ₃
#M317	NHCH ₂ SO ₃ Na	Ph	H	#M334	NEt ₂	(8)	H
#M318	NHCH ₂ CH ₂ OH	H	Me	#M335	NEt ₂	(9)	H
#M319	NHEt	H	CF ₃	#M336	NEt ₂	(10)	H
#M322	NH(CH ₂) ₃ SO ₃ Na	H	Me	#M337	NEt ₂	(11)	H
#M323	NH(CH ₂) ₃ SO ₃ Na	H	Me	#M338	NMe(CH ₂) ₃ SO ₃ Na	H	Me
#M324	NMe ₂	H	H	#M339	N[(CH ₂) ₃ SO ₃ Na] ₂	H	Me

Table XVII-2 (continued).

Dye No.	X	R ₃	R ₄	#M358	—	C ₂ H ₅ COO	H
#M340	N[(CH ₂) ₄ SO ₃ Na] ₂	H	Me	#M359	—	CH ₃ COOH	H
#M341	(12)	Ph	H	#M360	(13)-Ph	Ph	H
#M342	H	H	H	#M361	(14)-PhMe	Ph	H
#M343	Me	H	H	#M362	(14)-MeEt	(15)	H
#M344	H	H	CF ₃	#M363	(14)-PhMe	(15)	H
#M345	Me	H	CF ₃	#M364	(16)	<i>p</i> -tolyl	H
#M346	Et	H	CF ₃	#M365	(15)	<i>p</i> -tolyl	H
#M347	(CH ₂) ₅ SO ₃ Na	H	Me	#M366	(15)-Me ₂	Ph-OCH ₃	H
#M348	(CH ₂) ₄ SO ₃ Na	H	Me	#M367	(13)-MeCl	(17)	H
#M349	H	H	CF ₃	#M368	(18)	(13)-Cl	H
#M350	Me	H	CF ₃	#M369	(14)-MeEt	(17)	H
#M351	—	H	H	#M370	(17)	<i>p</i> -tolyl	H
#M352	—	H	Me	#M375	OH	H	Me
#M353	—	H	CF ₃	#M376	NH ₂	Me	Me
#M355	—	COMe	H	#M377	NMe ₂	H	Me
#M356	—	CN	H	#M378	(19)	H	Me
#M357	—	COOH	H				

Table XVI-3. Abbreviations used in Table XVII-2.

(1) $-\text{CH}_2\text{N} \begin{matrix} \text{CH}_2\text{COOH} \\ \text{CH}_2\text{COOH} \end{matrix}$	(5)	(9)	(13)	(17)
(2)	(6) $-\text{CO}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3$	(10)	(14)	(18)
(3)	(7)	(11)	(15)	(19)
(4)	(8)	(12)	(16)	<i>iso</i> -propyl $-\text{CH}_2-\text{CH}_3$ allyl $-\text{CH}_2-\text{CH}=\text{CH}_2$ amyl $-\text{CH}_2-(\text{CH}_2)_3-\text{CH}_3$ <i>p</i> -tolyl $-\text{C}_6\text{H}_4-\text{Me}$ <i>n</i> -biphenyl $-\text{C}_6\text{H}_4-\text{C}_6\text{H}_5$

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