

## ABSORPTION SPECTRA OF PHYTOXANTHONES

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Abstract — The Ultraviolet Absorption Spectra of Phytoxanthones are reviewed.

In recent years a large number of xanthones have been isolated from plant as well as microbial sources. Among other plants Guttiferae and Gentianaceae represent the principal sources of xanthone derivatives<sup>1-17</sup>. Reviews by Robberts<sup>2</sup>, Gottlieb<sup>4</sup>, Scheinmann<sup>6</sup>, and Hostettman<sup>18</sup>, concerning chemotaxonomic importance and chemistry of natural xanthones have appeared. Ultraviolet absorption spectroscopy has played an important role in determining the oxygenation pattern on xanthone skeleton. In this article the importance of this technique is reviewed and absorption maxima for over one hundred natural xanthones in the presence of different additives, are tabulated.

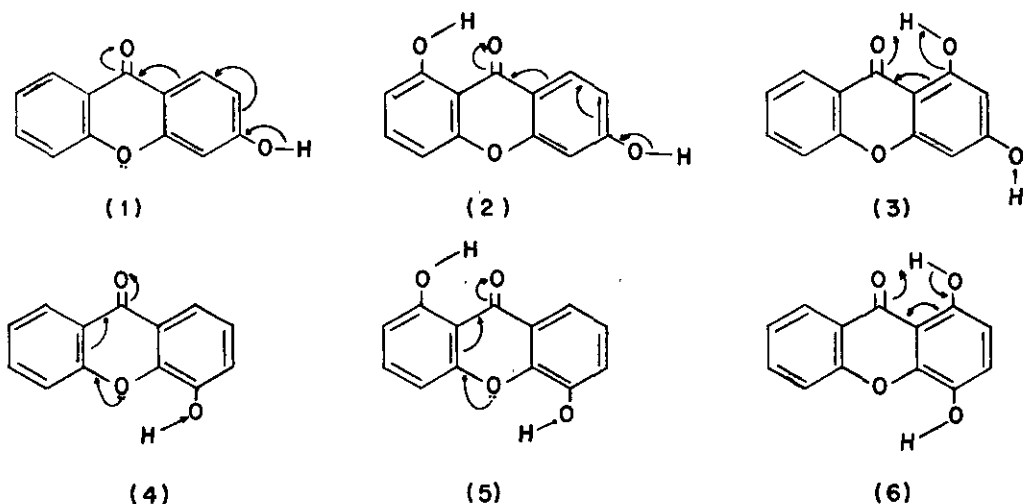
The ultraviolet absorption spectra of most xanthones consist of three intense bands in the region 230-340 nm, and a fourth, less intense, band at higher wavelengths which account for their yellow colour. The utility of ultraviolet spectral studies in assigning the oxygenation pattern of a xanthone is of great value. This is because the ultraviolet spectra of polyoxygenated xanthones vary significantly with change in the oxygenation pattern<sup>2,16,22</sup>.

The approach is largely empirical which provides information on the general oxygenation pattern of the carbon skeleton of xanthone<sup>20</sup>. This permits location of free hydroxyl groups in the presence of certain additives such as sodium hydroxide, sodium acetate, aluminium chloride or 2,6-dichlorobenzoquinone chlorimide.

Addition of sodium hydroxide ionises hydroxyl groups at all positions of xanthone skeleton resulting in significant alterations in the absorption spectrum. 1-hydroxyxanthones show a reduction of the intensity of second principal maximum along with red shifts of this and other maxima at higher wavelengths. 3-hydroxyxanthones in alkaline media give bands at 345-365 nm, where other xanthones, including relatively acidic 4-hydroxy derivatives absorb feebly.

A hydroxyl group in the 3-(or 6-) position of xanthone nucleus has enhanced acidity due to the presence of the *p*-ring carbonyl group and can be readily detected by its solubility in

sodium hydrogen carbonate<sup>2,10</sup>. Sodium acetate being a weaker base ionises only the hydroxyl group at 3- (3- or 6-) position. However, 1,3-dihydroxy system has been shown<sup>21</sup> to be less acidic, since the curves in the presence of sodium hydroxide and sodium acetate are not superimposable. This has been attributed to the mesomeric withdrawal of electrons by the C-1 (OH) group, since 3-hydroxy-1-methoxyxanthenes have been shown to display the usual high acidity of 3-hydroxy derivatives. The mesomeric effect of hydroxy group at different positions in xanthenes has been outlined as in structures (1-6).



The UV spectra of 4-hydroxyxanthenes in the presence of sodium hydroxide or sodium acetate are very similar, thus suggesting partial ionisation of the C-4(OH) group. This makes it possible to differentiate between 3- and 4-hydroxyxanthenes for the former shows a hyperchromic shift whereas in the latter case an alteration of band intensity in the 345-365 nm region is observed, after addition of sodium acetate. The presence of a second hydroxyl group at C-1 or C-8 in 4-hydroxyxanthenes produce significant alterations than in the 3-hydroxyxanthone (2) series. Thus 4,8-dihydroxyxanthenes (5) in the presence of sodium acetate show red shift as compared to the spectra in neutral solution. Whereas 1,4-hydroxyxanthenes (6) spectra in neutral solution and in the presence of sodium acetate have been shown to be superimposable<sup>21</sup>. This reflects the acidity of two types of xanthenes.

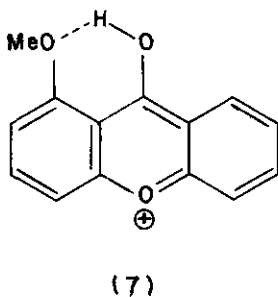
1,6-dihydroxy (2) give identical changes in the ultraviolet spectrum in methanol by addition of either sodium hydroxide or sodium acetate, whereas 1,5-dihydroxyxanthenes (5) in sodium hydroxide and sodium acetate are different, indicating partial ionisation of the C-5(OH) group in sodium acetate<sup>16</sup>

2-hydroxyxanthenes are insoluble in sodium carbonate and their spectra in neutral and sodium

acetate media are superimposable. Whereas 1-hydroxyxanthenes are insoluble even in sodium hydroxide and their UV spectra and those of 1,8-dihydroxyxanthenes are unaffected in sodium acetate. However, the presence of C-1(OH) group in xanthenes has been shown to undergo a strong reduction of intensity and a red shift of about 20 nm of the second principal maximum, in the presence of aluminium chloride. It should be borne in mind that ortho dihydroxyxanthenes show the same spectral modifications. However, the presence of o-dihydroxy group in xanthenes, is confirmed by observing spectral shifts after addition of boric acid and sodium acetate.

Xanthenes with unsubstituted p-position to hydroxyl group give characteristic absorptions between 660 and 700 nm and 710 and 750 nm by Gibbs test. 1-Hydroxy and 1,7-hydroxyxanthenes are reported<sup>28</sup> to show the high wavelength maximum. However, xanthenes with perihydroxyl or a 3-alkyl group, a second maximum of relatively low intensity appears between 430 and 460 nm.

1-methoxyxanthenes are shown to be more acidic than their 1-hydroxy counterparts<sup>23,24</sup>. In acidic medium, they are reported to be protonated to give ion (7).



Solvents:

a = Methanol

b = Ethanol

List of plants referred in the tables:

- 1) *Mammea americana* L.
- 2) *M. africana* G. Don.
- 3) *Kielmeyera coriacea* Mart.
- 4) *K. excelsa* Camb.
- 5) *K. candidissima* A.P. Duarte.
- 6) *K. rubriflora* Camb.
- 7) *K. rupestris* A.P. Duarte.
- 8) *K. ferruginea* A.P. Duarte.
- 9) *K. speciosa* St. Hill.
- 10) *K. corymbosa* (Spr.) Mart.
- 11) *K. petiolaris* (Spr.) Mart.
- 12) *Calophyllum brasiliense* Camb.
- 13) *C. cardato oblongum* Thw.
- 14) *C. warkeri* Wight.
- 15) *C. thwaitesii* Planch & Triana.
- 16) *C. trapezifolium* Thw.
- 17) *C. calaba* L.
- 18) *C. inophyllum* L.
- 19) *C. scriblitifolium* Hend & Wyatt - Smith.
- 20) *C. sclerophyllum* Vesq.
- 21) *C. fragrans* Ridley.
- 22) *C. bracteam* Thw.
- 23) *C. ramiflorum* Schwarz.
- 24) *C. Neo-ebudicum* Guillaumin.
- 25) *C. cuneifolium* Thw.
- 26) *C. canum* Hook f.
- 27) *Garcinia buchananii* Baker.
- 28) *G. echinocarpa* Thw.
- 29) *G. terpnephylla* Thw.
- 30) *G. eugeniifolia* Wall.
- 31) *G. mangostana* L.
- 32) *G. morella* Desr.
- 33) *G. hanburryi*.
- 34) *G. multiflora*.
- 35) *G. pendunculata* A.
- 36) *Musa ferrea* L.
- 37) *M. thwaitesii* Planch & Triana.
- 38) *Ochrocarpos odoratus* (Rafin) Merrill.
- 39) *Allanblackia floribunda* Oliver.
- 40) *Pentaphalangium solomonse* Warb.
- 41) *Pentadesma butyracea* Sabine.
- 42) *Plantonia insignis* Mart.
- 43) *Harungana madagascariensis*.
- 44) *Symphonia globulifera* L.
- 45) *Tovomito choisyana* pl. et. Tr.
- 46) *T. macrophylla* pl. et. Tr. Walp.
- 47) *T. pyriformis* pl. et. Tr.
- 48) *Chlorophora tinctoria*.
- 49) *Caraipa densiflora* Mart.
- 50) *Cratoxylon celebicum* Blume.
- 51) *Lorostemon coelhoi* Paula.
- 52) *L. megresis* Fros.
- 53) *Maclura pomifera* Raf.
- 54) *Kayea stylosa* Thw.
- 55) *Canscora decussata* Schult.
- 56) *Frasera albicaulis* Dougl ex. Griesb.
- 57) *F. Caroliniensis* Walt.
- 58) *Gentia lutea*.
- 59) *G. bellidifolia* Franch.
- 60) *G. corymbifera* T. Kirk.
- 61) *G. kochiana* Perr. et Song.
- 62) *G. bavarica* L.
- 63) *G. verna* L.
- 64) *G. brachyphylla*.
- 65) *G. favrati*.
- 66) *G. nivalis*.
- 67) *G. rostani*.
- 68) *G. verna*.
- 69) *G. utriculosa*.
- 70) *G. schleicheri*.
- 71) *G. acaulis*.
- 72) *G. campestris* L.
- 73) *G. clusii*.
- 74) *G. ciliata*.
- 75) *Polygala macradenia* Gray.
- 76) *P. paenea* L.
- 77) *Swertia chirata* Buch-Ham.
- 78) *S. bimaculata* Hf. & T.
- 79) *S. decussata* Nimmo.
- 80) *S. lawii*.
- 81) *S. purpurascens* Wall.
- 82) *S. perennis* L.
- 83) *S. tosaensis* Makino.
- 84) *S. gracilescens*.
- 85) *S. dilatata*.
- 86) *S. randaiensis*.
- 87) *Anthocleista vogelii*.
- 88) *A. djalonesis* (A. Chev.)
- 89) *Macrocarpaea glabra* (L.f.) Olig.
- 90) *Halenia asclipidea* (HBK) G. Don.
- 91) *Athyrium mesosorum* Makino.
- 92) *Cudrania javanensis*.
- 93) *Swertia japonica*.
- 94) *Swertia bravarica* L.

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon \log_e$	Ref.
<u>Mono-oxygenated</u>					
<u>Xanthenes</u>					
2-Hydroxy	1,4,6,9	a		237,247 inf. 299,357	6,25-32
	36,38		NaOH	(28,600;24,200;3,000;4,600) 252,275 inf. 310	34,28
2-Methoxy	1,3,10,	a		236,248,297,302,359	20,34-36
	36			(4.59,4.52,3.68,3.66,3.88)	
4-Hydroxy	1,12,13,	b		235 sh,250,282,290,353	27,31,34
	36		NaOH	(4.45,4.59,3.80,3.73,3.66) 235,269,301,311,402	37,38
			NaOAc	(4.44,4.51,3.94,3.94,3.51) 234,251,267,293,350	
				(29,200;31,300;12,900;5,100;4,400)	
<u>Dioxygenated</u>					
<u>Xanthenes</u>					
1,2-Methylene-dioxy	4	b		246,270 sh,308,353 (45,500;10,600;18,000;14,000)	28
2-Hydroxy-1-methoxy	9	b		239,254,275 sh,369 (30,200;27,000;10,100;5,300)	39
		NaOH		225,275 (29,600;24,700)	
3-Hydroxy-2-methoxy	38	b		240,273,309,349 (32,500;7,100;11,500;10,000)	25
		NaOAc		231,267 sh,377 sh,360 (37,000;8,500;6,400;21,200)	
		NaOH		231,267,277,360 (38,400;10,600;8,300;24,600)	
3-Hydroxy-4-methoxy	13,36	b		235,282,337,370 (4.47,3.97,4.19,4.11)	34,38
		NaOAc		235,292,335,370	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
1,5-Dihydroxy	1,2,9,14 15,16 27-29 36-39	b	NaOH	(4.48,3.98,4.19,3.71)	19,27,31 34,39-46 25
				252,318,378	
				(4.62,3.92,3.73)	
				252,318,358,416	
5-Hydroxy-1-methoxy	2,38,40	b		236,245,304,351	33,44,47
				(4.37,4.63,4.48,3.81)	
1-Hydroxy-5-methoxy	36	a		251,311,375	33,44,47
6-(3,3-dimethylallyl)- 1,5-dihydroxy (Guanandin)	12,14 17-19	b	NaOH	(41.4,7.78,4.97) x 10 <sup>-3</sup>	37,40 48-52
				252.2,317.5,367.5	
				(4.62,4.04,3.57)	
				260,315,366,	
				(22,700;4,200;6,500)	
				NaOAc	
252,275,320,365					
			AlCl <sub>3</sub>	(26,400;7,200,7,300;2,800)	
			AlCl <sub>3</sub>	257.5,340,365	
				(4.45,3.68,3.28)	
Dehydrocycloguanandin	12	b	NaOH	235,265,305 sh,345	52,53
				(23,500;22,300;4,800;15,300)	
				238,250,290,300 sh,346	
				(23,200;22,100;10,600;9,400;10,600)	
			AlCl <sub>3</sub>	235,275,330,378	
				(22,000;19,700;4,000;10,900)	
6-(4-Hydroxy-3-(methoxybutanyl)-1,5-dihydroxy	13,17,19	b		234,245,297,365	48
				(29.4,31.5,10.1,5.34) x 10 <sup>-3</sup>	
Isoguanadin 4,8-Dihydroxy-1-(3',3',-dimethylallyl)	12	b	NaOH	235 sh,251,320,376	37,52
				(25.7,40.4,2.7,5.0) x 10 <sup>-3</sup>	
				246,320,350	
				(37,400;6,000;9,600)	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
1,7-Dihydroxy (Euxanthone)	1,2,4,5 10,14,15 21-23 28-30 36,37,39 42-44	b	NaOAc	252,275 sh,323,381 (38,000;10,500;10,100;4,400)	18,19,27, 28,31 34,40 42-44 46,49 54-64
			AlCl <sub>3</sub>	235 sh,251,274 sh,320,265 (25,500;36,000;8,700;7,400;5,100)	
			AlCl <sub>3</sub>	230.5,280,287,385 (29,500;36,330;6,700;7,600)	
			AlCl <sub>3</sub>	236,277 (43,000;33,400)	
			AlCl <sub>3</sub>	234,260,286,380 (4.31,4.40,3.63,3.68)	
			AlCl <sub>3</sub>	234,277,307,330 (45,600;45,400;13,500;3,000)	
1-Hydroxy-7-methoxy	4,10,36	b		234,260,286,380 (4.31,4.40,3.63,3.68)	28,34 35,42
<u>Trioxxygenated</u>					
<u>Xanthenes</u>					
1-Methoxy-2,3-dihydroxy	9	b		239,255 sh,313,355 (29,500;20,400;14,300;6,100)	29,39 65
			NaOH	231,275,354 (29,300;11,200;16,300)	
			NaOAc	235,270 sh,364 (34,400;12,400;19,600)	
			AlCl <sub>3</sub>	235,260,330 (24,300;18,300;17,800)	
			H <sub>3</sub> BO <sub>3</sub> / NaOAc	237,315,355 (29,600;12,600;7,600)	
				241,280,305,340 sh (35,200;8,700;14,200;7,100)	
3-Hydroxy-1,2-dimethoxy	7,9	b		233,280 sh,356, (37,500;6,600;20,200)	29,39 66,67
			NaOH	233,280 sh,356, (37,500;6,600;20,200)	
			NaOAc	234,280 sh,356	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
				(34,900;6,600;20,100)	
			AlCl <sub>3</sub>	241,280,305,340 sh (36,600;9,000;14,900;6,700)	
2,3,4-Trihydroxy	38	b		231,317,376	25
3,4-Dihydroxy-2-methoxy	3,10	b		240,258,286,337 (30.1,28.2,6.1,12.8) x 10 <sup>-3</sup>	20,35
			NaOAc	232,276,364 (26,100;14,300;12,500)	
4-Hydroxy-2,3-dimethoxy	3,6-10	b		237,256,290 sh,307,354 (26,0,33.4,9.1,9.9,5.4) x 10 <sup>-3</sup>	6,20,26 29,35,39
			NaOH	213,235 sh,275,298,335,396 (48.6,24.3,23.1,10.0,7.6,3.95) x 10 <sup>-3</sup>	67,68
			NaOAc	210,236,255,295,305,350 (29.1,24.3,24.3,13.6,9.1,6.4) x 10 <sup>-3</sup>	
3-Hydroxy-2,4-dimethoxy	3,6,9	b		240,280,313,350 sh,380 (36.9,6.8,13.6,9.4,1.6) x 10 <sup>-3</sup>	6,26,29, 65,69,70
4-Hydroxy-2,3-methylenedioxy	3,6 9,10	b		244,287,322 (34,000;6,600;12,800)	20,26,29, 35,39
			NaOH	242,275,349 (31,300;21,800;11,900)	
			NaOAc	241,275,348 (34,300;20,600;11,700)	
4-Methoxy-2,3-methylenedioxy	3,6,7, 10	b		245,280,310 (35,100;5,800;12,100)	20,35,58, 67,69,70
Globuxanthone	44	b		251,267,310 sh,406 (35,980;37,440;11,210;9,095)	71,72
2,8-Dihydroxy-1-methoxy	4,9,11, 17,21	b		238,262,290,322 (26,800;32,800;5,200;4,400)	28,49,55 73-75
			NaOH	254,275,350 (31,400;25,300;4,000)	



Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
1,2-Dimethoxy-8-hydroxy	11	b	AlCl <sub>3</sub>	238,277,311,350 (28,800;28,500;6,200;4,000)	73,74
			NaOH	238,260,290,322 (29,800;35,200;5,600;5,000)	
			AlCl <sub>3</sub>	238,263,326 (37,600;17,800;7,000)	
2-Hydroxy-1-8-dimethoxy	17	b	AlCl <sub>3</sub>	238,276,310,351 (31,900;30,800;6,700;4,400)	49
1,5,6-Trihydroxy (Mesuxanthone B)	2,13,17- 19,21,27, 30,36-38, 44	b		242,257,285,315 (30,300;31,200;5,700;5,200)	18,25,34, 38,43-45, 49,50,55, 56,62,63,76
1,6-Dihydroxy-5-methoxy	13,17,18, 21,27	b		251,315,332 (38,130;6,480;15,060)	8,45,49 55,56
1,6,7-Trihydroxy	2,23,30	b		243,267,313,357 (39.0,10.5,13.3,8.9) x 10 <sup>-3</sup>	44,57,58
Tovoxanthone	45	b		251,268 sh,296,313 sh,360 (22.1,9.1,8.6,6.9,10.1) x 10 <sup>-3</sup>	77
			AlCl <sub>3</sub>	242,265,319 (45,500;36,750;28,500)	
			NaOH	248,330 inf. (45,250;17,050)	
			NaOAc	254,327 inf. (46,500;14,250)	
1,3,5-Trihydroxy	39	b	AlCl <sub>3</sub>	243,267,334 (46,500;31,300;27,150)	19
			NaOH	220 sh,247,313,360 sh (4,20,4.53,4.21,3.62)	
			NaOAc	257,291,348 (21,800;13,400;18,500)	
			NaOAc	244,265 sh,341 (25,800;13,800;12,400)	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
			AlCl <sub>3</sub>	246,267,335 (13,900;22,000;14,700)	
2-(3,3-Dimethylallyl)- 1,3,5-trihydroxy	14,18,19 40	b		235 sh,248,301,358 (4.42,4.40,4.26,3.50)	40,47, 57,76
6-Deoxyjacareubin	8,9,12, 16-19,21, 22,24,25	b		240,255, 286,309,369 (19,000;18,900;42,000,19,6000,4,000)	29,37,41, 49,51,52,
			NaOH	225,297,344 (19,700;37,400;14,900)	55,56,68, 76,79-82
			NaOAc	286,296,320 sh,385 (35,900;35,400;12,900;3,400)	
			AlCl <sub>3</sub>	240,251,290,305 sh,348 (18,900;19,700;37,900;28,200;10,000)	
1,3-Dihydroxy-5- methoxy	3,8,10, 12	a		240,312,350 (35,000;15,200;6,800)	6,20,53, 68,81
1,5-Dihydroxy-3- methoxy (Mesuaxanthone)	3,7,9, 10,36,55	b		250,274 sh,310,355 (4.43,3.80,4.09,3.4)	6,8,20,39, 67,69
			NaOH	240 sh,263,278 sh,344 (23,100;34,400;12,000;13,900)	83
			NaOAc	253,287,314 (26,400;14,200;12,000)	
			AlCl <sub>3</sub>	240,267,335 (16,900;29,100;15,700)	
5-Hydroxy-1,3-di- methoxy	3,5,7- 37	b		248,304,344 (41,800;18,200;4,600)	20,29,35, 39,43,60,
			NaOH	241,265,283,308 (36,900;26,600;26,400;19,800)	67,68,70
			NaOAc	247,285,303 (36,200;14,500;16,700)	
1,3,5-Trihydroxy-4- (3-methyl-but-2-enyl)	40	b		239,244,256,310,318,368 (4.48,4.48,4.45,4.11,4.15,3.62)	47

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ $\log_e$	Ref.
6,11-Dihydroxy-3,3-dimethyl-pyrano-(2,3-c)xanthene-7(H)-one	40	b		232,250,268,308,329 (4.26,4.54,4.51,3.92,4.02)	84
8-Deoxygartanin	31	b		244,260,324,375 (4.47,4.37,4.17,3.55)	64
Trapezifolixanthone (3-methylbut-2-enyl) pyrano(3,2-b)-xan- thene-6(2H)-one	16,25	b	$AlCl_3$	232,250,275 sh,292,315,380 (3.90,3.85,4.01,4.24,3.84,3.18) 237,255,280,304,309,357 (4.08,4.02,3.90,4.16,4.18,3.88)	80,85
Morellin	32	b		234,279,291,361 (30,200;17,400;17,400;14,300)	86,87
Gambogic acid	32,33	b		217,280,291,362 (26,000;16,700;17,000;14,900)	88
1,7-Dihydroxy-3-methoxy (Gentisin)	12,30,36 58	b		205,237.5,307,375 (3.91,4.31,4.43,3.99)	1,6,7,37, 42,58,89- 93
1-Hydroxy-3,7-dimethoxy. (Methylgentisin)	12	b		238,259,308,396 (28,800;38,950;13,800;6,250)	24
2-(3,3-dimethylallyl)-1,3,7-trihydroxy	19,26,39			241,263,314,337 (33.87,32.89,17.14,6.5) $\times 10^{-3}$	19,76,94
Osajaxanthone	8,10,19, 41,53	b	NaOH $AlCl_3$	240,249,285,339,382 (4.27,4.26,4.67,3.90,3.68) 243,302 (25,400;43,500) 235,289,349 (19,600;38,400;8,300)	35,52,68, 76,95-98
Mbarraxanthone (Dimethyl ether)	44	b		233,264.5,314,385 (31.72,41.02,14.22,8.2) $\times 10^{-3}$	71,72
Calabaxanthone	14,16,17			240,287,292 sh,314,384	40,49,80

Compound	Source	Sovl.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
	22			(34,100;77,250;72,210;28,830;8,420)	
Thwaitesixanthone	15	b		245,275 sh,283,292,299 sh,329,403 (4.13,4.37,4.49,4.52,4.45,4.13,3.64)	40
1-Hydroxy-3,5-di- methoxy	55	b		245,308 (4.60,4.27)	99,100
1,3,5-Trimethoxy	56	b		245,300,335-340 sh (4.63,4.23,3.79)	24
3-O-Rutinosyl-1- Methoxy-5-Hydroxy	55	b		244,270 sh,325 (0.71,0.65,0.35)	101
1-Methoxy-3,5-di- hydroxy	55	b		245,288,305,336 (0.59,0.18,0.16,0.27)	101
1,3,7-Trihydroxy	58,77	b		220 sh,238,260,310,373 (4.22,4.47,4.55,4.18,3.82)	2,89,102
1,3-Dihydroxy-7- methoxy (isogentisin)	58,77	a		280 sh,236,259,311,370 (4.05,4.45,4.53,4.11,3.77)	2,89,102, 103
1,3,7-Trimethoxy	56,58	b		207,239 sh, 255,303,356 (3.20,3.47,3.60,3.12,2.82)	24,89,102
<u>Tetraoxygenated</u>					
<u>xanthenes</u>					
1,3,6,7-Tetrahydroxy (Norathyriol)	2,28,29, 31,35, 38-40,44, 48,53,55, 91	a		237,254,312,361 (4.40,4.55,4.24,4.12)	19,25,44, 46,62
			NaOAc/H <sub>3</sub>	224 sh,259,317,368	104-110
			BO <sub>3</sub>		
			NaOAc	235,256,316,370	
			AlCl <sub>3</sub>	210,231,266,285 sh,317,351,418	
			AlCl <sub>3</sub> /HCl	204,230,262,280 sh,336,402	
1,7-Dihydroxy-3,6- dimethoxy	18	b		238,256,315,372 (4.36,4.24,3.77,4.18)	51
			AlCl <sub>3</sub>	231,263,333,396	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon \log_e$	Ref.
4-(1,1-dimethylallyl)- 1,3,6,7-tetrahydroxy (as cyclic derivative)	39	a		(4.32,4.29,4.13,3.86) 238,259,273 sh,312,370	19
			NaOAc	(21,400;25,100;13,100;10,400;10,200) 236,262,298 sh,378 (26,400;22,000;5,600;17,400)	
6,7-Dihydroxy-1- methoxypyran (2',3':3,4) xanthone (Lorostemin)	51,52	b		275,338 (42,000;19,000)	111
			NaOH	268,372 (39,000;25,000)	
			NaOAc	263,370 (38,500;29,600)	
			NaOAc/H <sub>3</sub>	270,347	
			BO <sub>3</sub>	(37,000;19,400)	
			AlCl <sub>3</sub>	270,350 (34,500;17,000)	
Normangostin ( $\nu$ -Mangostin)	31	b		234,260,317,360 (4.48,4.49,4.36,4.05)	112,113
Mangostin	28,29,31	b		242,258,308,349 (4.54,4.44,4.38,3.86)	22,46,112, 114,115
$\beta$ -Mangostin	31	b		245,258,317,356 (4.55,4.45,4.30,4.10)	112,115, 116
Tovopyrifolin - A	46	b		279 inf.,292,340 (36,700;46,900;28,200)	117
			NaOH	324 (29,400)	
	46,47	b	NaOAc	280,337 inf.,386 (41,200;18,400;31,400)	117,119
			NaOH	248,271,330 (43,600;53,900;35,300) 253,272,325	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
Tovophyllin - B	46,47			(40,200;43,100;24,000) 250 sh,292,392 sh,335 (11,900;27,000;24,600;12,800)	117,118
			NaOH	235,262 sh,315 (23,700;21,800;24,700)	
Pentadesmaxanthone	41			249,261,279 sh,323,340 sh,370 (4.42,4.51,4.25,4.23,3.89)	98
			NaOAc	249,261,279 sh,324,340 sh,370 (4.45,4.51,4.25,4.18,4.10,4.06)	
			AlCl <sub>3</sub>	239,272,289 sh,349,370,420 (4.45,4.51,4.25,4.35,4.11,3.92)	
Cudranixanthone	92	a		254,283,327 (4.53,4.89,4.23)	119
			NaOAc	256,287,345	
			AlCl <sub>3</sub>	242,257,343	
2-(3,3-Dimethylallyl)- 1,3,5,6-tetrahydroxy	18-21,23, 24,26	a		251,283,324 (4.42,3.81,4.21)	54-57,78, 79
Jacareubin	8,12-22, 24,26,41	b		240,283,332 (4.26,4.62,4.28)	37,38,40, 41,49,51, 52,54-56, 68,76,78, 79,97,98, 106,120- 123,
Ugaxanthone	44	a		243,287, inf.,319,355 inf.,377 inf., (37.57,10.98,27.72,32.38,7.51) x 10 <sup>-3</sup>	71,72
Macluraxanthone	8,53	b		242,283,338, (4.31,4.64,4.28)	95,124,125
10-O-Methylmaclura- xanthone	54	b		235,281,293,342,360 (4.22,4.57,4.49,4.15,4.27)	126

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ $\log_e$	Ref.
Alvaxanthone	53	b	AlCl <sub>3</sub>	242,281,290,334 (4.31,4.55,4.57,4.27)	17
				257,280,332 (4.48,3.94,4.38)	
1,3,5,7-Tetrahydroxy	35	b		237,254,268 sh,312,361 (4.3,4.4,3.9,4.1,3.9)	104
Gartanin	31	b		259,284,325 sh,351 (4.3,4.38,3.87,4.05)	112
			NaOAc	240,284,380 (4.48,4.40,4.34)	
			AlCl <sub>3</sub>	269,299,330 sh,383 (4.36,4.42,3.94,4.07)	
1,6-Dihydroxy-7,8-methylenedioxy	49	b		229,254,322,361 (31,000;38,000;12,300;11,000)	127
			NaOH	246,260,289,351 (34,000;32,200;14,200;12,000)	
			NaOAc	231,250,275 sh,356 (29,200;34,500;20,000;16,400)	
			AlCl <sub>3</sub>	234,258,287,339 (33,600;28,200;16,200;16,300)	
1,5-Dihydroxy-2,3-dimethoxy	14	b		205,245,255,265 sh,308,365 (3.92,3.91,3.87,3.81,3.77,3.56)	40
			AlCl <sub>3</sub>	245,255 sh,265 sh,275,312 (3.91,3.92,3.91,3.87,3.81)	
Kayeaxanthone	54	b		260 sh,269,292,368 (4.29,4.31,4.63,3.42)	126
1,2-Dimethoxy-3,8-dihydroxy	16	b		250 sh,268,305,358 (4.50,4.26,4.29,4.04)	41
			NaOAc	235,261 sh,364 (4.58,4.26,4.36)	
			AlCl <sub>3</sub>	234,266,279,327,414	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon \log_e$	Ref.
1,3-Dihydroxy-2,8-dimethoxy	5	b		(4.51, 4.23, 4.34, 4.25, 3.9)	60
				224, 252, 296, 315, 371 (13,100; 16,100; 5,600; 5,700; 6,500)	
			NaOH	225, 260 sh, 283, 345, 390 (20,400; 8,400; 5,300; 6,200; 11,100)	
			AlCl <sub>3</sub>	223, 252, 280, 321 (15,100; 12,100; 9,150; 8,350)	
1,3,8-Trihydroxy-7-methoxy	9,55	b		237, 262, 336 (28,100; 32,300; 17,200)	29,83
			NaOH	244, 265 sh, 279, 355 (30,600; 19,900; 15,000; 18,100)	
			NaOAc	236, 260 sh, 269, 360 (36,200; 23,100; 24,900; 27,500)	
			AlCl <sub>3</sub>	225, 241, 277, 328, 362 (20,700; 23,100; 28,400; 11,900; 16,400)	
Tovopyrifolin-B	46	b		247 inf., 257, 322, 272 (20,200; 23,000; 18,100; 9,200)	117
			NaOH	350 (9,500)	
			NaOAc	260, 286, 323 (21,000; 11,800; 14,100)	
			AlCl <sub>3</sub>	250 inf., 273, 330 (15,000; 19,600; 15,800)	
1,4,7-Trihydroxy-3-methoxy	30	b		263, 314, 380 (27.4, 10.1, 5.1) x 10 <sup>-3</sup>	58
1,5-Dihydroxy-6,7-dimethoxy	49	b		236, 260, 315, 379 (19,600; 32,600; 11,000; 6,400)	128
			NaOH	264, 285 sh, 351 (30,500; 11,800; 9,200)	
			NaOAc	249, 265 sh, 351 (26,400; 22,200; 10,700)	



Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon \log_e$	Ref.
			$AlCl_3$	235,267,286,324 (23,500;27,200;18,600;11,100)	
Celebixanthone	50	b		240 sh,252,330,370 sh. (27,000;30,160;14,000,5.400)	129,130
Symphoxanthone	44	b		238,260,323 sh,389 (43,390;43,870;7,800;5,363)	71,72
1-Hydroxy-2,3,5-tri- methoxy	56,57, 90	b		243,253,263,272 sh,304,370 (1.007,0.95,0.62,0.50,0.50,0.11)	24,131, 132
1-Hydroxy-2,3,7-tri- methoxy	56,57	b		238,262,300,320 sh,363 (27,600;28,600;11,700;10,600;5,100)	132
Swerschirin (methylbellidifolin)	56,57, 59,60,77	b		237,254,278,336 (19,900;26,900;16,900;11,300)	132,8-10 15,24
1,3-Dihydroxy-4,5- dimethoxy	57,78	b		243,260,290,319,360 (31,000;23,000;18,400;13,800;4,100)	132,133
1,3-Dihydroxy-4,7- dimethoxy	56	b		234,266,316,376 (25,600;26,600;9,200;6,140)	24
1-Hydroxy-2,3,7-tri- methoxy (methoxy derivative)	56	b		243,258,280,312,355 (32,100;32,700;11,150;11,600;6,600)	24
1-Hydroxy-3,4,5-tri- methoxy	56	b		240 sh,248,308,351 (30,600;43,200;16,300;16,000)	24
1-Hydroxy-3,4,7- trimethoxy (methoxy derivative)	56	b		337,259,309,367 (26,000;39,800;10,300;7,720)	24
2-Hydroxy-1,3,7-tri- methoxy	56	b		225 sh,245,255 sh,284,322,368 (24,200;36,500;28,700;12,500;12,700; 7,390)	24
1,3,4,7-Tetramethoxy	56	b		236,260,310,368	24
Gentiakochianine	61-68,	a		234,267,325,383	134-139,

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
(Swertianin)	77,79,80, 93,94		NaOAc AlCl <sub>3</sub> AlCl <sub>3</sub> / HCl	270,325,400 246,278,350,430 240,272,330,360,238,256,306,364	141-142
1-Hydroxy-3,7,8-tri- methoxy (Decussatin)	55,61,62, 64-70, 77-81, 88,94	a	NaOH NaOAc AlCl <sub>3</sub> AlCl <sub>3</sub> / HCl	240,261,312,374 (24,400;28,300;8,350;3,340) 240,261,316,376 240,261,312,376 238,275,330,425 238,275,330,425	2,14,99 133-137, 139,141 143
1,7-Dihydroxy-3,8-Di- methoxy (Gentianacaulin)	61,62, 64-71 87	a	NaOH NaOAc AlCl <sub>3</sub> AlCl <sub>3</sub> / HCl	239,261,311,375 273,310,418 239,261,311,375 236,276,330,428 236,276,330,428	135,137, 144,141, 147
3,8-Dihydroxy-1,7- dimethoxy (Isogentiacaulin)	61	a		240,260,308,372	135
1,8-Dihydroxy-3,7- dimethoxy (Swertia- peremine,methylswer- tianin)	61,77,80 82,87	a		240,263,330 (4.32,4.46,4.18)	135,139, 140,144, 146,99
1,3,7,8-tetrahydroxy (Norswertianin)	55,62,68, 77,80,81, 93	a	NaOH NaOAc AlCl <sub>3</sub> AlCl <sub>3</sub> / HCl	240,266-268,332 (4.37,4.31,3.99) 238,265,329,385 270,360 244,278,360 240,270,332 sh,360 sh	99,137, 139-141, 143,145, 146

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
1,3,7,8-tetrahydroxy (Desmethylbellidifolin)	59,72,	a		254,278,335,390 sh	8,9,139
	77,80,	b		239,267,332,390	145,146
	81			(4.28,4.52,4.10,3.88)	
			NaOAc	250,272,360	
1,5,8-Trihydroxy-3- methoxy (Bellidifolin)	59,72,	b		220,240,255,277,305,310 sh,329	8,146,
	77,81			(4.28,4.15,4.20,4.10,3.71,3.92)	148-150
		a		255,279,334,390 sh	
			NaOMe	267,285 sh,368	
1,3,8-Trihydroxy-5- methoxy (Isobellidi- folin)	59,77	b		231,251,276,342	9,10,136
	81			(4.35,4.3,4.2,4.1)	145,146
			NaOMe	267,285 sh,368	
			NaOAc	255,279,334,390 sh	
1,8-Dihydroxy-3,5- dimethoxy (Methylbe- llidifolin,Swerschirin)	59,77,			230,254,278,300 sh,335	8,133,
	78			(4.3,4.4,4.2,3.8,4.0)	146
			NaOMe	267,285 sh,368	
			NaOAc	255,279,334,390 sh	
1-Hydroxy-3,5,8-tri- methoxy	77,80	b		220,230-235 sh,274,332	8,139
				(4.08,4.15,4.40,3.92,3.88)	
1,3,5-trihydroxy- 6-methoxy	55	b		245,261 sh,268-70,340	83
				(4.76,4.32,4.48,4.06)	
1,5,6-Trihydroxy- 3-methoxy	55	b		248,280 inf.,335	110
				(4.61,3.94,3.98)	
1,3,5,6-tetrahydroxy- C <sub>2</sub> -glucoside	55	b		240 sh,250,280 inf.,335	110
				(4.32,4.44,3.88,3.99)	
3,7,8-Trimethoxy-1-O- prime-veroside (Decus- satin-O-primeveroside)	62,68,	a		242,250,304,355	137,138,
	73,74		NaOMe	242,250,304,355	151,152
			AlCl <sub>3</sub>	242,250,304,355	
7-Hydroxy-3,8-dimeth- oxy-1-O-prime-veroside)	62,68	a		242,253,304,362	137,138,
			NaOMe	246,275,408	153

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
(Gentiabavaroside)			NaOAc	242,253,304,362	
			AlCl <sub>3</sub>	242,253,304,362	
1,8-Dihydroxy-3-methoxyxanthone-7-O-acetylrutinoside	62	a		237,362,330,378	137,153
			NaOMe	242,275,330,400	
			NaOAc	264 sh,275 sh,330,400	
(Gentiabavarutinoside)			AlCl <sub>3</sub>	278,339,360,408	
			AlCl <sub>3</sub> / HCl	273,334,355	
7-8-Dihydroxy-3-methoxyxanthone-1-O-primeveroside (Isogentianochianoside)	62,68	a		240,270,312,380	137,138, 153
			NaOMe	246,275,307,435	
			NaOAc	240,280,312,380	
			AlCl <sub>3</sub>	248,280,341,440 sh	
			AlCl <sub>3</sub> / HCl	245,280,338,440 sh	
3,7,8-Trihydroxy-1-O-primeveroside (Norswertiaprimeveroside)	62	a		242,267,315,378	137
			NaOMe	257,283,305,351	
			AlCl <sub>3</sub>	247,278,347,435	
			AlCl <sub>3</sub> / HCl	245,278,343,435	
3,7,8-Trihydroxy-1-O-glucoside (Norswertianin-1-O-glucoside)	62,84,85	a		242,267,315,378	137,153
			NaOMe	257,283,305,351	
			NaOAc	262,351	
			AlCl <sub>3</sub>	247,278,347,435	
			AlCl <sub>3</sub> / HCl	245,278,343,435	
1,7-Dihydroxy-3-methoxy-8-O- $\beta$ -D-glucopyranoside (Swertianin-8-O-glucoside)	68	a		236,264,315,380	138
			NaOMe	248,270,308,405	
			NaOAc	266,313,400	
			AlCl <sub>3</sub>	238,276,328,422	
			AlCl <sub>3</sub> / HCl	238,276,328,422	

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.		
1,3,5-Trihydroxy-8-O- $\beta$ -D-glucopyranoside (Demethylbellidifolin- 8-O-glucoside)	72	a		252,275,328	149		
			NaOMe	233,258,297,358			
			NaOAc	248,266,288 sh,354			
			AlCl <sub>3</sub>	263 sh,267,283,324 sh,362			
1,5-Dihydroxy-3-meth- oxy-8-O- $\beta$ -D-glucopy- ranoside (Bellidifo- lin-8-O-glucoside)	72	a		254,276,325	149,154		
			NaOMe	248,254,286,344			
			NaOAc	254,277 sh,288,324			
			AlCl <sub>3</sub>	267,284,324,362			
			5,8-Dihydroxy-3-meth- oxy-1-O-glucoside (Swertianolin)	81,83,93	b	252,275,325	11,13,154
						(4.40,4.22,3.95)	
3,5,8-Trihydroxy-1-O glucoside (Norswertia- nolin)	81,86	b		250,275,280,325	140,154, 155		
				(4.38,4.15,3.84)			
			NaOAc	250,275,360			
<u>Pentaoxygenated</u>							
<u>Xanthones</u>							
3,6-Dihydroxy-1,7,8- trimethoxy	36	b		244,253,283 sh,311,332,358	34		
				(4.52,4.59,4.15,4.21,4.88)			
			NaOAc	244,254,283,311,342,358			
			(4.42,4.51,4.06,4.12,4.06,3.85)				
1,8-Dihydroxy-2,3,7- trimethoxy	22	b		242,264,307,380	49		
				(12,390;12,290;9,830;3,720)			
			NaOH	248,282,310 sh,420			
				(10,930;13,260;3,580;2,500)			
			NaOAc				
			or				
H <sub>3</sub> BO <sub>3</sub> /	No alteration						
NaOAc							
AlCl <sub>3</sub>	238,270,277,324						
	(11,470;9,670;10,030;7,170)						

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.				
2,3,8-Trihydroxy-1,7-dimethoxy	6	b		231,255,281,325,394 (21,100;20,050;18,600;11,300;3,800)	26				
			NaOH	237,274,368 (26,500;10,950;15,050)					
			NaOAc	237,274,368 (26,750;14,900;21,450)					
			NaOH/HCl	255,281,324,390 (20,500;19,300;10,850;3,500)					
			AlCl <sub>3</sub>	256,289,335,377 (15,200;18,800;10,200;8,500)					
			AlCl <sub>3</sub> / HCl	256,283,330,380 (15,950;17,500;10,200;5,400)					
			NaOAc/ H <sub>3</sub> BO <sub>3</sub>	237,277,368 (22,700;14,200;15,500)					
			1,3,6-Trihydroxy-7,8-dimethoxy	36		b		239,260,270 sh,325,345 (4.24,4.33,4.18,4.14,4.01)	34
							NaOAc	237,252,262,270,333,345 (4.25,4.29,4.27,4.25,4.06,4.09)	
AlCl <sub>3</sub>	228,264,272,288 sh,325,337 (4.30,4.37,4.43,3.97,4.15,4.14)								
1-Hydroxy-2,3,4,7-tetramethoxy	56,57, 78,90,	b		237,270,301,317 sh,287 (0.84,1.0,0.31,0.29,0.16)	24,131- 133				
1,2,3,5,8-pentamethoxy	57	b		237,242,260 sh,273,292,360 (1.0,0.99,0.76,0.67,0.41,0.23)	132				
1-Hydroxy-2,3,4,5-tetramethoxy	56,57 78,90	b		240,21,275 sh,312,375 (0.92,1.0,0.65,0.37,0.14)	24,131- 133				
2-Hydroxy-1,3,4,7-tetramethoxy	56	b		241,267,290,320,379 (29,200;27,700;9,360;6,750;6,000)	24				
7-Hydroxy-1,2,3,4-tetramethoxy	75	b		243,261,288 - 310,370 (27,200;35,800;8,300;5,600)	156				
			NaOH	260,410					

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
1-Methoxy-2,3,6,7-di-methylenedioxy	75			248,259,282,321-350 (32,200;20,600;20,600;20,600)	156
1,2,3-trimethoxy-6,7-methylenedioxy	75	b		248,272,313,345 (34,500;16,200;16,200;8,100)	156
1,4-Dihydroxy-2,3,7-trimethoxy	78	b		236,269,305,392 (0.32,0.38,0.12,0.06)	133
1,2,4-trimethoxy-6,7-methylenedioxy (Polygalaxanthone - A)	76	b	NaOH	249,314 (4.52,4.21) 272,357 (3.8,3.76)	157
1,2,3,4,7-pentamethoxy (Polygalaxanthone - B)	76	b		240,260,287,307,365 (18,500;24,000;9,000;6,700;6,700)	157
1,3-Dihydroxy-4,5,8-trimethoxy	78	b		232,258,278,300 sh,350 (0.46,0.67,0.34,0.089,0.28)	133
1,3,8-trihydroxy-4,5-dimethoxy (4,5-Di-O-methylcorymbin)	59,60	b	NaOAc NaOAc/ H <sub>3</sub> BO <sub>3</sub>	227,255,278,352 (4.22,4.27,4.16,4.03) 225,247,281,371 225 sh,250,279,358	9,10,158
1,3,8-trihydroxy-4,7-dimethoxy (4,7-Di-methoxy bellidifolin)	59	b	NaOAc	238,269,315,346,378 sh (4.27,4.38,3.75,4.02,3.8) 236,272,277 sh,368	10
1-Hydroxy-3,5,6,7-tetramethoxy	55	b		240,260,308,355 (4.06,4.62,3.90,3.84)	99,159
1,7-Dihydroxy-3,5,6-trimethoxy	55	b		253,280-282,318,330 (4.48,3.96,4.21,4.05)	99,159
1,3,6,7,8-pentahydroxy	55	b		255,283,320-325 (4.47,3.97,4.22)	99
1,6,7-trihydroxy-3,5-	55			255,280,320,335	99,159

Compound	Source	Solv.	Additive	Absorption maxima $\lambda$ max. nm / $\epsilon$ log <sub>e</sub>	Ref.
dimethoxy				(4.53,4.01,4.32,4.18)	
1,3,7-trihydroxy-5,6-dimethoxy	55	b		253,280 inf.,335,355 (15.0,4.7,5.2,4.2) x 10 <sup>-3</sup>	99
			NaOAc	255,374 (75.2,43.2) x 10 <sup>-3</sup>	
1-Hydroxy-3,4,7,8-tetramethoxy	80,81	b		240,262,270,275 sh,312,380 (0.63,0.78,0.44,0.305,0.09)	139,145
1-Hydroxy-3,5,7,8-tetramethoxy	81	b		241,264,315,384 (4.27,4.41,3.92,3.60)	150
<u>Hexaoxygenated</u>					
<u>Xanthone</u>					
1,2,3,4,6,7-Hexamethoxy	75	b		247,257,280,312,344 (32,800;32,800;15,400;17,700;8,100)	156



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