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[1-17]. Reviews by Robberts[2], Gottlieb[4], Scheinmann[6], and Hostettman[18], concerning chemotoxonomic 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.

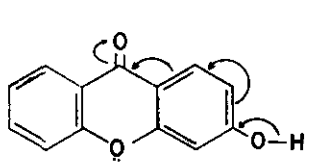
The ultraviolet absorption spectra of most xanthones consist of three intense bands in the region 230-340 nm, and a fourth, less intense, band at higher wavelengths which account for their yellow colour. The utility of ultraviolet spectral studies in assigning the oxygenation pattern of a xanthone is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

The approach is largely emperical which provides information on the general oxygenation pattern of the carbon skeleton of xanthone[20]. 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 it's solubility in

sodium hydrogen carbonate[2,10]. 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[21] 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-methoxyxanthones have been shown to display the usual high acidity of 3-hydroxy derivatives. The mesomeric effect of hydroxy group at different positions in xanthones has been outlined as in structures (1-6).



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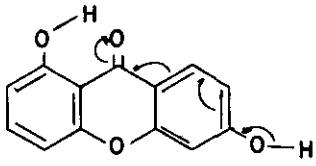

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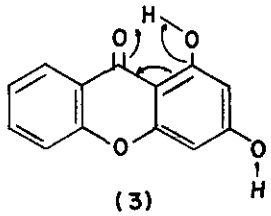

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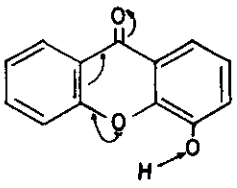

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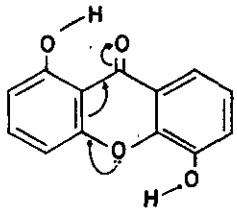

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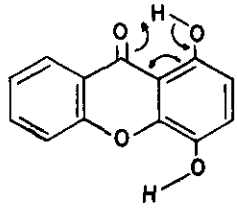


(6)

The UV spectra of 4-hydroxyxanthones 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 differenciate between 3-and 4-hydroxyxanthones for the former shows a hyperchromic shift wheras 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-hydroxyxanthones produce significant alterations than in the 3-hydroxyxanthon (2) series. Thus 4,8-dihydroxyxanthones (5) in the presence of sodium acetate show red shift as compared to the spectra in neutral solution. Whereas 1,4-hydroxyxanthones (6) spectra in neutral solution and in the presence os sodium acetate have been shown to be superimposable[21]. This reflects the acidity of two types of xanthones.

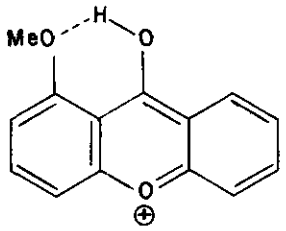
1,6-dihydroxy (2) give identical changes in the ultraviolet spectrum in methanol by addition of either sodium hydroxide or sodium acetate, whereas 1,5-dihydroxyxanthones (5) in sodium hydroxide and sodium acetate are different, indicating partial ionisation of the C-5(OH) group in sodium acetate[16]

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

acetate media are superimposable. Whereas 1-hydroxyxanthones are insoluble even in sodium hydroxide and their UV spectra and those of 1,8-dihydroxyxanthones are unaffected in sodium acetate. However, the presence of C-1(OH) group in xanthones 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 dihydroxyxanthones show the same spectral modifications. However, the presence of o-dihydroxy group in xanthones, is confirmed by observing spectral shifts after addition of boric acid and sodium acetate.

Xanthones 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-hydroxyxanthones are reported[28] to show the high wavelength maximum. However, xanthones with perihydroxyl or a 3-alkayl group, a second maximum of relatively low intensity appears between 430 and 460 nm.

1-methoxyxanthones are shown to be more acidic than their 1-hydroxy counterparts[23,24]. In acidic medium, they are reported to be protonated to give ion (7).



(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. Durate. 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. hanburry. 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. pyrifolium 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 albicaubis 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.) Glig. 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 λ max. nm / ε $\log_e$	Ref.
Mono-oxygenated					
Xanthones					
2-Hydroxy	1,4,6,9	a		237,247 inf. 299,357	6,25-32
	36,38			(28,600;24,200;3,000;4,600)	34,28
			NaOH	252,275 inf. 310	
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			(4.45,4.59,3.80,3.73,3.66)	37,38
			NaOH	235,269,301,311,402	
				(4.44,4.51,3.94,3.94,3.51)	
			NaOAc	234,251,267,293,350	
				(29,200;31,300;12,900;5,100;4,400)	
Dioxygenated					
Xanthones					
1,2-Methylene-dioxy	4	b		246,270 sh,308,353	28
				(45,500;10,600;18,000;14,000)	
2-Hydroxy-1-methoxy	9	b		239,254,275 sh,369	39
				(30,200;27,000;10,100;5,300)	
			NaOH	225,275	
				(29,600;24,700)	
3-Hydroxy-2-methoxy	38	b		240,273,309,349	25
				(32,500;7,100;11,500;10,000)	
			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	34,38
				(4.47,3.97,4.19,4.11)	
			NaOAc	235,292,335,370	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	Ref.
				(4.48,3.98,4.19,3.71)	
1,5-Dihydroxy	1,2,9,14	b		252,318,378	19,27,31
	15,16			(4.62,3.92,3.73)	34,39-46
	27-29		NaOH	252,318,358,416	25
	36-39			(4.62,3.82,3.93,3.86)	
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
				(41.4,7.78,4.97) x 10^{-3}	
6-(3,3-dimethylallyl)-	12,14	b		252.2,317.5,367.5	37,40
1,5-dihydroxy	17-19			(4.62,4.04,3.57)	48-52
(Guanandin)			NaOH	260,315,366,	
				(22,700;4,200;6,500)	
			NaOAc	252,275,320,365	
				(26,400;7,200,7,300;2,800)	
			$AlCl_3$	257.5,340,365	
				(4.45,3.68,3.28)	
Dehydrocycloguanandin	12	b		235,265,305 sh,345	52,53
				(23,500;22,300;4,800;15,300)	
			NaOH	238,250,290,300 sh,346	
				(23,200;22,100;10,600;9,400;10,600)	
			$AlCl_3$	235,275,330,378	
				(22,000;19,700;4,000;10,900)	
6-(4-Hydroxy-3-(meth-	13,17,19	b		234,245,297,365	48
oxybutanyl)-1,5-di-				(29.4,31.5,10.1,5.34) x 10^{-3}	
hydroxy					
Isoguanadin	12	b		235 sh,251,320,376	37,52
4,8-Dihydroxy-1-				(25.7,40.4,2.7,5.0) x 10^{-3}	
(3',3',-dimethylallyl)			NaOH	246,320,350	
				(37,400;6,000;9,600)	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	Ref.
			NaOAc	252,275 sh,323,381	
				(38,000;10,500;10,100;4,400)	
			$AlCl_3$	235 sh,251,274 sh,320,265	
				(25,500;36,000;8,700;7,400;5,100)	
1,7-Dihydroxy	1,2,4,5	b		230.5,280,287,385	18,19,27,
(Euxanthone)	10,14,15			(29,500;36,330;6,700;7,600)	28,31
	21-23		$AlCl_3$	236,277	34,40
	28-30			(43,000;33,400)	42-44
	36,37,39				46,49
	42-44				54-64
1-Hydroxy- 7-methoxy	4,10,36	b		234,260,286,380	28,34
				(4.31,4.40,3.63,3.68)	35,42
			$AlCl_3$	234,277,307,330	59
				(45,600;45,400;13,500;3,000)	
Trioxygenated Xanthones					
1-Methoxy-2,3-dihydro-	9		b	239,255 sh,313,355	29,39
xy				(29,500;20,400;14,300;6,100)	65
			NaOH	231,275,354	
				(29,300;11,200;16,300)	
			NaOAc	235,270 sh,364	
				(34,400;12,400;19,600)	
			$AlCl_3$	235,260,330	
				(24,300;18,300;17,800)	
			H_3BO_3 /	237,315,355	
			NaOAc	(29,600;12,600;7,600)	
3-Hydroxy-1,2-dimeth-	7,9		b	241,280,305,340 sh	29,39
oxy				(35,200;8,700;14,200;7,100)	66,67
			NaOH	233,280 sh,356,	
				(37,500;6,600;20,200)	
			NaOac	234,280 sh,356	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε log$_e$	Ref.
				(34,900;6,600;20,100)	
			$AlCl_3$	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	20,35
				(30.1,28.2,6.1,12.8) x 10^{-3}	
			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	6,20,26
				(26,0,33.4,9.1,9.9,5.4) x 10^{-3}	29,35,39
			NaOH	213,235 sh,275,298,335,396	67,68
				(48.6,24.3,23.1,10.0,7.6,3.95) x 10^{-3}	
			NaOAc	210,236,255,295,305,350	
				(29.1,24.3,24.3,13.6,9.1,6.4) x 10^{-3}	
3-Hydroxy-2,4-dimethoxy	3,6,9	b		240,280,313,350 sh,380	6,26,29,
				(36.9,6.8,13.6,9.4,1.6) x 10^{-3}	65,69,70
4-Hydroxy-2,3-methylenedioxy	3,6	b		244,287,322	20,26,29,
	9,10			(34,000;6,600;12,800)	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,	b		245,280,310	20,35,58,
	10			(35,100;5,800;12,100)	67,69,70
Globuxanthone	44	b		251,267,310 sh,406	71,72
				(35,980;37,440;11,210;9,095)	
2,8-Dihydroxy-1-methoxy	4,9,11,	b		238,262,290,322	28,49,55
	17,21			(26,800;32,800;5,200;4,400)	73-75
			NaOH	254,275,350	
				(31,400;25,300;4,000)	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm /ε $\log_e$	Ref.
			$AlCl_3$	238,277,311,350	
				(28,800;28,500;6,200;4,000)	
1,2-Dimethoxy-8-hydr-	11	b		238,260,290,322	73,74
oxy				(29,800;35,200;5,600;5,000)	
			NaOH	238,263,326	
				(37,600;17,800;7,000)	
			$AlCl_3$	238,276,310,351	
				(31,900;30,800;6,700;4,400)	
2-Hydroxy-1-8-di	17	b		242,257,285,315	49
methoxy				(30,300;31,200;5,700;5,200)	
1,5,6-Trihydroxy	2,13,17-	b		251,315,332	18,25,34,
(Mesuxanthone B)	19,21,27,			(38,130;6,480;15,060)	38,43-45,
	30,36-38,				49,50,55,
	44				56,62,63,76
1,6-Dihydroxy-5-	13,17,18,	b		243,267,313,357	8,45,49
methoxy	21,27			$(39.0,10.5,13.3,8.9) \times 10^{-3}$	55,56
1,6,7-Trihydroxy	2,23,30			251,268 sh,296,313 sh,360	44,57,58
				$(22.1,9.1,8.6,6.9,10.1) \times 10^{-3}$	
Tovoxanthone	45	b		242,265,319	77
				(45,500;36,750;28,500)	
			NaOH	248,330 inf.	
				(45,250;17,050)	
			NaOAc	254,327 inf.	
				(46,500;14,250)	
			$AlCl_3$	243,267,334	
				(46,500;31,300;27,150)	
1,3,5-Trihydroxy	39	b		220 sh,247,313,360 sh	19
				(4.20,4.53,4.21,3.62)	
			NaOH	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 λ max. nm /ε $\log_e$	Ref.
			$AlCl_3$	246,267,335	
				(13,900;22,000;14,700)	
2-(3,3-Dimethylallyi)-	14,18,19	b		235 sh,248,301,358	40,47,
1,3,5-trihydroxy	40			(4.42,4.40,4.26,3.50)	57,76
6-Deoxyjacareubin	8,9,12,	b		240,255, 286,309,369	29,37,41,
	16-19,21,			(19,000;18,900;42,000,19,6000,4,000)	49,51,52,
	22,24,25		NaOH	225,297,344	55,56,68,
				(19,700;37,400;14,900)	76,79-82
			NaOAc	286,296,320 sh,385	
				(35,900;35,400;12,900;3,400)	
			$AlCl_3$	240,251,290,305 sh,348	
				(18,900;19,700;37,900;28,200;10,000)	
1,3-Dihydroxy-5-	3,8,10,	a		240,312,350	6,20,53,
methoxy	12			(35,000;15,200;6,800)	68,81
1,5-Dihydroxy-3-	3,7,9,	b		250,274 sh,310,355	6,8,20,39,
methoxy	10,36,55			(4.43,3.80,4.09,3.4)	67,69
(Mesuaxanthone)			NaOH	240 sh,263,278 sh,344	83
				(23,100;34,400;12,000;13,900)	
			NaOAc	253,287,314	
				(26,400;14,200;12,000)	
			$AlCl_3$	240,267,335	
				(16,900;29,100;15,700)	
5-Hydroxy-1,3-di-	3,5,7-	b		248,304,344	20,29,35,
methoxy	37			(41,800;18,200;4,600)	39,43,60,
			NaOH	241,265,283,308	67,68,70
				(36,900;26,600;26,400;19,800)	
			NaOAc	247,285,303	
				(36,200;14,500;16,700)	
1,3,5-Trihydroxy-4-	40	b		239,244,256,310,318,368	47
(3-methyl-but-2-enyl)				(4.48,4.48,4.45,4.11,4.15,3.62)	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm /ε 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	16,25	b		232,250,275 sh,292,315,380 (3.90,3.85,4.01,4.24,3.84,3.18)	80,85
(3-methylbut-2-enyl) pyrano(3,2-b)-xanthene-6(2H)-one			$AlCl_3$	237,255,280,304,309,357 (4.08,4.02,3.90,4.16,4.18,3.88)	
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) x 10^{-3}	19,76,94
Osajaxanthone	8,10,19, 41,53	b		240,249,285,339,382 (4.27,4.26,4.67,3.90,3.68)	35,52,68, 76,95-98
			NaOH	243,302 (25,400;43,500)	
			$AlCl_3$	235,289,349 (19,600;38,400;8,300)	
Mbarraxanthone (Dimethyl ether)	44	b		233,264.5,314,385 (31.72,41.02,14.22,8.2) x 10^{-3}	71,72
Calabaxanthone	14,16,17			240,287,292 sh,314,384	40,49,80

Compound	Source	Sovl.	Additive	Absorption maxima λ max. nm / ε $\log_e$	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
Tetraoxygenated xanthones					
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
			$NaOAc/H_3BO_3$	224 sh,259,317,368	104-110
			NaOAc	235,256,316,370	
			$AlCl_3$	210,231,266,285 sh,317,351,418	
			$AlCl_3$/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
			$AlCl_3$	231,263,333,396	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	Ref.
				(4.32,4.29,4.13,3.86)	
4-(1,1-dimethylallyl)-	39	a		238,259,273 sh,312,370	19
1,3,6,7-tetrahydroxy				(21,400;25,100;13,100;10,400;10,200)	
(as cyclic derivative)			NaOAc	236,262,298 sh,378	
				(26,400;22,000;5,600;17,400)	
6,7-Dihydroxy-1-	51,52	b		275,338	111
methoxypyrano				(42,000;19,000)	
(2',3':3,4) xanthone			NaOH	268,372	
(Lorostemin)				(39,000;25,000)	
			NaOAc	263,370	
				(38,500;29,600)	
			$NaOAc/H_3$	270,347	
			BO_3	(37,000;19,400)	
			$AlCl_3$	270,350	
				(34,500;17,000)	
Normangostin	31	b		234,260,317,360	112,113
(ν-Mangostin)				(4.48,4.49,4.36,4.05	
Mangostin	28,29,31	b		242,258,308,349	22,46,112,
				(4.54,4.44,4.38,3.86)	114,115
β-Mangostin	31	b		245,258,317,356	112,115,
				(4.55,4.45,4.30,4.10)	116
Tovopyrifolin - A	46	b		279 inf.,292,340	117
				(36,700;46,900;28,200)	
			NaOh	324	
				(29,400)	
			NaOAc	280,337 inf.,386	
				(41,200;18,400;31,400)	
	46,47	b		248,271,330	117,119
				(43,600;53,900;35,300)	
			NaOH	253,272,325	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	Ref.
				(40,200;43,100;24,000)	
Tovophyllin - B	46,47			250 sh,292,392 sh,335	117,118
				(11,900;27,000;24,600;12,800)	
			NaOH	235,262 sh,315	
				(23,700;21,800;24,700)	
Pentadesmaxanthone	41			249,261,279 sh,323,340 sh,370	98
				(4.42,4.51,4.25,4.23,3.89)	
			NaOAc	249,261,279 sh,324,340 sh,370	
				(4.45,4.51,4.25,4.18,4.10,4.06)	
			$AlCl_3$	239,272,289 sh,349,370,420	
				(4.45,4.51,4.25,4.35.4.11,3.92)	
Cudraniaxanthone	92	a		254,283,327	119
				(4.53,4.89,4.23)	
			NaOAc	256,287,345	
			$AlCl_3$	242,257,343	
2-(3,3-Dimethylallyl)-	18-21,23,	a		251,283,324	54-57,78,
1,3,5,6-tetrahydroxy	24,26			(4.42,3.81,4.21)	79
Jacareubin	8,12-22,	b		240,283,332	37,38,40,
	24,26,41			(4.26,4.62,4.28)	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.,	71,72
				(37.57,10.98,27.72,32.38,7.51) x 10^{-3}	
Macluraxanthone	8,53	b		242,283,338,	95,124,125
				(4.31,4.64,4.28)	
10-O-Methylmaclura-	54	b		235,281,293,342,360	126
xanthone				(4.22,4.57,4.49,4.15,4.27)	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm /ε $\log_e$	Ref.
			$AlCl_3$	242,281,290,334	
				(4.31,4.55,4.57,4.27)	
Alvaxanthone	53	b		257,280,332	17
				(4.48,3.94,4.38)	
1,3,5,7-Tetrahydroxy	35	b		237,254,268 sh,312,361	104
				(4.3,4.4,3.9,4.1,3.9)	
Gartanin	31	b		259,284,325 sh,351	112
				(4.3,4.38,3.87,4.05)	
			NaOAc	240,284,380	
				(4.48,4.40,4.34)	
			$AlCl_3$	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	127
				(31,000;38,000;12,300;11,000)	
			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)	
			$AlCl_3$	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	40
				(3.92,3.91,3.87,3.81,3.77,3.56)	
			$AlCl_3$	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	126
				(4.29,4.31,4.63,3.42)	
1,2-Dimethoxy-3,8-dihydroxy	16	b		250 sh,268,305,358	41
				(4.50,4.26,4.29,4.04)	
			NaOAc	235,261 sh,364	
				(4.58,4.26,4.36)	
			$AlCl_3$	234,266,279,327,414	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	Ref.
				(4.51,4.23,4.34,4.25,3.9)	
1,3-Dihydroxy-2,8-di-methoxy	5	b		224,252,296,315,371	60
				(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	
			$AlCl_3$	223,252,280,321	
				(15,100;12,100;9,150;8,350)	
1,3,8-Trihydroxy-7-methoxy	9,55	b		237,262,336	29,83
				(28,100;32,300;17,200)	
			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)	
			$AlCl_3$	225,241,277,328,362	
				(20,700;23,100;28,400;11,900;16,400)	
Tovopyrifolin-B	46	b		247 inf.,257,322,272	117
				(20,200;23,000;18,100;9,200)	
			NaOH	350	
				(9,500)	
			NaOAc	260,286,323	
				(21,000;11,800;14,100)	
			$AlCl_3$	250 inf.,273,330	
				(15,000;19,600;15,800)	
1,4,7-Trihydroxy-3-methoxy	30	b		263,314,380	58
				(27.4,10.1,5.1) x 10^{-3}	
1,5-Dihydroxy-6,7-dimethoxy	49	b		236,260,315,379	128
				(19,600;32,600;11,000;6,400)	
			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 λ max. nm / ε $\log_e$	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-trimethoxy	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-trimethoxy	56,57	b		238,262,300,320 sh,363 (27,600;28,600;11,700;10,600;5,100)	132
Swerchirin (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-trimethoxy (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-trimethoxy	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-trimethoxy	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 λ max. nm / ε $\log_e$	Ref.
(Swertianin)	77,79,80,		NaOAc	270,325,400	141-142
	93,94		$AlCl_3$	246,278,350,430	
			$AlCl_3$/	240,272,330,360,238,256,306,364	
			HCl		
1-Hydroxy-3,7,8-tri-	55,61,62,	a		240,261,312,374	2,14,99
methoxy	64-70,			(24,400;28,300;8,350;3,340)	133-137,
(Decussatin)	77-81,		NaOH	240,261,316,376	139,141
	88,94		NaOAc	240,261,312,376	143
			$AlCl_3$	238,275,330,425	
			$AlCl_3$/	238,275,330,425	
			HCl		
1,7-Dihydroxy-3,8-Di-	61,62,	a		239,261,311,375	135,137,
methoxy	64-71		NaOH	273,310,418	144,141,
(Gentianacaulin)	87		NaOAc	239,261,311,375	147
			$AlCl_3$	236,276,330,428	
			$AlCl_3$/	236,276,330,428	
			HCl		
3,8-Dihydroxy-1,7-	61	a		240,260,308,372	135
dimethoxy					
(Isogentiacaulin)					
1,8-Dihydroxy-3,7-	61,77,80	a		240,263,330	135,139,
dimethoxy (Swertia-	82,87			(4.32,4.46,4.18)	140,144,
peremine,methylswer-					146,99
tianin)					
1,3,7,8-tetrahydroxy	55,62,68,	a		240,266-268,332	99,137,
(Norswertianin)	77,80,81,			(4.37,4.31,3.99)	139-141,
	93		NaOH	238,265,329,385	143,145,
			NaOAc	270,360	146
			$AlCl_3$	244,278,360	
			$AlCl_3$/	240,270,332 sh,360 sh	
			HCl		

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	Ref.
1,3,7,8-tetrahydroxy	59,72,	a		254,278,335,390 sh	8,9,139
(Desmethylbellidifol-in)	77,80,	b		239,267,332,390	145,146
	81			(4.28,4.52,4.10,3.88)	
			NaOAc	250,272,360	
			$AlCl_3$	263,290,328 sh,372	
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	
			NaOAc	255,279,334,390 sh	
			$AlCl_3$	265,291,325,372	
1,3,8-Trihydroxy-5-methoxy (Isobellidifolin)	59,77	b		231,251,276,342	9,10,136
	81			(4.35,4.3,4.2,4.1)	145,146
1,8-Dihydroxy-3,5-dimethoxy (Methylbellidifolin,Swerchirin)	59,77,			230,254,278,300 sh,335	8,133,
	78			(4.3,4.4,4.2,3.8,4.0)	146
1-Hydroxy-3,5,8-trimethoxy	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_2-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 (Decussatin-O-primeveroside)	62,68,	a		242,250,304,355	137,138,
	73,74		NaOMe	242,250,304,355	151,152
			$AlCl_3$	242,250,304,355	
7-Hydroxy-3,8-dimethoxy-1-O-prime-veroside	62,68	a		242,253,304,362	137,138,
			NaOMe	246,275,408	153

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm /ε $\log_e$	Ref.
(Gentiabavaroside)			NaOAC	242,253,304,362	
			$AlCl_3$	242,253,304,362	
1,8-Dihydroxy-3-meth-		a		237,362,330,378	137,153
oxyxanthone-7-O-	62		NaOMe	242,275,330,400	
acetylrutinoside			NaOAc	264 sh,275 sh,330,400	
(Gentiabavarutinoside)			$AlCl_3$	278,339,360,408	
			$AlCl_3$/	273,334,355	
			HCl		
7-8-Dihydroxy-3-meth-	62,68	a		240,270,312,380	137,138,
oxyxanthone-1-O-prime-			NaOMe	246,275,307,435	153
veroside (Isogentia-			NaOAc	240,280,312,380	
kochianoside)			$AlCl_3$	248,280,341,440 sh	
			$AlCl_3$/	245,280,338,440 sh	
			HCl		
3,7,8-Trihydroxy-1-O-	62	a		242,267,315,378	137
primeveroside (Nor-			NaOMe	257,283,305,351	
swertiaprimeveroside)			$AlCl_3$	247,278,347,435	
			$AlCl_3$/	245,278,343,435	
			HCl		
3,7,8-Trihydroxy-1-O-	62,84,85	a		242,267,315,378	137,153
glucoside (Norswertia-			NaOMe	257,283,305,351	
nin-1-O-glucoside)			NaOAc	262,351	
			$AlCl_3$	247,278,347,435	
			$AlCl_3$/	245,278,343,435	
			HCl		
1,7-Dihydroxy-3-meth-	68	a		236,264,315,380	138
oxy-8-O- β -D-gluco-			NaOMe	248,270,308,405	
pyranoside (Swertia-			NaOAc	266,313,400	
nin-8-O-glucoside)			$AlCl_3$	238,276,328,422	
			$AlCl_3$/	238,276,328,422	
			HCl		

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm /ε $\log_e$	Ref.
1,3,5-Trihydroxy-8-O-β-D-glucopyranoside (Demethylbellidifolin-8-O-glucoside)	72	a		252,275,328	149
			NaOMe	233,258,297,358	
			NaOAc	248,266,288 sh,354	
			$AlCl_3$	263 sh,267,283,324 sh,362	
1,5-Dihydroxy-3-methoxy-8-O-β-D-glucopyranoside (Bellidifolin-8-O-glucoside)	72	a		254,276,325	149,154
			NaOMe	248,254,286,344	
			NaOAc	254,277 sh,288,324	
			$AlCl_3$	267,284,324,362	
5,8-Dihydroxy-3-methoxy-1-O-glucoside (Swertianolin)	81,83,93	b		252,275,325 (4.40,4.22,3.95)	11,13,154
3,5,8-Trihydroxy-1-O glucoside (Norswertianolin)	81,86	b		250,275,280,325 (4.38,4.15,3.84)	140,154, 155
			NaOAc	250,275,360	
Pentaoxygenated Xanthones					
3,6-Dihydroxy-1,7,8-trimethoxy	36	b		244,253,283 sh,311,332,358 (4.52,4.59,4.15,4.21,4.88)	34
			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 (12,390;12,290;9,830;3,720)	49
			NaOH	248,282,310 sh,420 (10,930;13,260;3,580;2,500)	
			NaOAc or H_3BO_3/ NaOAc	No alteration	
			$AlCl_3$	238,270,277,324 (11,470;9,670;10,030;7,170)	

Compound	Source	Solv.	Additive	Absorption maxima λ max. nm / ε $\log_e$	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)	
			$AlCl_3$	256,289,335,377 (15,200;18,800;10,200;8,500)	
			$AlCl_3$/ HCl	256,283,330,380 (15,950;17,500;10,200;5,400)	
			NaOAc/ H_3BO_3	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)	
			$AlCl_3$	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 λ max. nm / ε $\log_e$	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	76	b		249,314 (4.52,4.21)	157
(Polygalaxanthone - A)			NaOH	272,357 (3.8,3.76)	
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		227,255,278,352 (4.22,4.27,4.16,4.03)	9,10,158
			NaOAc	225,247,281,371	
			NaOAc/ H_3BO_3	225 sh,250,279,358	
1,3,8-trihydroxy-4,7-dimethoxy (4,7-Di-methoxy bellidifolin)	59	b		238,269,315,346,378 sh (4.27,4.38,3.75,4.02,3.8)	10
			NaOAc	236,272,277 sh,368	
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 λ max. nm / ε $\log_e$	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^{-3}	99
			NaOAc	255,374 (75.2,43.2) x 10^{-3}	
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
Hexaoxygenated Xanthone					
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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