SYNTHESIS OF NEW 10-ARYLTHIOANTHRALINS AND OXIDATION OF THIOANTHRALINS TO THEIR CORRESPONDING SULFONES

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Abstract : *Treatment of 10-bromoanthralin (1) with several thiophenols (2) gave the corresponding 10-arylthioanthralins (3) in high yields. Oxidation of thioanthralins (3a-c) and (3k-m) using an excess of m-chloroperbenzoic acid gave the corresponding sulfones (4a-c) and (4k-m) in good yields. Oxidation of thioanthralins (3d-f) gave a mixture of the corresponding sulfones (4d-f) and anthralin -10, 10´-dehydrodimer (5). Oxidation of thioanthralins (3g-j) afforded only anthralin-10, 10´-dehydrodimer (5) with no evidence of sulfone.*

KEYWORDS: *Anthralin, Dithranol, Psoriasis, Anthrones, Thioanthralins, Sulfonylanthralins.*

INTRODUCTION

Psoriasis occurs worldwide, and is a chronic inflammatory skin disorder characterised by the formation of squamous plaques [1,2]. There is no cure, but it can be controlled by treatment with a variety of drugs [3], of which topical anthralin (dithranol) is particularly important [1-5]. It confers acceptable remission of the symptoms in most patients, but suffers from two particular side-effects which limit its acceptability. These are perilesional irritation, and staining of the skin and other materials with which it comes into contact.

The mechanism of action of anthralin is unknown, but equilibration with its enolic tautomer (1,8,9-trihydroxyanthracene) may be essential. This enol, and the corresponding enolate, are readily oxidised by electron transfer to molecular oxygen yielding the anthralin radical and superoxide, a known irritant; both species are implicated in the staining process [6].

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Several 10-thioanthralins that we have synthesized previously [7,9], have been evaluated clinically and some of them show activity comparable with that of anthralin whilst having markedly reduced side-effects. This evaluation has provided guidlines for improving the efficacy still further, and pointed the way to the design of new thioanthralins which may be even more effective.

We now report on the synthesis of new 10-arylthioanthralins *(3)* and a convenient route to the oxidation of thioanthralins to their corresponding sulfones *(4)* that should be less susceptible to subsequent oxidation and therefore potentially less irritating and less staining.

EXPERIMENTAL

Infrared spectra were obtained using a *Perkin-Elmer* 1710 FT instrument. ^{1}H NMR spectra, referenced to internal tetramethylsilane, were recorded using a *Bruker* AC/300 instrument. Low resolution mass spectra were determined with a *Kratos* MS25 spectrometer, and high resolution spectra with a *Kratos Concept IS* instrument.

10-Arylthio-1,8-dihydroxy-9-anthrone 3a-j; General Procedure

A solution of the thiol(3.3 mmol) and 10-bromo-1,8-dihydroxy-9-anthrone [9,10] (1) (915 mg, 3 mmol) in dichloromethane (20 mL) was stirred at room temperature. The solvent was removed under reduced pressure and the residue recrystallized to give *3a-i.*

To obtain *3j* , the solution was stirred at room temperature overnight, during which time precipitate was formed. The reaction mixture was concentrated to half of its volume, and the precipitate was filtered, washed with hexane-chloroform (4:1) to give the product.

The reaction conditions, melting points, yields, elemental analysis and ^{1}H NMR spectra of the products are reported in Tables 1 and 2.

Table 1: 10-Arylthio-1,8-dihydroxy-9-anthrones (3a-j) prepared

Product	Reaction Time(h)	Yield [%][a]	MP (°C)	Crystn. Solvent	Molecular Formula	Found (%)				Required (%)			
						C	H	F	S	C	H	F	S
3a	5	87 (lit[11],55)	156-157 (lit[11],145)	Hexane/CHCl3 (10:1)	$C_{20}H_{14}O_3S$	71.8	4.2	-	9.9	71.85	4.2	-	9.6
3b	40	90	154-155	Hexane/$CHCl_3$ (3:1)	$C_{20}H_{13}FO_3S$	M 352.0567				M 352.0569			
3c	5	85	132-133	Hexane/$CHCl_3$ (3:1)	$C_{21}H_{16}O_4S$	68.7	4.7	-	8.65	69.2	4.39	-	8.79
3d	5	88	142-143	Hexane/$CHCl_3$ (3:1)	$C_{21}H_{16}O_4S$	69.0	4.3	-	9.0	69.2	4.39	-	8.79
3e	5	85	145-147	Hexane/$CHCl_3$ (2:1)	$C_{20}H_{13}FO_3S$	67.9	3.7	5.4	8.9	68.18	3.69	5.39	9.09
3f	5	82	155-158 (decomp.)	Hexane/$CHCl_3$ (3:1)	$C_{21}H_{13}F_3O_3S$	62.8	3.4	14.1	8.0	62.68	3.24	14.18	7.96
						M 402.0532				M 402.0537			
3g	72	78	164-167 (decomp.)	Hexane/$CHCl_3$ (2:1)	$C_{20}H_9F_5O_3S$	56.4	2.1	22.7	7.3	56.6	2.1	22.4	7.5
3h	5	84	128-129	Hexane/$CHCl_3$ (4:1)	$C_{21}H_{16}O_3S$	72.4	4.65	-	9.5	72.4	4.59	-	9.19
						M 348.0818				M 348.0820			
3i	5	77	131-132	Hexane	$C_{22}H_{18}O_3S$	72.85	5.1	-	8.9	72.9	4.97	-	8.8
3j	16	70	183-184 (decomp.)	Hexane/$CHCl_3$ (4:1)	$C_{20}H_{13}FO_3S$	M 352				M 352			

a: The yields are of recrystallized materials.

Table 2: ^1H NMR spectra of 10-arylthio-1,8-dihydroxy-9-anthrones(3a-j).

Compound	Signal δ[ppm]	Assignment
3a	δ(CDCl3,200MHZ)5.43(s,1H)	H-10
	6.75(dd,J_1=7.5Hz,J_2=1.5Hz,2H)	H-2′+H-6′
	6.90(d,J=7.5Hz, 2H)	H-2+H-7
	7.02(d,J=7Hz,2H)	H-4-H-5
	7.13(t,J=7Hz,2H)	H-3′+H-5′
	7.34(t,J=7Hz,1H)	H-4′
	7.51(t,J=7Hz,1H)	H-3+H-6
	11.83(s,2H)	1-OH+8-OH
3b	δ(CDCl3, 300MHz) 5.44(s,1H)	H-10
	6.52(dt,J_1=7.1Hz,J_2= 1.6Hz, 1H)	H-2′
	6.57(dt,J_1=6.1Hz,J_2= 1.1Hz, 1H)	H-6′
	6.90(d, J=6.8Hz, 2H)	H-2+H-7
	6.98(d, J=6.2Hz, 2H)	H-4+H-5
	7.01(t,J=6.5Hz, each line split into a dd, J_1=1.8Hz, J_2=1.1Hz, 1H)	H-4′
	7.11(td,J_1= 6.1Hz,J_2=1.3Hz,1H)	H-5′
	7.48(t,J=6.5Hz, 2H)	H-3+H-6
	11.87(s,2H)	1-OH+8-OH
3c	δ(CDCl3, 300MHz)3.68(s,3H)	OMe
	5.56(s,1H)	H-10
	6.77(d,J =4.3Hz,1H)	H-3′
	6.83(d,J =8.3Hz,1H)	H-6′
	6.90(d,J =8.8Hz,2H)	H-2+H-7
	6.91(d,J=7.0Hz, 2H)	H-4+H-5
	7.37(t,J=4.5 Hz, 1H)	H-4′ or H-5′
	7.40(t,J=4.5Hz, 1H)	H-5′ or H-4′
	7.45(t,J=7.9Hz, 2H)	H-3+H-6
	11.95(s,2H)	1-OH+8-OH
3d	δ(CDCl3,200MHz)3.77(s,3H)	OMe
	5.34(s,1H)	H-10
	6.63(d,J=9Hz, 2H)	H-3′+H-5′
	6.75(d,J=9Hz, 2H)	H-2′+H-6′
	6.87(dd,J_1= 8.2Hz,J_2=1Hz,2H)	H-2+H-7
	7.00(d,J= 7.6Hz,2H)	H-4+H-5
	7.48(t,J= 7.9Hz,2H)	H-3+H-6
	11.82(s, 2H)	1-OH+8-OH
3e	δ(CDCl3, 300MHz)5.39(s,1H)	H-10
	6.66(dd,J_1= 8.7Hz,J_2=5.5Hz,2H)	H-2′+H-6′
	6.81(t,J=8.7Hz, 2H)	H-3′+H-5′
	6.89(dd,J_1= 8.5Hz,J_2=1Hz,2H)	H-2+H-7
	7.00(d,J=7.5Hz, 2H)	H-4+H-5
	7.50(t,J=8Hz, 2H)	H-3+H-6
	11.83(s, 2H)	1-OH+8-OH
3f	δ(CDCl3, 300MHz)5.49(s,1H)	H-10
	6.91(d,J =7.7Hz, 2H)	H-2′+H-6′
	6.92(d,J =8.2Hz, 2H)	H-2+H-7
	6.99(d,J=7.5 Hz, 2H)	H-4+H-5
	7.38(d,J =7.7Hz, 2H)	H-3′+H-5'
	7.49(t,J =7.9Hz, 2H)	H-3+H-6
	11.85(s, 2H)	1-OH+8-OH
3g	δ(CDCl3, 200MHz)5.47(s,1H)	H-10
	6.74(d,J =7.4Hz, 2H)	H-2+H-7
	6.98(dd,J_1=8.6Hz,J_2=1Hz,2H)	H-4+H-5
	7.44(t,J=8Hz, 2H)	H-3+H-6
	12.00(s, 2H)	1-OH+8-OH
3h	δ(CDCl3, 300MHz)1.84(s,3H)	Me
	5.36(s, 1H)	H-10
	6.74(dd,J_1=7.8Hz,J_2=1Hz,1H)	H-6′
	6.85(d,J=7.4 Hz,2H)	H-2+H-7
	6.90(dd,J_1= 8.3Hz,J_2=1Hz,2H)	H-4+H-5
	6.97(td,J_1=7.5Hz,J_2=1Hz,1H)	H-5′
	7.14(d,J=7.7Hz, 1H)	H-3′
	7.24(td,J_1= 7.4Hz,J_2=1.1Hz,1H)	H-4′
	7.42(t,J=7.8Hz, 2H)	H-3+H-6
	11.86(2,2H)	1-OH+8-OH
3i	δ(CDCl3,200MHz)0.94(t,J=7.5Hz, 3H)	CH3
	2.17(q,J=7.5Hz, 2H)	CH2
	5.35 (s, 1H)	H-10
	6.79(dd,J_1= 7.8Hz,J_2=1.4Hz,1H)	H-6′
	6.82(dd,J_1=7.1Hz,J_2=0.8Hz,2H)	H-2+H-7
	6.90(dd,J_1= 8.4Hz,J_2=1.2Hz,2H)	H-4+H-5
	6.98(td,J_1= 7.45Hz,J_2=1.5Hz,1H)	H-5′
	7.15(dd,J_1= 7.45Hz,J_2=1.2Hz,1H)	H-3′
	7.29(td,J_1= 7.45Hz,J_2=1.4Hz,1H)	H-4′
	7.42(t,J=7.8Hz, 2H)	H-3+H-6
	11.88(s, 2H)	1-OH+8-OH
3j	δ(CDCl3,300MHz)5.48(s,1H)	H-10
	6.71(t,J=7.4Hz, 1H)	H-6′
	6.85(d,J=7.5Hz, 2H)	H-2+H-7 or H-4+H-5
	6.88(dd,J_1= 8.5Hz,J_2=1Hz,2H)	H-4+H-5 or H-2+H-7
	6.91(td,J_1= 7.5Hz,J_2=1.3Hz,1H)	H-5′
	6.98(td,J_1= 8.5Hz,J_2=1.3Hz,1H)	H-4′
	7.28-7.37(m , 1H)	H-3′
	7.40(t,J=8Hz, 2H)	H-3+H-6
	11.93(s, 2H)	1-OH+8-OH

Sulfones (4a-c) and (4k-m); General Procedure

The thioanthralin (1 mmol) was dissolved in acetic acid (20 mL) by heating over steam bath. The solution was allowed to cool to 35°C. It was then added to a solution of m-chloroperbenzoic acid (wet solid 55%, 5.3 g, excess) in acetic acid (20 mL) all at once. The solution was left at room temperature overnight. The precipitate was filtered and washed with cold methanol (10 mL) and dried to give the corresponding sulfone as pale yellow needles.

Melting points, yields, elemental analysis and ^{1}H NMR spectra of the products are reported in Tables 3 and 4.

1,8-Dihydroxy-10-(4-methoxyphenylsulfonyl)-9-anthrone (4d)

This was obtained using the general procedure from 1,8-dihydroxy-10-(4- methoxy phenylthio)-9-anthrone (33 mg) to give pale brown needles (23.4 mg), which was shown by ^{1}H NMR spectroscopy in $CDCl_3$ to be a 7:1 mixture of 1,8-dihydroxy-10-(4- methoxyphenyl sulfonyl)-9-anthrone (δ5.43, H-10) and 1,1′, 8,8′-tetrahydroxy-10,10′-dianthrone (δ4.58, H-10). The mixture was separated by silica gel PLC using chloroform. The first band was isolated to give 1,1′,8,8′-tetrahydroxy-10, 10′-dianthrone (2.8 mg) as yellow needles, MP= 226-227°C (lit 8, MP = 220-223°C) .

The second band was isolated, and recrystallized from hexane-chloroform (2:1) to give the major component, 1,8-dihydroxy-10-(4-methoxyphenylsulfonyl)-9-anthrone (16 mg, 45%) as pale yellow needles, MP = 195-205°C (decomp.) (Found C, 63.5; H, 3.9; S, 8.3 . $C_{21}H_{16}O_6$ S requires C, 63.6; H, 4.04; S, 8.08%).

It had δ($CDCl_3$, 300MHz) 3.84(s, OMe), 5.45 (s, H-10), 6.72(dt, J_1= 9 Hz, J_2= 1.8 Hz, H-2′ + H-6′), 6.88(dt, J_1= 9 Hz, J_2= 1.8 Hz, H-3′ + H-5′), 7.03(dd, J_1= 8.2 Hz, J_2= 1 Hz, H-2 + H-7), 7.18(d, J= 7.4 Hz, H-4 + H-5), 7.57(t,J = 7.8 Hz, H-3 + H-6), 11.71(s, 1-OH + 8-OH); IR: ν_{max}(film) 2916w, 1628s, 1599s, 1482m, 1450s, 1294vs, 1271vs, 1212 s, 1139vs, 833s, 736vs cm^{-1}; MS: m/z - ve FAB (m-nitrobenzyl alcohol) 396 ($M^{\cdot+}$,28), 395(86), 341(36), 320(42), 304(66), 290(37), 274(33), 259(26), 225(64), 215(27), 200(43), 188(100), 171(98), 138(62).

Table 3: Sulfones (4a - c) and (4k - m)

Product	Yield [%]	MP (°C)	Molecular Formula	Found(%)				Required(%)			
				C	H	F	S	C	H	F	S
4a	70	210-220 (decomp.)	$C_{20}H_{14}O_5S$	65.4 M	4.0 366.0569	-	8.5	65.5 M	3.8 366.0562	-	8.7
4b	57	210-220 (decomp.)	$C_{20}H_{13}FO_5S$	62.3 (M+1)	3.4 385.0542	5.1	8.3	62.5 (M+1)	3.38 385.0546	4.94	8.3
4c	72	215-225 (decomp.)	$C_{21}H_{16}O_6S$	63.7	4.1	-	7.9	63.6	4.04	-	8.08
4k	69	210-211	$C_{16}H_{14}O_5S$	60.1	4.4	-	10.3	60.37	4.4	-	10.06
4l	75	190 - 200 (decomp.)	$C_{17}H_{14}O_7S$	57.0	3.75	-	8.7	56.85	3.86	-	8.8
4m	63	192	$C_{18}H_{16}O_7S$	57.25	4.2	-	8.2	57.4	4.25	-	8.5

general procedure from 1,8-dihydroxy-10-(4-trifluoromethylphenylthio)-9-anthrone (80.4 mg). The precipitate was filtered and dried to give pale yellow needles (68.6 mg), shown by ^{1}H NMR spectroscopy to be mainly sulfone with a small amount of tetrahydroxydianthrone. The mixture (20 mg) was separated by silica gel PLC using chloroform.

The first band was isolated to give 1,1′, 8,8′-tetrahydroxy-10,10′-dianthrone(2.4 mg)as yellow needles, MP= 225-227°C (lit 8, MP=220-223°C).

The second band was isolated to give 1,8-dihydroxy-10-(4-trifluoromethylphenylsulfonyl)-9- anthrone (11.9 mg, 47%) as very pale yellow needles, MP= 223 - 225°C. (Found C, 58.3; H, 3.0; F, 13.5; S, 7.6 . $C_{21}H_{13}F_3O_5S$ requires C, 58.06; H, 2.99; F, 13.13; S, 7.37%) .

It had δ($CDCl_3$, 300MHz)5.49 (s, H-10); 7.08 (dd, J_1 = 8.4 Hz, J_2 = 0.9 Hz, H-2 + H-7), 7.14 (d, J = 7.2 Hz, H-4 + H-5), 7.19 (d, J = 8.2 Hz, H-2′ +H-6′),7.55(t, J=7.8 Hz, H-3 + H-5), 7.56 (d, J= 8.2 Hz, H-3′ +H-5′),11.66 (s, 1-OH+ 8-OH); IR: ν_{max}(film)2958b,1628s, 1601s, 1403m, 1322vs, 1270vs, 1146s, 735s cm^{-1}; and MS: m/z + ve FAB (m-nitrobenzyl alcohol) 435 [$(M + 1)^+$, 26], 391(8), 226(80), 225(100), 197 (7), 171(7).

Treatment of 1,8-dihydroxy-10- penta fluorophenylthio-9-anthrone with m-chloroperbenzoic acid.

1,8-Dihydroxy-10-pentafluorophenylthio-9-anthrone (42.4 mg) was dissolved in acetic acid (3 mL), and was then added to a solution of m-chloroperbenzoic acid (wet solid 55%, 627 mg, excess) in acetic acid (2 mL) all at once. The solution was left at room temperature overnight. The precipitate was filtered, washed with cold methanol (3 mL) and dried to give 1,1′,8,8′-tetrahydroxy-10,10′-dianthrone (17.8 mg, 79%) as yellow leaflets, MP= 218 - 220°C (decomp.) (lit 8, MP= 220 - 223°C).

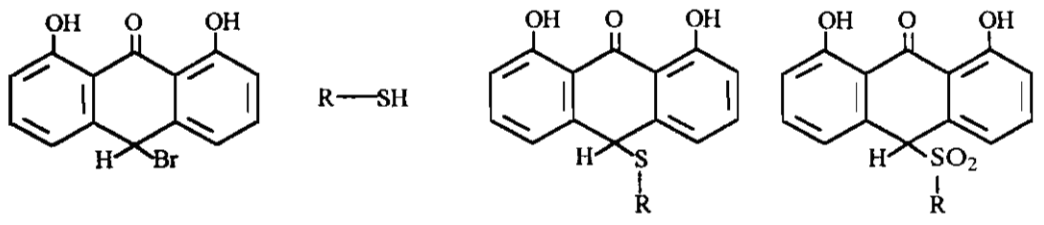
Treatment of (3h), (3i) and (3j) with m-chloroperbenzoic acid.

The reactions were carried out as described in the foregoing procedure to give 1,1′, 8,8′-tetrahydroxy-10, 10′- dianthrone in 81, 61 and 55% yield respectively. The ^{1}H NMR spectrum and TLC were identical with those of an authentic sample.

RESULTS AND DISCUSSION

Treatment of 10-bromoanthralins *(1)* with thiols *(2b)*, *(2c)*, *(2d)*, *(2e)*, *(2f)* and*(2h)* in dry dichloromethane at room temperature gave the corresponding 10-arylthioanthralins *(3b)*, *(3c)*, *(3d)*, *(3e)*, *(3f)* and *(3h)* in high yields and in the case of reactions with thiols *(2g)*, *(2i)* and *(2j)* the corresponding 10-arylthioanthralins *(3g)*, *(3i)* and *(3j)* were formed in lower yields.

Oxidation of the thioanthralins *(3a)*, *(3b)*, *(3c)*, *(3k)*, *(3l)* and *(3m)* using an excess of



(1) *(2)* *(3)* *(4)*

(a) R=C_6H_5-
(b) R=3-FC_6H_4-
(c) R=2-(MeO)C_6H_4-
(d) R=4-(MeO)C_6H_4-
(e) R=4-FC_6H_4-
(f) R=4-(F_3C)C_6H_4-
(g) R=2,3,4,5,6-F_5C_6-
(h) R=2-(Me)C_6H_4-
(i) R=2-(Et)C_6H_4-
(j) R=2-FC_6H_4-
(k) R=C_2H_5-
(l) R=HO_2C-$(CH_2)_2$-
(m) R=MeO_2C-$(CH_2)_2$-

Table 4 : ^{1}***H NMR spectra of sulfones (4a-c) and (4k-m)***

Compound	Signal δ[ppm]	Assignment	Compound	Signal δ[ppm]	Assignment
4a	δ(CD_3COCD_3,300MHZ)6.17(s,1H)	H-10	*4k*	δ($CDCl_3$, 300MHz)1.2(t,J=7.5Hz,	
	7.16(d,J=8.5Hz, 2H)	H-2+H-7		3H)	CH_3
	7.17(d,J=7.5Hz, 2H)	H-4+H-5		2.67(q,J=7.5Hz, 2H)	CH_2
	7.31(dd,J_1=8.3Hz,J_2=1.3Hz, 2H)	H-2´+H-6´		5.42(s, 1H)	H-10
	7.56(t,J=7.9Hz, 2H)	H-3´+H-5´		7.11(d,J=8.5Hz, 2H)	H-2+H-7
	7.69(t,J=8Hz, 2H)	H-3+H-6		7.23(d,J=7.5Hz, 2H)	H-4+H-5
	7.82(tt,J_1=7.5Hz,J_2=1.3Hz, 1H)	H-4´		7.58(t,J=8Hz, 2H)	H-3+H-6
	11.79(s, 2H)	1-OH+8-OH		11.98(s, 2H)	1-OH+8-OH
4b	δ($CDCl_3$, 300MHz)5.48(s,1H)	H-10	*4l*	δ(CD_3CO_2D,300MHZ)2.73(t,	
	6.79(d,J=8Hz, 1H)	H-2´ or H-6´		J=7.5Hz, 2H)	1×CH_2
	6.86(d,J=8Hz, 1H)	H-6´ or H-2´		3.32(t,J=7.5Hz, 2H)	1×CH_2
	7.08(dd,J_1=8.5Hz,J_2=1Hz, 2H)	H-2+H-7		5.88(s, 1H)	H-10
	7.14(d,J=7.2Hz, 2H)	H-4+H-5		7.18(dd,J_1=8.5Hz,J_2=1Hz, 2H)	H-2+H-7
	7.30(tt,J_1=6Hz,J_2=1.6Hz, 2H)	H-4´+H-5´		7.36(d,J=7.2Hz, 2H)	H-4+H-5
	7.56(t,J=7.9Hz, 2H)	H-3+H-6		7.68(t,J=7.9Hz, 2H)	H-3+H-6
	11.73(s, 2H)	1-OH+8-OH	*4m*	δ($CDCl_3$, 300MHz)2.60(t, J=	
4c	δ($CDCl_3$, 300MHz)4.0(s,3H)	OMe		7.5Hz,2H)	1×CH_2
	5.85(s, 1H)	H-10		3.07(t,J=7.5Hz, 2H)	1×CH_2
	6.90(bd,J=7Hz, 1H)	H-3´		3.68(s, 3H)	OMe
	6.92(td,J_1=7.6Hz,J_2=1Hz, 1H)	H-5´		5.51(s, 1H)	H-10
	7.05(dd,J_1=8.3Hz,J_2=1Hz, 2H)	H-2+H-7		7.14(dd,J_1=8.5Hz,J_2=1Hz, 2H)	H-2+H-7
	7.09(d,J=8Hz, 2H)	H-4+H-5		7.24(d,J=7.5Hz,2H)	H-4+H-5
	7.32(dd,J_1=7.9Hz,J_2=1.8Hz, 1H)	H-6´		7.59(dd,J_1=8.5Hz,J_2=7.5Hz, 2H)	H-3+H-6
	7.41(t,J=8.1Hz, 2H)	H-3+H-6		11.98(s, 2H)	1-OH+8-OH
	7.61(td,J_1=7.9Hz,J_2=1.8Hz, 1H)	H-4´			
	11.94(s, 2H)	1-OH+8-OH			

1,8-Dihydroxy-10-(4-fluorophenylsulfonyl)-9-anthrone (4e)

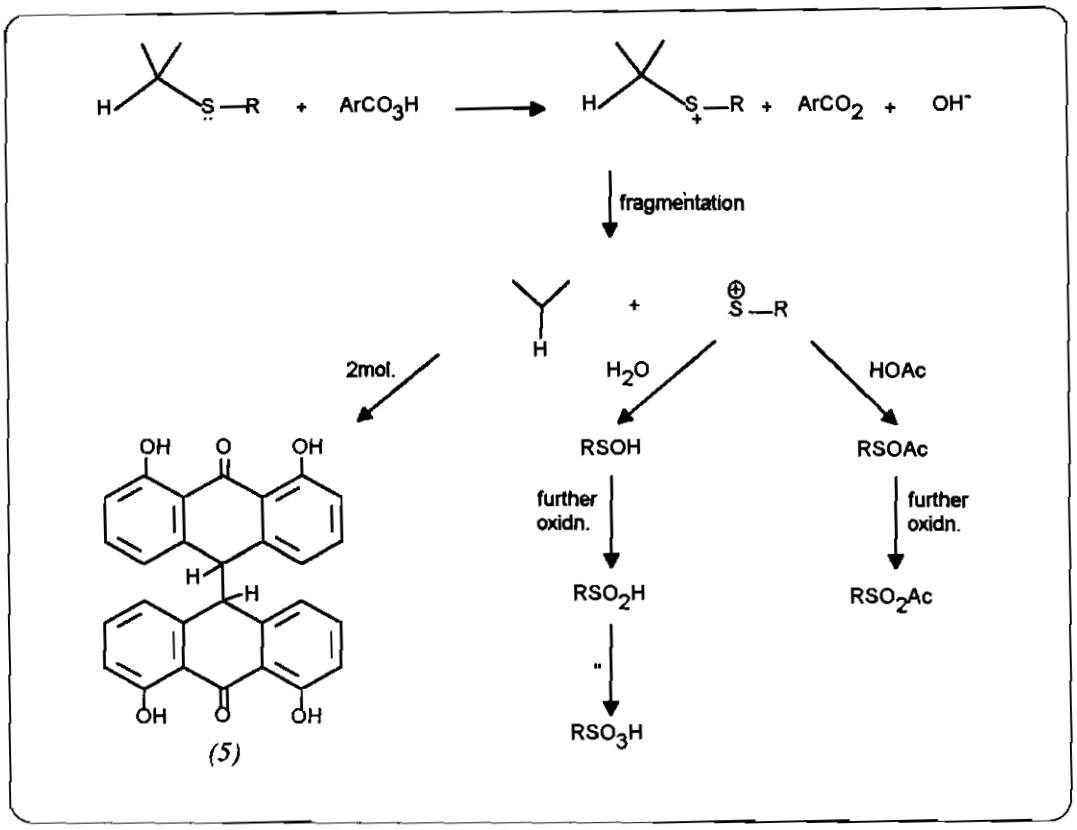
The general procedure was followed: 1,8-dihydroxy-10-(4-fluorophenylthio)-9-anthrone (35.2 mg) gave yellow needles (25 mg), shown by ^{1}H NMR spectroscopy in $CDCl_3$ to be a 3:1 mixture of 1,8-dihydroxy-10- (4-fluorophenyl- sulfonyl)-9-anthrone (δ 5.47, H-10) and 1,1´, 8,8´-tetrahydroxy-10, 10´-dianthrone (δ4.58, H-10). The mixture (16 mg) was separated by silica gel PLC using chloroform. The first band was isolated to give 1,1´,8,8´-tetrahydroxy-10, 10´-dianthrone (2.9 mg) as yellow needles, MP= 225-227°C (lit 8, MP= 220 - 223°C).

The second band was isolated, and recrystallized from hexane-chloroform (2:1) to give 1,8-dihydroxy-10-(4-fluorophenylsulfonyl)-9-anthrone (8.9 mg, 51%) as pale yellow needles, MP= 195 - 200°C (decomp.)

It had δ ($CDCl_3$, 300MHz) 5.47 (s, H-10), 6.97 (t, J =8.9 Hz, H-3´ +H-5´), 7.00 (dd, J_1= 8.9 Hz, J_2 = 5.8 Hz, H-2´ + H-6´), 7.06(dd,J_1= 8.4 Hz, J_2 = 1 Hz, H-2 + H-7), 7.17(d,J = 7.2 Hz, H-4 + H-5), 7.57 (t, J = 7.8 Hz, H-3 + H-5), 11.7(s, 1-OH+8-OH); IR:ν_{max}(film) 2916w, 1630m, 1597s, 1480m, 1449s, 1289s, 1273s, 1221s, 1140vs, 1076vs, 836vs, 755vs, 683vs cm^{-1}; and MS: m/z -ve FAB (m-nitrobenzyl alcohol) 383 $[(M - 1)^-$, 100], 159 ($C_6H_4FSO_2$ + ,10) .

1,8-Dihydroxy-10-(4-trifluoromethylphenylsulfonyl)-9-anthrone (4f)

The compound was obtained using the



m-chloroperbenzoic acid in acetic acid at room temperature gave the corresponding sulfones *(4a), (4b), (4c), (4k), (4l)* and *(4m)* in good yield.

Similarly oxidation of thioanthralins *(3d), (3e)* and *(3f)* gave a mixture of the corresponding sulfones *(4d), (4e)* and *(4f)* and anthralin-10,10′-dehydrodimer *(5)*. The mixtures were separated by chromatography on silica gel.

The mechanism of formation of the dehydrodimer may be as above.

Finally, oxidation of thioanthralins *(3g), (3h), (3i)* and *(3j)* gave only anthralin-10, 10′-dehydrodimer *(5)* with no evidence for formation of the sulfones.

An explanation for the substituent-dependence of the ratio of sulfone to dehydrodimer has yet to be elucidated.

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