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Synthesis of Aryl-sulphinyl Acetic Acids and Sulphoximides, and CD of their *in situ* Complexes with $[\text{Mo}_2(\text{OAc})_4]$

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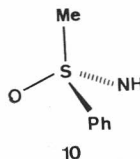
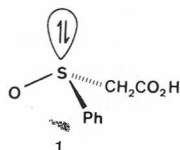
The syntheses of several optically active aryl-sulphinyl acetic acids and sulphoximides are described. They all give two or more Cotton effects in the presence of the metal cluster $[\text{Mo}_2(\text{OAc})_4]$ in DMSO solution above 300 nm, from which their absolute configuration can be determined unequivocally.

1. SYNTHESSES OF ARYL-SULPHINYL ACETIC ACIDS 1—7

All optically active acids used in this study were prepared starting from optically active alkylaryl sulphoxides Ar-S(O)-C(R,R')H by treatment with LDA in THF at 0°C , followed by quenching of the resulting carbanions with carbon dioxide. For details see EXPERIMENTAL.

2. SYNTHESSES OF SULPHOXIMIDES

All optically active sulphoximides used in this study are already known and have been prepared starting either from optically active *p*-tolyl alkyl sulphoxides¹ or dialkyl sulphoxides¹ with *o*-mesitylsulphonyl hydroxylamine



(»MSH«) according to the procedures reported by Johnson et al.² Their optical rotations are also given in Table I. IR and ^1H NMR spectral data were consistent with the assigned structures. Only the enantiomers of optically active methylphenyl sulphoximide 10 were obtained via classical resolution by means of (+)-camphor-10-sulphonic acid³ and had the specific rotations $+36.0$ and -22.0 (Na_D -line, acetone).

TABLE I

Preparation of Optically Active Aryl Sulphinyl Acetic Acids 1 to 7 from Their Corresponding Sulphoxides Ar—S(O)—CRR'H

No	aryl	R	R ¹	[α] _D ^a of sulphoxide	yield (%)	m. p. (°C)	[α] _D ^a
(R)-1	Ph	H	H	+54.5 (C)	31	116—119 ^b	+70.5 (M)
(R)-2	p-Tl	H	H	+131.0 (A)	20	103—105 ^c	+141.0 (M) ^c
(S)-2	p-Tl	H	H	-126.0 (A)	27	103—104 ^c	-162.2 (A) ^c
(R)-4	p-Tl	H	Me	+203.0 (A)	27	93—95	+27.2 (M)
(R)-5	p-Tl	Me	Me	+176.5 (A)	25	111—114	+31.0 (M)
(R)-6	m-Tl	H	H	+38.0 (A)	26	86—90 ^d	+35.0 (M)
(R)-7	o-Tl	H	H	+62.5 (A)	28	85—88	+93.0 (M)

^a A: acetone, C: chloroform, M: methylene chloride

^b Lit. 11: m. p. 119—120 °C, [α]_D = +180.6 (CHCl₃+C₂H₅OH)

^c Lit. 13: m. p. 105—106 °C, [α]_D = +192.4 (acetone) for starting (+)-(R)-sulphoxide

^d Lit. 12: m. p. 90—91 °C (racemate)

3. CHIROPTICAL PROPERTIES OF ACIDS 1—7

Although compounds 1—7 themselves show quite strong Cotton effects⁴ below 300 nm, we were interested to investigate whether optically active *in situ* complexes with transition metal clusters are formed, as we have found for many other chiral ligands.⁵ For this investigation we used as stock complex [Mo₂(OAc)₄], which is known to exchange its acetate ligands easily for other chiral bidentate moieties as e.g. acylates, and obtained two Cotton effects between 400 and 300 nm with 1 through 7. This reminds of the case of other carboxylic acids,⁵ and indeed no complex-induced Cotton effect could be detected for the methylester of (—)-(S)-2. As usual for such complexes, these two Cotton effects have opposite signs, and we found consistently that the compounds with an (S)-configuration have a negative first and a positive second effect (counted, as usual, from long to short wavelengths); for (R)-compounds the enantiomorphous behaviour is observed of course. Below 300 nm the onset of a strong Cotton effect is just detectable, which most probably is the first, very strong Cotton effect of the aryl-sulphoxide chromophore, which is found between 260 and 240 nm, since it always has the same sign as the latter.

4. CHIROPTICAL PROPERTIES OF SULPHOXIMIDES 8—14

Compounds 8 and 9 contain no other chromophore than the sulphoximido group, whereas the others have an aromatic ring directly bound to the sulphur atom. The chiroptical properties of diaryl derivatives have been published,⁶ but the authors mention that the absolute configuration cannot be deduced from the data. All sulphoximides described here show only a very slight and not characteristic Cotton effect below 220 nm.

Since the absorption and CD-spectra of these compounds differ very much, we have also tried to use the *in-situ* method with the same stock complex [Mo₂(OAc)₄]. All the compounds gave (at least) three Cotton effects in the presence of the metal cluster, and they appear around 500, 400, and 350 nm, regardless of whether one was dealing with an alkyl or an aryl group

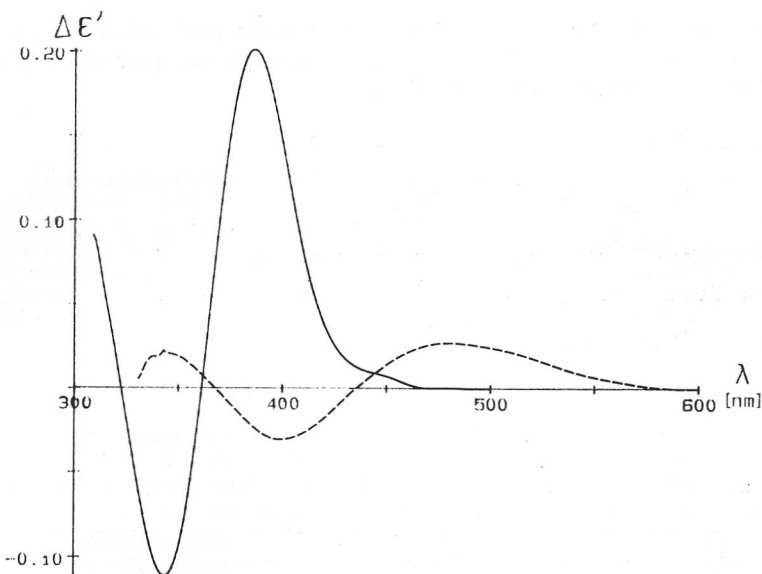


Figure 1. CD of (*R*)-1 (—) and of (*S*)-10 (---) in the presence of $[\text{Mo}_2(\text{OAc})_4]$ in DMSO solution. $\Delta\epsilon'$ refers to concentration of optically active compound.¹⁴

on S. For compounds with (*R*)-configuration (in our cases by chance »larger« and »smaller« groups always have 3. and 4. preference, resp., according to the CAHN-INGOLD-PRELOG rules⁷), this sign pattern for the Cotton effects is (−/+/−) for the three mentioned bands. Additional shoulders or smaller Cotton effects may appear but do not lead to misinterpretation. Since, in general, only bidentate ligands are accepted by the Mo_2 -cluster, most probably the O—S—NH moiety replaces the O—C—O grouping in these complexes.

TABLE II

Preparation of Optically Active Sulphoximides $R-S(O,NH)-R^1$ 8, 9, and 11–14 from Their Corresponding Sulphoxides $R-S(O)-R^1$ and MSH

No	R	R^1	$[\alpha]_D^a$ of sulphoxide	$[\alpha]_D^a$
(R)-8	Me	n-Pr	−44.7 (E)	−3.10 (A)
(R)-9	Me	n-Bu	−36.0 (E)	−2.85 (A)
(R)-11	Me	p-Tl	+131.0 (A)	−28.0 (A)
(R)-12	Et	p-Tl	+203.0 (A)	−21.5 (A)
(R)-13	n-Pr	p-Tl	+188.0 (A)	−18.0 (A)
(R)-14	n-Bu	p-Tl	+186.0 (A)	−16.85 (A)

^a A: acetone, E: ethanol

CONCLUSION

From the CD of such sulphinyl acetic acids and sulfoximides in the presence of the $[\text{Mo}_2(\text{OAc})_4]$ complex, it is always unequivocally possible to determine their absolute configuration.

EXPERIMENTAL

IR spectra were recorded on a Perkin Elmer spectrometer model 257. The ^1H NMR spectra were measured on a Tesla T-60 NMR spectrometer. Optical rotations were measured with a Perkin Elmer 241 M automatic polarimeter. Optically active *p*-tolyl-alkyl sulfoxides were prepared from (—)-(S) menthyl *p*-toluenesulphinate⁸ with the appropriate Grignard reagent in benzene solution.⁹ The other optically active methyl aryl sulfoxides were prepared from (—)-(R)-menthyl methyl sulphinate¹ and the corresponding aryl magnesium halides according to the general procedure developed by Anderson.¹⁰

General Procedure for the Synthesis of Aryl Sulphinyl Acetic Acids

An optically active sulfoxide (5–7 mmol) in dry THF (10 ml) was added to a solution of LDA (10% molar excess) in dry THF (30 ml) at 0 °C and the mixture was stirred at this temperature for 30 min. Then, CO_2 was bubbled through the solution for 20 min, and the reaction was quenched with a saturated solution of NH_4Cl (20 ml). Ether (150 ml) was added and, after acidification with 10% aqueous sulphuric acid solution, the organic layer was brought to dryness *i. vac.* The residue was then subjected to a base-acid work-up, and from the acidic fraction the pure sulfoxide was isolated in the usual way. Yields and physical constants are given in Table I. Compounds 1, 2, and 6 have already been recorded in the literature.^{11–13} The deuterated compounds (R)- and (S)-3 have been prepared by dissolution of (R)- and (S)-2, resp., in CH_3OD using NaOCH_3 as catalyst. After a while, water was added and the work-up was as usual.

(R)-2 ξ -Methyl 2-p-Tolyl Sulphinyl Acetic Acid (4)

IR (CHCl_3): 1720, 1020 cm^{-1} . ^1H NMR ($\text{CDCl}_3 + \text{CD}_3\text{OD}$): $\delta = 1.59$ (d, $J = 7$ Hz, 3H, CH_3CH), 2.39 (s, 3H, $\text{CH}_3\text{C}_6\text{H}_4$), 3.93 (q, $J = 7$ Hz, 1H, $\text{CH}-\text{CH}_3$), 7.45 (AA'BB' system, 4 aromatic H).

Anal. $\text{C}_{10}\text{H}_{12}\text{O}_3\text{S}$ (212.16) calc'd: C 56.56; H 5.70; S 15.11%;
found: C 56.16; H 5.85; S 15.14%.

(R)-2-Dimethyl 2-p-Tolyl Sulphinyl Acetic Acid (5)

IR (CHCl_3): 1710, 1023 cm^{-1} . ^1H NMR ($\text{CDCl}_3 + \text{CD}_3\text{OD}$): $\delta = 1.85$ (s, 6H, $(\text{CH}_3)_2\text{C}-$), 2.39 (s, 3H, $\text{CH}_3-\text{C}_6\text{H}_4$), 7.45 (AA'BB' system, 4 aromatic H).

Anal. $\text{C}_{11}\text{H}_{14}\text{O}_3\text{S}$ (226.17) calc'd: C 58.36; H 6.24; S 14.17%;
found: C 58.06; H 6.35; S 14.35%.

(R)-2-o-Tolyl Sulphinyl Acetic Acid (7)

IR (CHCl_3): 1717, 1010 cm^{-1} . ^1H NMR ($\text{CDCl}_3 + \text{CD}_3\text{OD}$): $\delta = 2.38$ (s, 3H, $\text{CH}_3-\text{C}_6\text{H}_4$); 3.69 (s, 2H, $\text{S}(\text{O})\text{CH}_2\text{CO}_2\text{H}$), 7.35–7.47 (m, 4 aromatic H).

Anal. $\text{C}_9\text{H}_{10}\text{O}_3\text{S}$ (198.14) calc'd: C 54.50; H 5.08; S 16.18%;
found: C 54.31; H 4.95; S 15.99%.

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SAŽETAK

Sinteza aril-sulfinil derivata octene kiseline i sulfoksimida, i CD spektri njihovih in situ kompleksa sa $[\text{Mo}_2(\text{OAc})_4]$

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Opisane su sinteze različitih optičkih aktivnih aril-sulfinil-derivata octene kiseline i sulfoksamida. Svi oni daju dva ili više Cottonovih efekata iznad 300 nm u prisutnosti metalnog klastera $[\text{Mo}_2(\text{OAc})_4]$ u otopini u DMSO, na osnovi kojih se može jednoznačno odrediti njihova apsolutna konfiguracija.