3'-Methylsulfinyl-3,4'-diquinolinyl Sulfides#

Maria J. Maślankiewicz [a] and Andrzej Maślankiewicz* [b]

[a] Institute of Chemistry, Silesian University, Szkolna 9, 40-004 Katowice, Poland
[b] Department of Organic Chemistry, Silesian School of Medicine, Jagiellońska 4, 41-200 Sosnowiec, Poland

Received October 25, 1995

Reactions of 4-methoxy- or 1,4-dihydro-4-oxo-3'-methylthio-3,4'-diquinolinyl sulfides **1** and **7** with a nitrating mixture ran as the 3'-methylthio group *S*-mono-oxidation followed by C_6- and C_8-nitration and led to the mixture composed of products **3**, **4**, **5** and **6** (in the case of substrate **1**) or compounds **5** and **6** (for substrate **7**). In the reaction with hydrochloric acid 4-methoxy-3'-methylsulfinyl-3,4'-diquinolinyl sulfides **3** and **4** could be hydrolysed to 3'-methylsulfinyl-4(1*H*)-quinolinones **5** or **6** respectively, the methylsulfinyl group remaining unaffected.

J. Heterocyclic Chem., **33**, 1153 (1996).

Introduction.

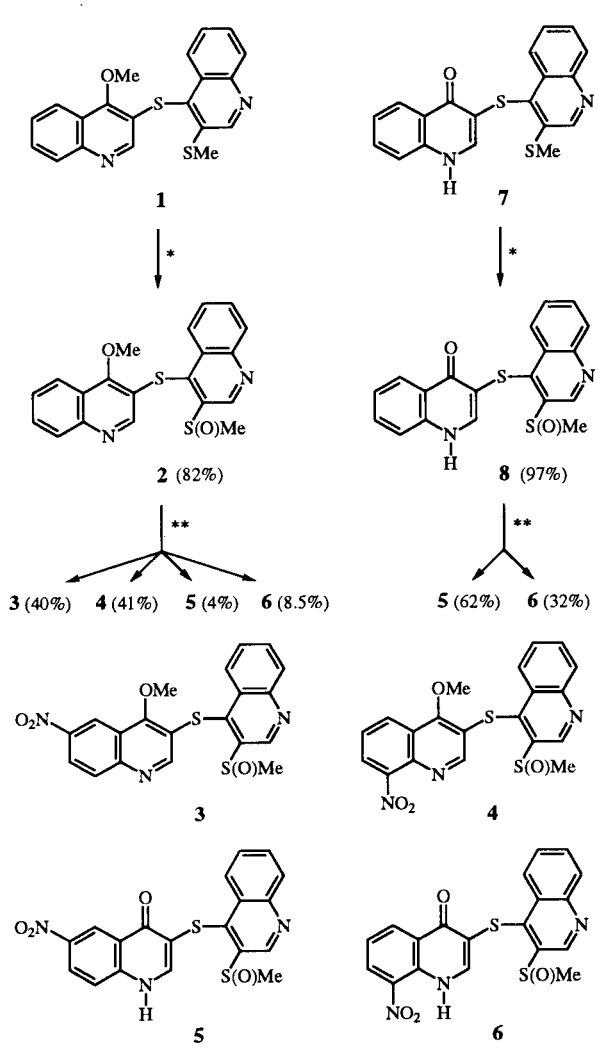
A previously elaborated method in the 3,4-functionalization of quinoline *via* thioquinanthrene supplies many 4-substituted 3'-alkylthio-3,4'-diquinolinyl sulfides [1-6]. Since the most interesting biologically active quinolines are the ones substituted at the benzene ring [7-9], we considered the transformation of 4-substituted 3'-methylthio-3,4'-diquinolinyl sulfides **1** and **7** into their benzene-ring substituted derivatives. The attempted nitration of thioquinanthrene as a precursor of sulfide **1**, provided only *S*-oxidation and led to thioquinanthrene-7-sulfoxide [10]. On the other hand, a report concerning nitration of 4-methoxyquinoline [11] to its 6- and 8-nitro derivatives encouraged us to study the behavior of the title compounds **1** and **7** after treatment with a nitrating mixture.

Reactions of 4-methoxy-3'-methylthio-3,4'-diquinolinyl sulfide **1** with a nitrating mixture led to the mixture of nitration-oxidation products **3** and **4** and hydrolysis-nitration-oxidation products **5** and **6**. To evaluate the sequence of the reactions leading from **1** to hydrolysis-nitration-oxidation products **5** and **6** we also studied the reaction of 4-quinolinone **7** with the nitrating mixture.

Results and Discussion.

Action of concentrated sulfuric acid in the case of both 4(1*H*)-quinolinone derivatives and 4-methoxyquinolines produces very closely related quinolinium species [11,12]. Furthermore, treatment of 4(1*H*)-quinolinones/concentrated sulfuric acid or 4-methoxyquinoline/sulfuric acid systems with the nitrating mixture ran as benzene ring nitration and gave mainly the 6-nitro derivatives or mixtures of 6-and 8-nitro derivatives [11,13,14]. Thus, in spite of the well-known nitric acid oxidation of aryl-alkyl sulfides to aryl-alkyl sulfoxides [15-16], one would expect that treatment of 4-methoxy-3'-methylthio-3,4'-diquinolinyl sulfide **1** with nitric acid would lead to its benzene-ring nitro derivatives. In fact, reaction of diquinolinyl sulfide **1** with nitric acid gave the nitration-oxidation products **3** and **4**, which were, however, accompanied by hydrolysis-nitration-oxidation products **5** and **6**.

Scheme 1



* fuming HNO_3 (1 molar equivalent), 96% H_2SO_4, 0-5°C, 0.5 hours
** fuming HNO_3 (3.6 molar equivalents), 96% H_2SO_4, 0-5°C, 1.5 hours

Structural Assignment of Nitro-sulfoxides **3**, **4**, **5** and **6**.

Elemental analysis and ms data have shown that compounds **3**, **4**, **5** and **6** were formed by addition of one oxygen atom and the introduction of one nitro group to the molecule of sulfide **1** in the reaction with the nitrating mixture. Additionally, in the case of compounds **5** and **6**, hydrolytic splitting of one methyl group took place simultaneously. To study the reaction sequences outlined in the Scheme 1, compounds **2** and **8** were also prepared.

The ir spectra (in potassium bromide pellets) of compounds **2**, **3**, **4**, **5**, **6** and **8** have shown, compared with the starting sulfides **1** or **7**, very strong new bands in sulfoxide region [17] at $\nu_{S=O}$ = 1025-1055 cm^{-1} and in the case of compounds **2**, **3**, **4**, **5** and **6** very strong new bands due to aromatic nitro groups at 1310-1350 cm^{-1} and 1500-1565 cm^{-1}. Data having the best diagnostic value for assigning the sulfinyl group in sulfoxides **2**, **3**, **4**, **5**, **6** and **8** came from the positions of 2'-quinolinyl-type protons. They are deshielded by the *ortho* 3'-methylsulfinyl group 0.37-0.69 or by 0.39-0.69 ppm relative to corresponding sulfide. It fits well with the substituted chemical shifts value of *ortho*-sulfinyl groups $\Delta\delta_{sulfoxide}-\delta_{sulfide}$ = 0.50-0.55 ppm for 3-quinolinyl sulfoxides [10,19] and with $\Delta\delta$ = 0.35 ppm for aryl sulfoxides [18]. Also, the protons of the *S*-methyl groups in sulfoxides **2**, **3**, **4**, **5**, **6** and **8** are deshielded by about $\Delta\delta$ = 0.25-0.35 ppm compared with that for the parent sulfides **1** and **7**.

Since nitromethoxyquinolines **3** and **4** could be hydrolysed to nitro-4(1*H*)-quinolinones **5** or **6**, respectively, the problem with structural assignment in terms of determining the position of nitro group may concern only pairs of compounds **3** and **4** or **5** and **6**. The ^1H nmr spectra of compounds **3**, **4**, **5** and **6** reveal signals due to seven aromatic protons and two signals (singlets) due to α-quinolinyl protons, thus the nitration had to take place at one of the benzene rings of **1**.

Very useful data in the ^1H nmr assignment of quinolines having methoxy, methylamino, methylthio, methyl and alkyl substituents come from NOE experiments with methyl or methylene protons [21-25]. That is why we started the assignment with methoxymethylsulfinylquinoline **2** (prepared for the reasons stated below) and nitromethoxymethylsulfinylquinolines **3** and **4**.

In the case of **2**, ^1H-^1H COSY spectrum allows segregation of eight benzene ring protons into two four-proton ABCD-type groups. They were further assigned, according to the values of $J_{H,H}$ coupling constants and data from the LAOCOON 3 program simulation as *quinolinyl-type* protons. Fortunately, as in the case of sulfide **1** [26], irradiation of methoxy group protons (δ = 4.14 ppm) involves the enhancement of signals due to both the H-5 proton (multiplet, δ = 8.05 ppm) and the H-5' proton (multiplet, δ = 8.31 ppm), by about 1.5% and 0.8% respectively. Since the peri effect induced by the sulfide group is stronger than that of the methoxy group [25-26], the more deshielded multiplet (δ = 8.31 ppm) must be attributed to H-5'. It shows the chemical shift values of other co-protons of both ABCD systems.

The ^1H-^1H COSY spectra show connectivities between seven benzene ring protons in **3** or in **4** and permit their segregation into two groups. The ^1H nmr spectrum of mononitro sulfide **3** exhibits signals due to two groups of the benzene ring protons. The first one is due to four protons of the ABCD system. The signals of the second group prove the presence of three protons of the ABX system with the nitro group at the position 6. They were further assigned, according to the values of $J_{H,H}$ coupling constants and data from the LAOCOON 3 program simulation as quinolinyl-type protons. The latter assignment was in agreement with the substituent effects caused by the nitro group in the benzene ring of nitroquinolines [20 and 19] (see Table 1). Moreover, position of the H-5 proton (doublet of doublet at δ = 9.01 ppm, with $^4J_{H,H}$ = 2.5 Hz, $^5J_{H,H}$ = ~0.5 Hz) was confirmed by the NOE experiment since irradiation of the methoxy group protons (δ = 4.31 ppm) causes enhancement of the H-5 proton signal by 2.2%. The ^1H nmr spectrum of sulfide **4** also reveals signals of two groups of benzene ring protons. The first one is due to four protons of the ABCD system. The signals of the second group confirm the presence of three protons of the ABC system with the nitro group at position **8**. This can be deduced from the values of the substituent effects and values of the coupling constant $J_{H,H}$ due to the nitro group in nitroquinolines [20,13] and is finally supported by results of LAOCOON-3 program simulation. Again, the position of the H-5 proton (doublet of doublet at δ = 8.29 ppm, with $^3J_{H,H}$ = 8.5 Hz and $^4J_{H,H}$ = 1.4 Hz) was confirmed by the NOE experiment since irradiation of methoxy group protons (δ = 4.23 ppm) causes enhancement of H-5 proton by 1.4%.

The ^1H nmr spectra of quinolinones **5** and **6** were inter-

Table 1

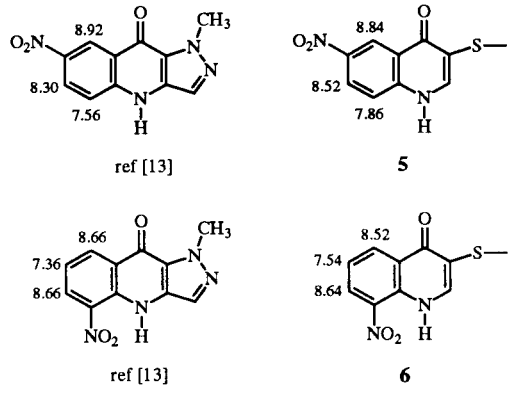
Substituents Effects Caused by the Nitro Group in Bz-nitroquinolines ($x\text{-}O_2N\text{-}Q$) Relative to Quinoline (Q), ref [20], versus those Measured for Nitro-3,4'-diquinolinyl Sulfides **3**, and **4** Relative to 4-Methoxy-3'-methylsulphinyl-3,4'-diquinolinyl Sulfide **2**

	Δδ = δ Nitroquinoline - δ Parent Quinoline			
	Δδ H-5	Δδ H-6	Δδ H-7	Δδ H-8
$5\text{-}O_2N\text{-}Q/Q$	—	0.89	0.22	0.36
$6\text{-}O_2N\text{-}Q/Q$	1.05	—	0.75	0.19
$7\text{-}O_2N\text{-}Q/Q$	0.29	0.79	—	0.76
$8\text{-}O_2N\text{-}Q/Q$	0.31	0.22	0.39	—
3/2	0.96	—	0.75	0.13
4/2	0.24	0.09	0.33	—

preted in the same manner. Positioning of the nitro groups in 4(1*H*)-quinolinone parts of **5** and **6** was based on the comparison of substituent effects and coupling constant values $J_{H,H}$ caused by the nitro group in the benzene ring of 5-nitro- and 7-nitro-4*H*-pyrazolo[4,3-*b*]quinolin-9-ones [13] (see Scheme 2).

The position of the H-5 proton signal (δ = 8.52 ppm) in

Scheme 2



ref [13] **5** ref [13] **6**

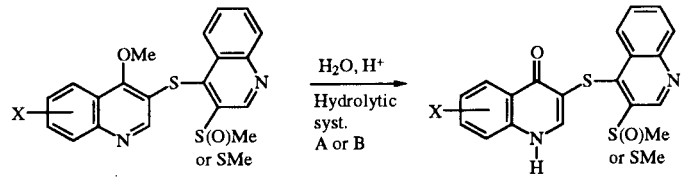
the ^{1}H nmr spectra of compound **6** was confirmed by long-range proton-carbon correlation with C-4 carbon atom (δ_C = 172.6 ppm) found in selective INEPT experiment (in preparation for publication).

Study of the Reaction Sequence Leading from **1** to **3**, **4**, **5** and **6**.

It was of interest for us to explain the formation of products **5** and **6**, starting from sulfide **1**. Considering the 4(1*H*)-quinolinone **7** as a primary product of the reaction of diquinolinyl sulfide **1** with the nitrating mixture, we examined the reaction of **7** with increasing amounts of nitric acid acting both as an oxidant and as a nitrating agent. It appeared that the reaction yields methylsulfinylquinolinone **8** as the primary product and further treatment of **8** with nitric acid run as C_6- and C_8-nitrations to give nitrodiquinolinyl sulfoxides **5** and **6**. Treatment of methylthioquinolinone **7** with total amount of nitric acid yielded immediately 6- and 8-nitrodiquinolinyl sulfoxides **5** and **6**. Thus, the oxidation of 3'-methylthio function in quinolinone **7** should be the first step, but the C_6- and C_8-nitration reactions are sequential in the process of transformation of **7** to **5** and **6**.

However, methoxydiquinolinyl sulfide **1** appeared to be stable in 96% sulfuric acid at 0° for 4 hours. Thus, to find the primary product, the reaction course of **1** with increasing amounts of the nitrating mixture was monitored by tlc. (For this purpose all quinoline bases were isolated in the manner described for the preparation of **2**). After addition of *ca.* 1 molar equivalent of nitric acid we observed complete consumption of starting sulfide **1** and its oxidation to sulfoxide **2**. Futher addition of nitric acid mixture (up to 3.6 molar equivalents of nitric acid) caused the formation of nitromethoxymethylsulfinylquinolines **3** and **4** and nitrosulfinylquinolinones **5** and **6**, even in the case of the non-consumed sulfoxide **2**. It suggests that methoxy-methylsulfinylquinolines **3** and **4** should be the "true" precursors of quinolinones **4** and **5** in the processes presented in the "left" part of Scheme 1. To confirm the hydrolysis ability of 4-methoxyquinoline sulfoxides we treated compounds **2**, **3** and **4** with some potentially hydrolytic systems: **A**) azeotropic hydrochloric acid, 60°, 10 minutes, and **B**) concentrated sulfuric acid, 0°, 24 hours.

Scheme 3



2 (X = H)
3 (X = 6-NO_2)
4 (X = 8-NO_2)

8 (X = H)
5 (X = 6-NO_2)
6 (X = 8-NO_2)

Hydrolytic system: A) HCl_{aq} (1:1), 60°C, 10 minutes, B) conc. H_2SO_4, 0°C, 24 hours.

Substrate	Hydrolytic system	Non-Converted substrate	Products(s) [yield]
2	**A**	45% [a]	**8** (22%), 7 (4%) [a]
2	**B**	83% [a]	**8** (4%) [a]
3	**A**	—	**5** (89%)
3	**B**	71% [a]	**5** (10%) [a]
4	**A**	—	**6** (92%)
4	**B**	76% [a]	**6** (12%) [a]
1	**A**	75% [a]	**7** (17%) [a]
1	**B**	91%	—

[a] The content of substrate in its mixture with product was determined by means of the quantitative tlc method.

The above-presented data show that methoxymethylsulfinylquinolines **2**, **3** and **4** are more sensitive to acid hydrolysis than parent sulfide **1**. Additionally, hydrolysis of **3** and **4** with hydrochloric acid at 60° gave 3'-sulfinyl-4(1*H*)-quinolinones **5** and **6**, respectively, the sulfinyl group remaining unaffected.

Conclusions.

Both substrates **1** and **7** studied represent multifunctional structures. However, in reactions with a nitrating mixture, the 3'-methylthio group of **1** or **7** is the first to react undergoing oxidation to 3'-methylsulfinyl in products **2** or **8** respectively. These primary products then undergo nitration at the positions 6 and 8 of the benzene ring of 4-methoxy- or 1,4-dihydro-4-oxo-3-quinolinyl sulfide moieties of **2** and **8**. The same orientation was observed in the nitration of 4-methoxyquinoline [11], or the 4(1*H*)-quinolinone-type compounds in strong acidic solutions [11,14,13]. During this study no nitration products of 3,4-quinolinediyl bis-sulfide moieties were detected.

As to hydrolysis ability of compounds **2**, **3** and **4**, it seems most probable, that introduction of the sulfoxide moiety in the 3' position disturbs the steric relationship between both pairs of *ortho-ortho'* adjusted heteroatom substituents and therefore makes the environment of the 4-methoxy group more crowded. It should lead to an increase in the hydrolysis susceptibility of methoxysulfoxides **2**, **3** and **4** relative to the parent methoxy sulfide **1**.

EXPERIMENTAL

All melting points are uncorrected. The ^1H nmr spectra were recorded on a Bruker MSL 500 spectrometer at 500.13 MHz in deuteriochloroform (in the case of compounds **2**, **3** and **4**) or in hexadeuteriodimethyl sulfoxide (in the case of compounds **5**, **6** and **8**) solutions with tetramethylsilane (δ 0.0 ppm) as the internal standard. The NOE difference measurements were performed at 500 MHz on the same samples used to determine ^1H nmr spectra. The samples were not degassed and T_1 was determined by an average 3 s by inversion recovery. A signal was irradiated for $5T_1$ = 15 s with decoupling, and an FID acquired without decoupling. Percent enhancements were obtained by integration of the NOE difference spectra. Typically 40 transients were acquired using 16 K data points. All assignments were simulated by the LAOCOON-3 program.

The ir spectra were taken on an UR-10 apparatus (Carl Zeiss, Jena) in potassium bromide pellets. EI mass spectra were determined on a LKB GC MS 2091 spectrometer at 15 and 70 eV and a temperature of 80-100°. CI mass spectra were recorded with Finnigan MAT 95 spectrometer using isobutane as a reagent gas and the temperature of the ion source set at 180°. FAB mass spectra were also recorded on Finnigan MAT 95 spectrometer in FAB mode (Cs^+, 13 keV, nba).

Analyses (tlc) were performed employing Merck's silica gel 60 F_{254} plates and a solution of chloroform-methanol (25 - 2, v/v) as an eluent (system I) or Merck's aluminium oxide 60 F_{254} neutral (type E) plates using mixture of chloroform-methanol (60:1, v/v) as an eluent (system II).

4-Methoxy-3'-methylthio-3,4-diquinolinyl sulfide **1** was prepared from thioquinanthrene and sodium methoxide followed by *S*-methylation with methyl iodide as described previously [1]. 1,4-Dihydro-4-oxo-3'-methylthio-3,4'-diquinolinyl sulfide **7** was prepared by hydrolysis of 4-methoxy-3,4'-diquinolinyl sulfide **1** with boiling azeotropic hydrochloric acid [1].

Reaction of 3,4'-Diquinolinyl Sulfides **1** and **7** with the Nitrating Mixture.

A) General Procedure.

Diquinolinyl sulfide (2.5 mmoles) was dissolved with stirring in 96% sulfuric acid (7.5 ccm) at 0°. The nitrating mixture (fuming nitric acid, d = 1.50 g/ml, 0.4 ml, *ca.* 9 mmoles of nitric acid and 0.4 ml of concentrated sulfuric acid) was then added dropwise at 0-5°. The mixture was maintained at 0° for 1.5 hours, then cautiously poured on 125 g of ice, and neutralized at 0° with concentrated aqueous ammonia to *p*H 5.5. The solid was filtered off, washed twice with cold water, then with cold methanol, and air-dried to give a yellow-colored mixture of products. Their composition was determined by quantitative thin layer chromatography and summarized in the Scheme 1. Column chromatographic separation of the products mixture is described below.

Treatment of sulfoxides **2** or **8** in the manner presented above led to the product mixture of the same composition as for the reactions of the parent sulfides **1** or **7**.

Column Chromatographic Separation of the Products Resulting from Treatment of Sulfide **1** by procedure A.

A solution of the products (1.0 g) in a chloroform/carbon tetrachloride mixture was placed in a chromatographic column packed with silica gel (< 200 mesh) (80 g). The mixture was eluted with the following solvents: chloroform/carbon tetrachloride (1:1, v/v) to give compound **4** (R_f syst I = 0.84); chloroform/carbon tetrachloride (3:1, v/v) to give compound **3** (R_f syst I = 0.81); chloroform/carbon tetrachloride (6:1, v/v) to give compound **2** (R_f syst I = 0.73); chloroform to give compound **6** (R_f syst I = 0.54) and chloroform/methanol (9:1, v/v) to give compound **5** (R_f syst I = 0.22). The eluates were evaporated to dryness and the residue was crystallized from methanol to give the pure compound.

Column Chromatographic Separation of the Products Resulting from Treatment of Sulfide **7** by procedure A.

A solution of the products (*ca.* 1.0 g) in chloroform was placed in a chromatographic column packed with neutral aluminium oxide (Brockmann II) (120 g). The mixture was eluted with chloroform to give compound **6** (R_f syst II = 0.83) and chloroform/methanol (9:1, v/v) to give compound **5** (R_f syst II = 0.32). The eluates were evaporated to dryness and the residue was crystallized from methanol to give the pure compound.

B) Oxidation Procedure Leading to Sulfoxides **2** or **8**.

The solution of diquinolinyl sulfide in concentrated sulfuric acid prepared as in procedure A was treated with *ca.* 1/3 volume of nitrating mixture used in procedure A. The reaction was stopped when the deep-cherry colored reaction mixture turned yellow. The solution was then cautiously poured on 125 g of ice, and neutralized at 0° with concentrated aqueous ammonia, to *p*H 5.5. The solid was filtered off, washed twice with cold water, then with cold methanol, and air-dried. The aqueous filtrate was extracted twice with chloroform (10 ml). The extracts were dried with anhydrous sodium sulfate. The solvent was distilled off to leave the second portion of solid products.

The combined solid products were twice recrystallized from methanol to give pure sulfoxides **2** or **8**.

Hydrolysis of Methoxysulfoxides **2**, **3** or **4** to 4(1*H*)-Quinolinone Derivatives **5**, **6** or **8** with Hydrochloric Acid.

A mixture of 4-methoxy-3'-methylsulfinyl-3,4'-diquinolinyl sulfide **2**, **3** or **4**, (3 mmoles) and azeotropic hydrochloric acid (20 ml) was heated upon stirring at 60° for 10 minutes. The solution was then cooled to 10°. The solid was filtered off and triturated with 5% aqueous sodium bicarbonate solution (20 ml). The resultant solid was filtered off, and air-dried to give crude 4(1*H*)-quinolinone derivatives **5**, **6** or **8** respectively (For results see Scheme 3).

Attempted Hydrolysis of Methoxyquinolines **1**, **2** or **3** with Cold Concentrated Sulfuric Acid.

The solution of diquinolyl sulfide **1**, **2** or **3** (1 mmole) in 96% sulfuric acid (2.5 ml) prepared as in procedure A was kept at 0°

for 24 hours. The organic compounds were then isolated in the typical manner (see procedure A).

4-Methoxy-3'-methylsulfinyl-3,4'-diquinolinyl Sulfide (**2**).

This compound had mp 174-176°, yield 86%, procedure B; ^{1}H nmr (deuteriochloroform): δ 2.89 (s, 3H, CH_3SO); 4.14 (s, 3H, CH_3-O), 7.58 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.4 Hz, ^{4}J = 1.2 Hz, H-6), 7.59 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.3 Hz, ^{4}J = 1.2 Hz, H-6'), 7.68 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.4 Hz, ^{4}J = 1.5 Hz, H-7), 7.80 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.4 Hz, ^{4}J = 1.4 Hz, H-7'), 7.99 (m, 1H, ^{3}J = 8.5 Hz,.^{4}J = 1.2 Hz, ^{5}J = 0.7 Hz, H-8), 8.05 (m, 1H, ^{3}J = 8.5 Hz, ^{4}J = 1.2 Hz, ^{5}J = 0.7 Hz, H-5), 8.23 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.2 Hz, ^{5}J = 0.6 Hz, H-8'), 8.31 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.4 Hz, ^{5}J = 0.6 Hz, H-5'), 8.27 (s, 1H, H-2), 9.49 (s, 1H, H-2'); ir (potassium bromide): $\nu_{S=O}$ = 1035 cm^{-1} , EI ms: (15 eV) m/z (relative intensity) 380 (55.5, M$^+$), 206 (100).

Anal. Calcd. for $C_{20}H_{16}N_2S_2O_2$: C, 63.14; H, 4.24; N, 7.36; S, 16.85. Found: C, 63.28; H, 4.36; N, 7.18; S, 16.69.

4-Methoxy-3'-methylsulfinyl-6-nitro-3,4'-diquinolinyl Sulfide (**3**).

This compound had mp 203-204°, yield 40%, procedure A; ^{1}H nmr (deuteriochloroform): δ 2.95 (s, 3H, CH_3SO), 4.31 (s, 3H, CH_3-O), 7.63 (m, 1H, ^{3}J = 8.2 Hz, ^{3}J = 6.9 Hz, ^{4}J = 1.2 Hz, H-6'), 7.86 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.4 Hz, ^{4}J = 1.3 Hz, H-7'), 8.12 (m, 1H, ^{3}J = 9.2 Hz, ^{5}J = 0.5 Hz, H-8), 8.28 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.2 Hz, ^{5}J = 0.5 Hz, H-8'), 8.28 (m, 1H, ^{3}J = 8.2 Hz, ^{4}J = 1.3 Hz, ^{5}J = 0.5 Hz, H-5'), 8.31 (s, 1H, H-2), 8.43 (m, 1H, ^{3}J = 9.2 Hz, ^{4}J = 2.5 Hz, H-7), 9.01 (m, 1H, ^{4}J = 2.5 Hz, ^{5}J= 0.5 Hz, H-5), 9.52 (s, 1H, H-2'); ir (potassium bromide): $\nu_{S=O}$ = 1055 cm^{-1}, ν_{NO2} = 1340 and 1525 cm^{-1}; ms: EI (15 eV) m/z (relative intensity) 425 (4.04, M$^+$).

Anal. Calcd. for $C_{20}H_{15}N_3S_2O_4$: C, 56.46; H, 3.56; N, 9.88; S, 15.04. Found C, 56.58; H, 3.66; N, 10.10; S, 15.39.

4-Methoxy-3'-methylsulfinyl-8-nitro-3,4'-diquinolinyl Sulfide (**4**).

This compound had mp 182-182.5°, yield 41%, procedure A; ^{1}H nmr (deuteriochloroform): δ 2.93 (s, 3H, CH_3SO), 4.23 (s, 3H, CH_3-O), 7.64 (m, 1H, ^{3}J = 8.3 Hz, ^{3}J = 6.9 Hz, ^{4}J = 1.1 Hz, H-6'), 7.67 (m, 1H, ^{3}J = 8.2 Hz, ^{3}J = 6.9 Hz , ^{4}J = 1.1 Hz, H-6), 7.86 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.4 Hz, ^{4}J = 1.2 Hz, H-7'), 8.01 (m, 1H, ^{3}J = 9.2 Hz, ^{4}J = 2.2 Hz, H-7), 8.26 [2H, (s, 1H, H-2) and (m, 1H, ^{3}J = 8.3 Hz, ^{4}J = 1.4 Hz, ^{5}J = 0.5 Hz, H-5')], 8.28 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.1 Hz, ^{5}J = 0.5 Hz, H-8'), 8.29 (m, 1H, ^{3}J = 8.3 Hz, ^{4}J = 1.4 Hz, H-5), 9.51 (s, 1H, H-2'); ir (potassium bromide): $\nu_{S=O}$ = 1025 cm^{-1}, ν_{NO2} = 1350 and 1520 cm^{-1}; ms: FAB (13 keV) m/z (relative intensity) 426 (66, M$^+$+1).

Anal. Calcd. for $C_{20}H_{15}N_3S_2O_4$: C, 56.46; H, 3.56; N, 9.88; S, 15.04. Found: C, 56.60; H, 3.66; N, 9.97; S, 15.3.

1,4-Dihydro-4-oxo-3'-methylsulfinyl-6-nitro-3,4'-diquinolinyl Sulfide (**5**).

This compound had mp 237-237.5°, yield 62%, procedure A, as a substrate compound **7** was applied; ^{1}H nmr (hexadeuteriodimethyl sulfoxide): δ 3.01 (s, 3H, CH_3SO), 7.68 (m, 1H, ^{3}J = 8.3 Hz, ^{3}J = 6.9 Hz, ^{4}J = 1.4 Hz, H-6'), 7.77 (m, 1H, ^{3}J = 9.2 Hz, ^{5}J = 0.6 Hz, H-8), 7.86 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.3 Hz, ^{4}J = 1.3 Hz, H-7'), 8.15 (m, 1H, ^{3}J = 8.3 Hz, ^{4}J = 1.4 Hz, ^{5}J = 0.5 Hz, H-8'), 8.36 (s, 1H, H-2), 8.41 (m, 1H, ^{3}J = 8.3 Hz, ^{4}J = 1.3 Hz, ^{5}J = 0.5 Hz, H-5'), 8.42 (m, 1H, ^{3}J = 9.2 Hz, ^{4}J = 2.7 Hz, H-7), 8.75 (m, 1H, ^{4}J = 2.7 Hz, ^{5}J = 0.6 Hz, H-5), 9.25 (s, 1H, H-2'), 12.72 (s, 1H, N_1-H); ir (potassium bromide): $\nu_{S=O}$ = 1035 cm^{-1}; ν_{NO2} = 1335 and 1565 cm^{-1}; ms: CI (15 eV) m/z (relative intensity) 412 [13.1, (M + 1)$^+$].

Anal. Calcd. for $C_{19}H_{13}N_3S_2O_4$: C, 55.47; H, 3.19; N, 10.22; S, 15.56. Found: C, 55.29; H, 3.3; N, 10.0; S, 15.69.

1,4-Dihydro-4-oxo-3'-methylsulfinyl-8-nitro-3,4'-diquinolinyl Sulfide (**6**).

This compound had mp 272-274°, yield 32%, procedure A, as a substrate compound **7** was used; ^{1}H nmr (hexadeuteriodimethyl sulfoxide): δ 3.01 (s, 3H, CH_3SO), 7.54 (m, 1H, ^{3}J = 8.0 Hz, ^{3}J = 8.0 Hz, H-6), 7.73 (m, 1H, ^{3}J = 8.3 Hz, ^{3}J = 6.9 Hz, ^{4}J = 1.1 Hz, H-6'), 7.82 (s, 1H, H-2), 7.90 (m, 1H, ^{3}J = 6.9 Hz, ^{3}J = 8.3 Hz, ^{4}J = 1.3 Hz, H-7'), 8.19 (m, 1H, ^{3}J = 8.3 Hz, ^{4}J = 1.1 Hz, ^{5}J = 0.7 Hz, H-8'), 8.41 (m, 1H, ^{3}J = 8.3 Hz, ^{4}J = 1.3 Hz, ^{5}J = 0.7 Hz, H-5'), 8.52 (m, 1H, ^{3}J = 8.0 Hz, ^{4}J = 1.5 Hz, H-5), 8.64 (m, 1H, ^{3}J = 8.0 Hz, ^{4}J = 1.5 Hz, H-7), 9.29 (s, 1H, H-2'), 12.03 (d, 1H, N_1-H); ir (potassium bromide): $\nu_{S=O}$ = 1030 and 1055 cm^{-1}; ν_{NO2} = 1310 and 1500 cm^{-1}; ms: FAB (13 keV) m/z (relative intensity) 412.1 [51.45, (M + 1)$^+$].

Anal. Calcd. for $C_{19}H_{13}N_3S_2O_4$: C, 55.47; H, 3.19; N, 10.22; S, 15.56. Found: C, 55.2; H, 3.3; N, 9.9; S, 15.4.

1,4-Dihydro-4-oxo-3'-methylsulfinyl-3,4'-diquinolinyl Sulfide **8**.

This compound had mp 263-264°, yield 97%, procedure B; ^{1}H nmr: δ (hexadeuteriodimethyl sulfoxide): δ 3.01 (s, 3H, CH_3SO), 7.34 (m, 1H, ^{3}J = 8.1 Hz, ^{3}J = 6.7 Hz, ^{4}J = 1.4 Hz, H-6), 7.59 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.4 Hz, ^{5}J = 0.5 Hz, H-8), 7.66 (m, 1H, ^{3}J = 8.4 Hz, ^{3}J = 7.0 Hz, ^{4}J = 1.3 Hz, H-6'), 7.67 (m, 1H, ^{3}J = 8.4 Hz, ^{3}J = 6.7 Hz, 4J = 1.4 Hz, H-7), 7.84 (m, 1H, ^{3}J = 8.4 Hz, ^{3}J = 7.0 Hz, ^{4}J = 1.4 Hz, H-7'), 8.00 (m, 1H, ^{3}J = 8.1 Hz, ^{4}J = 1.4 Hz, ^{5}J = 0.5 Hz, H-5), 8.13 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.3 Hz, ^{5}J = 0.5 Hz, H-8'), 8.33 (s, 1H, H-2), 8.47 (m, 1H, ^{3}J = 8.4 Hz, ^{4}J = 1.4 Hz, ^{5}J = 0.5 Hz, H-5'), 9.23 (s, 1H, H-2'), 12.25 (s, 1H, N_1-H); Ir (potassium bromide): $\nu_{S=O}$ = 1045 cm^{-1}; ms: CI (15 eV) m/z (relative intensity) 367.1 [4.81, (M + 1)$^+$].

Anal. Calcd. for $C_{19}H_{14}N_2S_2O_2$: C, 62.28; H, 3.85; N, 7.64; S, 17.50. Found: C, 62.1; H, 3.96; N, 7.5; S, 17.39.

REFERENCES AND NOTES

Part **XLI** in the series of Azinyl Sulfides.

[1] A. Maślankiewicz and S. Boryczka, *Recl. Trav. Chim. Pays-Bas*, **112**, 520 (1993).

[2] A. Maślankiewicz and S. Boryczka, *J. Heterocyclic Chem.*, **30**, 1623 (1994).

[3] K. Pluta, *Sulfur Letters*, **13**, 9 (1991).

[4] K. Pluta, *J. Heterocyclic Chem.*, **29**, 1599 (1992).

[5] K. Pluta, A.Maślankiewicz and A. Zięba, *J. Heterocyclic Chem.*, **31**, 447 (1994).

[6] A. Jończyk and K. Pluta, *Bull. Soc. Chim. Belg.*, **95**, 1067 (1986).

[7] H. J. Roth and A. Kleemann, Pharmazeutische Chemie I, Arzneistoffsynthese, Thieme, Stuttgart, New York, 1982.

[8] V. G. Belikov, Pharmacevtitcheskaya Khimiya, Moskva, Vysshaya Shkola, 1985.

[9a] H-J. Senf, *Pharmazie*, **43**, 444 (1988); [b] M. Q. Zhang and A. Haemers, *Pharmazie*, **46**, 687 (1991).

[10] M. J. Maślankiewicz, *Pol. J. Chem.*, **67**, 245 (1993).

[11] R. B. Moodie, J. R. Penton and K. Schofield, *J. Chem. Soc. B*, 1493 (1971).

[12]. W. Campbell in Rodd's Chemistry of Carbon Compounds, II Ed,

Elsevier, Amsterdam, Oxford, New York, 1976, Vol **IV F**, Chapter 26.

[13] Yu. A. Manaev, V. P. Perevalov, M. A. Andreeva, S. R. Grap and B. I. Stepanov, *Khim. Geterocikl. Soed.*, 1084 (1985).

[14] A. Adams and D. H. Hey, *J. Chem. Soc.*, 255 (1949).

[15] A. Polard and R. Robinson, *J. Chem. Soc.*, 3090 (1926).

[16] F. G. Bordwell and B. J. Boutan, *J. Am. Chem. Soc.*, **79**, 717 (1957).

[17] C. M. Hull and T. W. Bargar, *J. Org. Chem.*, **40**, 3152 (1975).

[18] R. Chandrasekaran, S. Perumal and D. A. Wilson, *Magn. Reson. Chem.*, **27**, 360 (1989).

[19] M. J. Maślankiewicz, *Pol. J. Chem.*, **68**, 2545 (1994).

[20] P. Hamm and W. von Philipsborn, *Helv. Chim. Acta*, **54**, 2363 (1971).

[21] D. Neuhaus and M. P. Williamson, The nuclear Overhauser Effect in Structural and Conformational Analysis, Verlag Chemie, Weinheim, New York, 1988.

[22] H. Gunther, NMR-Spektroskopie, III ed, Thieme Verlag, Stuttgart, New York, 1992, pp 358-364.

[23] A. G. Osborn, J. F. Warmsley and G. T. Dimitrova, *J. Nat. Prod.*, **55**, 589 (1992).

[24] M. P. Hutt and F. A. McKellar, *J. Heterocyclic Chem.*, **21**, 349 (1984).

[25] S. Boryczka, A. Maślankiewicz, M.Wyszomirski, T. Borowiak and M. Kubicki, *Recl. Trav. Chim. Pays-Bas*, **109**, 509 (1990).

[26] M.Wyszomirski, A. Gogoll, A. Maślankiewicz and S. Boryczka, *Phosphorus, Sulphur, Silicon*, **59**, 225 (1991).