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SULFENNAPHTHOQUINONES

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Abstract. Thiols, sulfenchlorides, sulfenates and sulfenamides of 1,4-naphthoquinone were synthesized and different methods of their synthesis were investigated. Synthesized thiols, sulfenates and sulfenamides are stable due to the large electron-withdrawing potential of the conjugated quinonic system. Computer and screening with the program PASS C&T and biological screening indicates the necessity of following evaluations of compounds of this combination.

Key words: thiol, sulfenchloride, sulfenate, sulfenamide, naphthoquinone.

1. Introduction

Intensive development of chemistry of sulfur-containing organic substances is due to their important scientific and practical significance. According to their unique properties these compounds were studied thoroughly. Different drugs were found among them, all of them possessing anti-inflammatory, antivirus and bactericide properties. Recently pharmaceutics and scientists have been greatly interested in sulfenic-containing substances because they are synthones for further conversions and they are compounds with a wide spectrum of biological activity.

They are used as synthons in preparations of such pharmaceutical preparations as phtalan, captan [1, 2], euparen, euparen–M [3, 4] and vulcanizing agents [5-10]. Besides, the derivatives of 1,4-naphthoquinone have revealed themselves as bacteriostatic, antiviral and fungistatic activity substances. The drugs based on the naphthoquinone possess a high antioxidant, anticancer and cytostatic activity.

The compounds containing sulfenalkyl- or sulfenalryl substitutient and naphthoquinone fragment have been unknown till present. The combination of such substitutients extend the possibility of usage of these sulfennaphthoquinones in different chemical conversions giving possibility to predict the existence of exceptional physico-chemical properties and biological activity in a wide spectrum of activity making the synthesis and investigation of this class compounds very important.

2. Experimental

Melting points were measured on a Nagema melting-point apparatus and are uncorrected. ^{1}H NMR spectra was recorded on Varian VXR (300 MHz) spectrometer as solutions in DMSO-d_6 with TMS as a internal standard. IR spectra were recorded on Specord M80 in tablets KBr.

Materials. 2-R-3-chloro-1,4-naphthoquinones **2a-h** [11].

2.1. General procedure of synthesis of 2-R-3-mercapto-1,4-naphthoquinones 3a-h

Method A. To a water-ethanol solution of 2-R-3-chloro-1,4-naphthoquinone (9.6 mmol) added a water solution of sodium sulfide (0.026 mol). Reaction mixture was warmed up for 3 hours, cooled and filtered. The filtrate was acidificated and brown crystals of thiol dropped of it which was washed by water and dried.

Method B. 0.024 mol of 2-R-3-chloro-1,4-naphthoquinone, 0.024 mol of thiocarbamide were suspended and then boiled during 12 hours. Then the solvent was evaporated in vacuo. Water solution of 0.109 mol of potassium hydroxide was added to isothiuronic salt and was boiled for 6 hours. Then the reaction mixture was filtered, the filtrate was acidificated, crystals were filtered and washed by diluted hydrochloric acid and dried. Residue was recrystallized from DMF/ethanol.

The constants of compounds **3a, 3g** obtained by both methods (see Table 1), match with the earlier described in the literature [12].

2.2. General procedure of sulfenchloride-1,4-naphthoquinones 4a-h synthesis

Method A. 0.05 mol of thiol and 0.05 mol of N-chlorosuccinimide were suspended in carbontetrachloride. The reaction mixture was left at room temperature for 24 hours and filtered. The precipitate was washed by small amount of carbontetrachloride. The filtrate was evaporated. The residue was recrystallized from benzene.

Method B. 0.1mol of Cl_2 (solution in CCl_4) was added to 0.05 mol of thiol suspended in carbontetrachloride,. The reaction mixture was left at room temperature for 24 hours and filtered. The precipitate was washed by small amount of carbontetrachloride. The filtrate evaporated. The residue was recrystallized from benzene (see Table 2).

Table 1

Data of 2-R-3-mercapto-1,4-naphthoquinones 3a-h

№	Formula, mp, K	Yield, %A/B	Calculated / Found, %				^{1}H NMR (δ, ppm)	IR, cm^{-1}
			C	H	N	S		
3a	$C_{12}H_{12}SNO_2$ 563-565	85/81	58.54 / 58.47	3.41 / 3.35	6.83 / 6.78	15.61 / 15.59	δ 7,63-8,29 (6H, m, ArH and NH_2); 8,51 (1H, s, SH);	2850 (SH), 1660 (C=O), 1351 (*tert*-N)
3b	$C_{14}H_{15}SNO_2$ 518-520	75/84	64.37 / 64.42	5.75 / 5.82	5.36 / 5.31	12.26 / 12.34	δ 1,08 (6H, t, CH_3), 3,42 (4H, q, CH_2), 7,56; 7,68 (2H, td, CH_{Ar}), 7,99;8,03 (2H, dd, CH_{Ar}), 8,52 (1H, s, SH);	2850 (SH), 1664 (C=O), 1350 (*tert*-N)
3c	$C_{16}H_{19}SNO_2$ 551	69/87	66.44 / 66.37	6.57 / 6.48	4.84 / 4.91	11.07 / 11.02	δ 0,89 (6H, t, $^3J_{HH}$=9,2 Hz, CH_3), 1,28 (8H, m, CH_2), 3,07 (4H, m, CH_2), 7,56;7,65 (2H, td, CH_{Ar}), 7,98;8,08 (2H, dd, CH_{Ar}), 8,53 (1H, s, SH);	2858 (SH), 1658 (C=O), 1360 (*tert*-N)
3d	$C_{15}H_{15}SNO_2$ 464	78/85	65.93 / 65.85	5.49 / 5.52	5.13 / 5.21	11.72 / 11.68	δ 1,31 (6H, m, CH_2), 3,72 (4H, m, CH_2), 7,6; 7,74 (2H, td, CH_{Ar}), 7,98;8,03 (2H, dd, CH_{Ar}), 8,48 (1H,s,SH);	2852 (SH), 1654 (C=O), 1362 (*tert*-N)
3e	$C_{14}H_{13}SNO_3$ 558	75/83	61.09 / 61.12	4.72 / 4.65	5.09 / 6.99	11.64 / 11.71	δ 3,51 (8H, m, $CH_{2\ morpholine}$), 7,47;7,67 (2H, td, CH_{Ar}), 8,03;8,06 (2H, dd, CH_{Ar}), 8,49 (1H,s,SH);	2855 (SH), 1658 (C=O), 1340 (*tert*-N)
3g	$C_{16}H_{11}SNO_2$ 554	78/85	68.33 / 68.42	3.91 / 3.87	4.98 / 4.87	11.38 / 11.45	δ 7,11 (5H, m, Ar), 7,35 (1H, s broad, NH), 7,59; 7,77 (2H, td, CH_{Ar}), 7,61;8,11 (2H, dd, CH_{Ar}), 8,49 (1H, s, SH);	3175 (-NH-), 2860 (SH), 1650 (C=O)
3h	$C_{16}H_{10}SNO_2$ 451-452	77/87	77.41 / 77.52	4.03 / 3.98	5.65 / 5.52	12.90 / 12.82	δ 6,98 (2H, d, $^3J_{HH}$ =8,3 Hz, CH_{Ar}), 7,2 (2H, d, $^3J_{HH}$ =8,4 Hz, CH_{Ar}), 7,42 (2H, s broad, NH), 7,66; 7,74 (2H, td, CH_{Ar}), 8,13;8,16 (2H, dd, CH_{Ar}), 8,47 (1H, s, SH);	3175 (-NH-), 2850 (SH), 1665 (C=O)

Table 2

Data of 2-R-3- sulfenchloride-1,4-naphthoquinones 4a-h

№	Formula, mp, K	Yield, % A/B	Calculated / Found, %					^{1}H NMR (δ, ppm)	IR, cm^{-1}
			C	H	S	Cl	N		
4a	$C_{10}H_6NSClO_2$ 389	66/63	56.85 / 56.91	4.77 / 4.80	10.84 / 10.67	11.99 / 11.84	4.74 / 4.65	7,63-8,29 (6H, m, ArH and NH_2);	1655 (C=O), 1358 (*tert*-N)
4b	$C_{14}H_{14}NSClO_2$ 397	59/54	61.44 / 61.32	6.30 / 6.37	9.11 / 9.01	10.07 / 10.11	3.98 / 3.91	1,08 (12H, t, CH_3), 3,41 (8H, q, CH_2), 7,66; 7,56 (4H, td, CH_{Ar}), 8,12;8,05 (4H, dd, CH_{Ar});	1650 (C=O), 1350 (*tert*-N)
4c	$C_{18}H_{22}NSClO_2$ 429	68/65	58.53 / 58.42	4.58 / 4.46	10.42 / 10.46	11.52 / 11.54	4.55 / 4.60	0,84 (12H, t, $^3J_{HH}$=9,3 Hz, CH_3), 1,32 (16H, m, CH_2), 3,06 (8H, m, CH_2), 8,03; 8,04 (4H, td, CH_{Ar}), 8,12;8,17 (4H, dd, CH_{Ar});	1655 (C=O), 1360 (*tert*-N)
4d	$C_{14}H_{18}NSClO_2$ 390	72/75	54.28 / 54.29	3.90 / 3.87	10.35 / 10.42	11.44 / 11.39	4.52 / 4.56	1,31 (12H, m, CH_2), 3,71 (8H, m, CH_2), 7,46; 7,78 (4H, td, CH_{Ar}), 7,98;8,17 (4H, dd, CH_{Ar});	1620, 1656 (C=O), 1340 (*tert*-N)
4e	$C_{14}H_{12}NSClO_3$ 407	6765	60.86 / 60.79	3.19 / 3.21	10.15 / 10.18	11.23 / 11.29	4.44 / 4.46	δ 3,49 (16H, m, $CH_{2\ morpholine}$), 7,56;7,67 (4H, td, CH_{Ar}), 8,02;8,05 (4H, dd, CH_{Ar});	1612, 1648 (C=O), 1355 (*tert*-N)
4g	$C_{16}H_{10}NSClO_2$ 435	73/72	54.87 / 54.76	2.59 / 2.61	9.16 / 9.21	20.25 / 20.31	4.00 / 4.01	δ 7,05 (10H, m, Ar), 7,33 (2H, s broad, NH), 7,62; 7,82 (4H, td, CH_{Ar}), 7,66;8,05 (4H, dd, CH_{Ar});	3160 (-NH-), 1610, 1650 (C=O)
4h	$C_{16}H_9NSCl_2O_2$ 418	62/61	52.45 / 52.36	2,14 / 2.17	9.97 / 9.89	15.53 / 15.63	4.50 / 4.42	6,94 (4H, d, $^3J_{HH}$ =8,4 Hz, CH_{Ar}), 7,1 (4H, d, $^3J_{HH}$ =8,4 Hz, CH_{Ar}), 7,41 (2H, s broad, NH), 7,63; 7,70 (4H, td, CH_{Ar}), 8,16;8,19 (4H, dd, CH_{Ar});	3160 (-NH-), 1612, 1648 (C=O)

2.3. General procedure of sulfenates synthesis of 1,4-naphthoquinone 5-11a,b

The mixture of alcohol (0.2 mol) and triethylamine (0.2 mol) was stirred for 10 min. in benzene. Benzene solution of sulfenchloride (0.2 mol) was added. The reaction mixture was left at room temperature for 24 hours, than warmed up 313 K for 5-6 hours. The reaction mixture was evaporated. The residue was recrystallized from hexane (see Table 3).

Table 3

Data of sulfenates of 1,4-naphthoquinone 5-11a,b

№	Formula, mp, K	Yield, %	Calculated / Found, %					^{1}H (δ, ppm)	IR, cm^{-1}
			C	H	S	N	Cl		
5a	$C_{11}H_9NSO_3$ 359	70	61,83 / 61,85	5,88 / 5,94	11,00 / 11,02	4,81 / 4,75		7,63;7,75 (2H, td, CH_{Ar}), 7,98;8,01 (2H, dd, CH_{Ar}); 6,7(2H, s, NH_2); 2,7 (3H, s, -OCH_3)	2813(OCH_3),1655(C=O), 1358(*tert*-N), 1590(NH_2)
5b	$C_{12}H_{11}NSO_3$ 335	73	62,93 / 62,98	6,27 / 6,31	10,50 / 10,47	4,59 / 4,61		7,66; 7,56 (4H, td, CH_{Ar}), 8,12;8,05 (4H, dd, CH_{Ar});6,73(2H, s, NH_2); 3,97(2H, q, CH_2); 1,1(3H, s, CH_3)	1640(C=O),1560(NH_2), 1370(CH_3)
6a	$C_{15}H_{17}NSO_3$ 364	73	64,84 / 64,87	6,95 / 6,98	9,62 / 9,64	4,20 / 4,26		7,56; 7,67 (4H, td, CH_{Ar}), 8,17;8,10(4H, dd, CH_{Ar}); 3,44-3,49(4H, m, -$N(CH_2)_2$); 2,78(3H, s, -OCH_3); 1,13(6H, t, $2CH_3$)	2817(OCH_3), 1648(C=O),
6b	$C_{16}H_{19}NSO_3$ 371	69	65,68 / 65,70	7,25 / 7,28	9,23 / 9,21	4,03 / 4,01		7,72; 7,63 (4H, td, CH_{Ar}), 8,12;8,04 (4H, dd, CH_{Ar}); 3,98(2H, m, -OCH_2); 3,44-3,49(4H, m, -$N(CH_2)_2$); 3,96(2H, q, -OCH_2);	1665(C=O), 1380(CH_3)
7a	$C_{19}H_{25}NSO_3$ 351	68	63,35 / 63,40	5,65 / 5,60	10,57 / 10,58	4,62 / 4,64		7,65; 7,57 (4H, td, CH_{Ar}), 8,14;8,07 (4H, dd, CH_{Ar}); 3,03-3,21(4H, m, $2CH_2$); 2,75(3H, s, -OCH_3); 1,23-1,41(4H, m, $2CH_2$); 0,8-0,98(6H, t, $2CH_3$)	2810(OCH_3), 1660(C=O), 1380(CH_3)
7b	$C_{20}H_{27}NSO_3$ 365	72	64,33 / 64,37	6,03 / 6,07	10,10 / 10,07	4,41 / 4,38		7,81; 7,69 (4H, td, CH_{Ar}), 8,15;8,08 (4H, dd, CH_{Ar}); 3,95-4,00(2H, m, -OCH_2); 3,08-3,13(4H, m, -$N(CH_2)_2$); 1,23-1,39(8H, m, $4CH_2$); 1,10(3H, t, CH_3); 0,86-0,91(6H, t, $2CH_3$)	1610(C=O), 1375(CH_3)
8a	$C_{16}H_{17}NSO_3$ 392	76	59,00 / 59,03	4,95 / 4,91	10,50 / 10,47	4,59 / 4,60		7,71; 7,64 (4H, td, CH_{Ar}), 8,20;8,16 (4H, dd, CH_{Ar}); 3,65-3,85(4H, m, -$N(CH_2)_2$); 2,76(3H, s, -OCH_3); 1,24-1,54(6H, m, $2CH_3$)	2810(OCH_3), 1660(C=O), 1362(*tert*-N),
8b	$C_{17}H_{19}NSO_3$ 391	71	60,17 / 60,23	5,37 / 5,35	10,04 / 10,05	4,39 / 4,41		7,63; 7,52 (4H, td, CH_{Ar}), 8,12;8,02 (4H, dd, CH_{Ar}); 3,69-3,83(4H, m, -$N(CH_2)_2$); 4,01(2H, m, -OCH_2); 1,27-1,41(6H, m, $2CH_3$); 1,19(3H, t, CH_3)	1661(C=O), 1470(CH_3), 1345(*tert*-N)
9a	$C_{15}H_{15}NSO_4$ 415	73	65,53 / 65,51	4,21 / 4,27	10,30 / 10,34	4,60 / 4,58		7,66; 7,56 (4H, td, CH_{Ar}), 8,12;8,05 (4H, dd, CH_{Ar}); 3,63-3,71(4H, m, -$N(CH_2)_2$); 3,33-3,51(4H, m, -$O(CH_2)_2$); 2,76(3H, s, -OCH_3)	2819(OCH_3), 1649(C=O), 1340(*tert*-N),
9b	$C_{16}H_{17}NSO_4$ 404	76	66,44 / 66,42	4,65 / 4,67	9,85 / 9,89	4,30 / 4,35		7,65; 7,79 (4H, td, CH_{Ar}), 8,12;8,05 (4H, dd, CH_{Ar}); 3,96(2H, q, -OCH_2); 3,61-3,72(4H, m, -$N(CH_2)_2$); 3,38-3,51(4H, m, -$O(CH_2)_2$); 1,15(3H, t, CH_3)	1661(C=O), 1450(CH_3), 1348(*tert*-N)
10a	$C_{17}H_{13}NSO_3$ 397	67	59,05 / 59,00	3,05 / 3,08	9,27 / 9,31	4,05 / 4,01		7,79; 7,81 (4H, td, CH_{Ar}), 8,15;8,05 (4H, dd, CH_{Ar}); 7,98(1H, s, -NH); 7,06-7,45(5H, m, CH_{Ar}); 2,85(3H, s, -OCH_3)	3160(-NH-), 2820(OCH_3), 1649(C=O), 1600(Ar)
10b	$C_{18}H_{15}NSO_3$ 401	69	60,08 / 60,11	3,92 / 3,95	8,91 / 8,93	3,89 / 3,85		7,66; 7,56 (4H, td, CH_{Ar}), 8,12;8,05 (4H, dd, CH_{Ar}); 7,83(1H, s, -NH); 7,07-7,27(5H, m, CH_{Ar}); 3,96(2H, t, CH_2); 1,1(3H, t, CH_3)	3158(-NH-), 1660(C=O), 1500(Ar), 1470(CH_3)
11a	$C_{17}H_{12}NClSO_3$ 408	71	51,88 / 51,91	2,77 / 2,79	12,59 / 12,61	4,05 / 4,10	13,92 / 13,90	7,66; 7,78(4H, td, CH_{Ar}), 8,08;8,02 (4H, dd, CH_{Ar}); 7,86(1H, s, -NH); 7,36(2H, d, CH_{Ar}); 7,01(2H, d, CH_{Ar}); 2,84(3H, s, -OCH_3)	3175(-NH-), 2812(OCH_3), 1658(C=O), 1450(Ar)
11b	$C_{18}H_{14}NClSO_3$ 422	72	53,64 / 53,61	3,38 / 3,39	11,93 / 11,96	3,89 / 3,91	13,19 / 13,15	7,66; 7,56 (4H, td, CH_{Ar}), 8,12;8,05 (4H, dd, CH_{Ar}); 7,89(1H, s, -NH); 7,35(2H, d, CH_{Ar}); 7,02(2H, d, CH_{Ar}); 3,98(2H, q, -OCH_2); 1,1(3H, t, CH_3)	3170(-NH-), 1651(C=O), 1450(Ar), 1374(CH_3)

2.4. General procedure of sulfenamide-1,4-naphthoquinones synthesis 6a-h

The mixture of pyridine (0.025 mol) and triethylamine (0.025 mol) was stirred for 10 min. in benzene. The benzene solution of sulfenchloride (0.025 mol) was added. The reaction mixture was left at room temperature for 24 hours, than was warmed up 313 K for 5-6 hours. The reaction mixture was evaporated. The residue was recrystallized from hexane (see Table 4).

Table 4

Data of sulfenamides of 1,4-naphthoquinone 6a-h

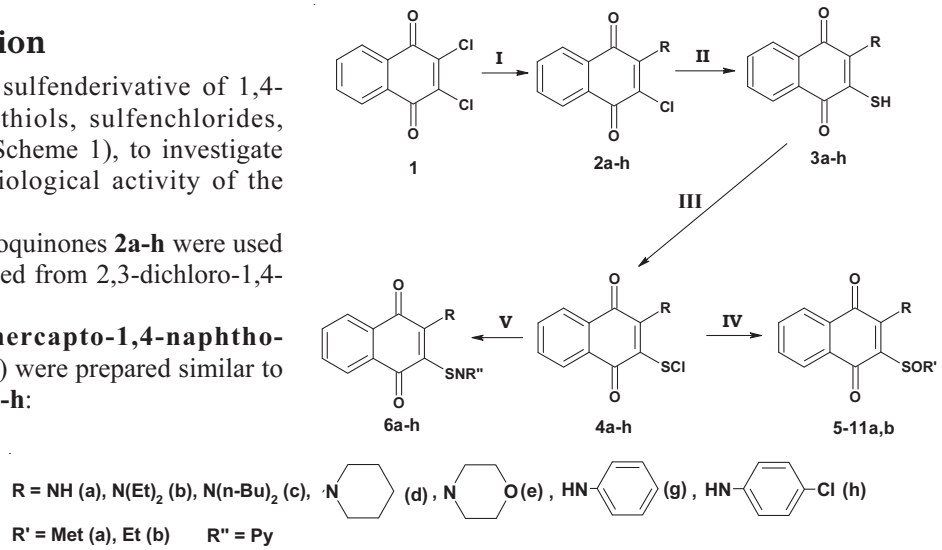
№	Formula, mp, K	Yield, %	Calculated Found, %					^{1}H (δ, ppm)	IR, cm^{-1}
6a	$C_{15}H_{16}N_2SO_2$ 366	67	62,48 62,47	5,59 5,67	11,12 11,10	9,71 9,75		7,68; 7,59 (4H, td, CH_{Ar}), 7,97;8,05 (4H, dd, CH_{Ar}); 6,72(2H, s, NH_2); 1,96-2,37(4H, m, -$N(CH_2)_2$); 1,08-1,54(6H, m, $3CH_2$)	1651(C=O), 1358(*tert*-N)
6b	$C_{19}H_{24}N_2SO_2$ 351	60	66,25 66,18	7,02 7,06	9,31 9,38	8,13 8,15		7,66; 7,78 (4H, td, CH_{Ar}), 8,21;8,11 (4H, dd, CH_{Ar}); 3,44-3,49(4H, m, -$N(CH_2)_2$); 1,96-2,41(4H, m, -$N(CH_2)_2$); 1,44-1,57(4H, m, -$O(CH_2)_2$); 1,12(6H, s, $2CH_3$)	1654(C=O), 1340(*tert*-N)
6c	$C_{23}H_{32}N_2SO_2$ 364	72	68,96 68,93	8,05 8,01	8,00 8,05	6,99 6,95		7,47; 7,56 (4H, td, CH_{Ar}), 7,98;8,02(4H, dd, CH_{Ar}); 3,09-3,12(4H, q, -$N(CH_2)_2$); 1,96-2,41(4H, m, -$N(CH_2)_2$); 1,12-1,35(8H, q, $4CH_2$); 0,86-0,91(6H, m, $2CH_3$)	1651(C=O), 1375(CH_3), 1355(*tert*-N)
6d	$C_{20}H_{24}N_2SO_2$ 385	76	67,37 67,41	6,79 6,74	8,99 8,97	7,86 7,95		7,56; 7,62 (4H, td, CH_{Ar}), 8,03;8,07 (4H, dd, CH_{Ar}); 1,95-3,2(8H, m, -$N(CH_2)_2$); 1,08-1,56(12H, q, $6CH_2$)	1645(C=O), 1360(*tert*-N)
6e	$C_{19}H_{22}N_2SO_3$ 362	71	63,66 63,78	6,19 6,08	8,94 8,91	7,81 7,86		7,79; 7,65 (4H, td, CH_{Ar}), 8,02;8,05 (4H, dd, CH_{Ar}); 3,55-3,67(4H, m, -$N(CH_2)_2$); 3,38-3,45(4H, m, -$O(CH_2)_2$); 1,96-2,3(4H, m, -$N(CH_2)_2$); 1,1-1,25(6H, m, $3CH_2$)	1652(C=O), 1351(*tert*-N)
6g	$C_{21}H_{20}N_2SO_2$ 382	73	69,21 69,25	5,53 5,62	8,80 8,82	7,69 7,62		7,45; 7,51 (4H, td, CH_{Ar}), 8,14;8,09 (4H, dd, CH_{Ar}); 7,07-7,3(5H, m, CH_{Ar}); 6,3(1H, s, -NH); 1,96-2,41(4H, m, -$N(CH_2)_2$); 1,09-1,52(6H, m, $3CH_2$)	3161(-NH-), 1650(C=O), 1600(Ar), 1350(*tert*-N)
6h	$C_{21}H_{19}N_2SO_2Cl$ 389	65	63,23 63,19	4,80 4,83	8,04 8,09	7,02 6,92	8,89 8,83	7,68; 7,61 (4H, td, CH_{Ar}), 8,22;8,15 (4H, dd, CH_{Ar}); 6,89(1H, s, -NH); 7,08(2H, d, CH_{Ar}); 7,36(2H, d, CH_{Ar}); 1,96-2,41(4H, m, -$N(CH_2)_2$); 1,09-1,52(6H, m, $3CH_2$)	3160(-NH-), 1650(C=O), 1580(Ar), 1350(*tert*-N)

3. Results and Discussion

We synthesized a new sulfenderivative of 1,4-naphthoquinone' synthesis: thiols, sulfenchlorides, sulfenates and sulfenamides (Scheme 1), to investigate the reactionary ability and biological activity of the synthesized compounds.

2-R-3-chloro-1,4-naphthoquinones **2a-h** were used as an initial compounds, obtained from 2,3-dichloro-1,4-naphthoquinone **1** (way I).

Synthesis of 2-R-3-mercapto-1,4-naphthoquinones 3a-h (way II, Table 1) were prepared similar to [13,14] by the interaction of **2a-h**:



Scheme 1

A – with sodium sulfide in water, followed by acidification of the reaction mixture;

B – with thiourea in alcohol, alkaline hydrolysis of isothiuronic salts and acidification of the reaction mixture.

3 a, g obtained by the method A, were described in literature [15, 16] earlier.

Thiols were prepared in high yields and purity from isothiuronic salts. They are synthones for the further chemical transformations with the purpose of preparation of new biologically active compounds.

Sulfenchlorides of 1,4-naphthoquinones 4a-h (way III, Table 2). We have investigated the chlorinolysis of thiols of 1,4-naphthoquinone under action of the some chlorinating agents – chlorine, sulfuryl chloride and N-chlorosuccinimide with catalysts conditions and without. Chlorinolysis of thiols of 1,4-naphthoquinone by chlorine and sulfuryl chloride was carried out with different ratios of reagents. For thiols is 1:1,4 was found the best ratio. When a smaller excess of chlorine is used poorer yields of sulfenchloride are obtained, a larger portion of disulfide being formed.

It was established that sulfenchlorides are better synthesized by the interaction of thiols with N-chlorosuccinimide or chlorine in inert solvents at room temperature [17].

Sulfenates of 1,4-naphthoquinones 5-11a,b. It's known that esthers of sulfenic acids have been obtained by the reaction of sulfenchlorides with alcoholate (phenolate) or alcohol (phenol) in the presence of the base [18-19]. The reaction is not always facile. Obtained sulfenates can react with sulfenylchloride forming disulfides and other by-products due to high nucleophility of sulphur. The reaction of sulfenchlorides with a strong electron-withdrawing group at the sulfur atom is more facile. It reduces the nucleophility of sulfur atom. We obtained sulfenates **5a-h** by the interaction of sulfenchlorides with methanol and ethanol in dry inert solvents in the presence of triethylamine (way IV, Table 3). The esters of sulfenic acids are labile compounds [18-20]. Synthesized sulfenates of 1,4-naphthoquinone are stable substances. It is explained by the influence of a conjugated quinonic system with a large electron-withdrawing potential.

Sulfenamides of 1,4-naphthoquinones 6a-h. The synthesis of the sulfenamides was carried out by the interaction of obtained sulfenchlorides with pyridine in the presence of triethylamine. Such reaction occurred with high yields and without formation of by-products quickly under mild conditions (way V, Table 4).

The structures of the obtained compounds were confirmed by NMR, IR and the element analysis. Synthesized thiols, sulfenates and sulfenamides are stable due to the large electron-withdrawing potential of the conjugated quinonic system.

Biological activity of synthesized compounds. Biological screening of antimicrobial activity of synthesized thiols and sulfenamides was carried out [21]. Primary estimation of antimicrobial action of synthesized compounds was tested on the cultures of two strains – *Staphylococcus aureus* and *Escherichia coli*. A determination of sensitiveness of bacteria to compounds *in vivo* was carried out by the using serial dilution and method of diffusion in a gelose. Fungicidic activity of some obtained compounds investigated on *Aspergilus niger*.

Aiming to search new regulators of plants growth we investigated the growth regulative activity on plantlets of lettuce, oat and onion. Computer screening **with computer program *PASS_C&T*** indicates the necessity of following evaluations of compounds of this combination.

4. Conclusions

For the first time we synthesized a new sulfenderivatives of 1,4-naphthoquinone: thiols, sulfenchlorides, sulfenamides, sulfenates. The structures of all obtained compounds were confirmed by NMR, IR and the element analysis. Synthesized thiols, sulfenates and sulfenamides are stable due to the large electron-withdrawing potential of the conjugated quinonic system. Biological screening of synthesized sulfennaphthoquinones indicates that a lot of the synthesized compounds have the activity, which exceed or meet the standards. They can be used as bactericides and growth regulators.

Computer screening with computer program PASS C&T and biological screening indicates the necessity of the following investigations of this order compounds.

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СУЛЬФЕННАФТОХІНОНИ

Анотація. *Були синтезовані тіоли, сульфенхлориди, сульфенати і сульфенаміди 1,4-нафтохінону та досліджені різні методи їх синтезу. Одержані тіоли, сульфенати і сульфенаміди стабільні завдяки великому електоно-акцепторному потенціалу спряженої хіноїдної системи Комп'ютерний скринінг за програмою PASS C&T та біологічний скринінг вказує на необхідність наступних досліджень у ряді даних сполук.*

Ключові слова: *тіол, сульфехлорид, сульфенат, сульфенамід, нафтохінон.*