REACTION OF CARBON DISULFIDE WITH ACTIVE METHYLENES: NOVEL SYNTHESIS OF THIOPHENE, THIENO[2,3-*b*]THIOPHENE, THIENO[3,2-*c*]PYRAZOLE AND THIENO[3,2-*b*]PYRIDINE DERIVATIVES

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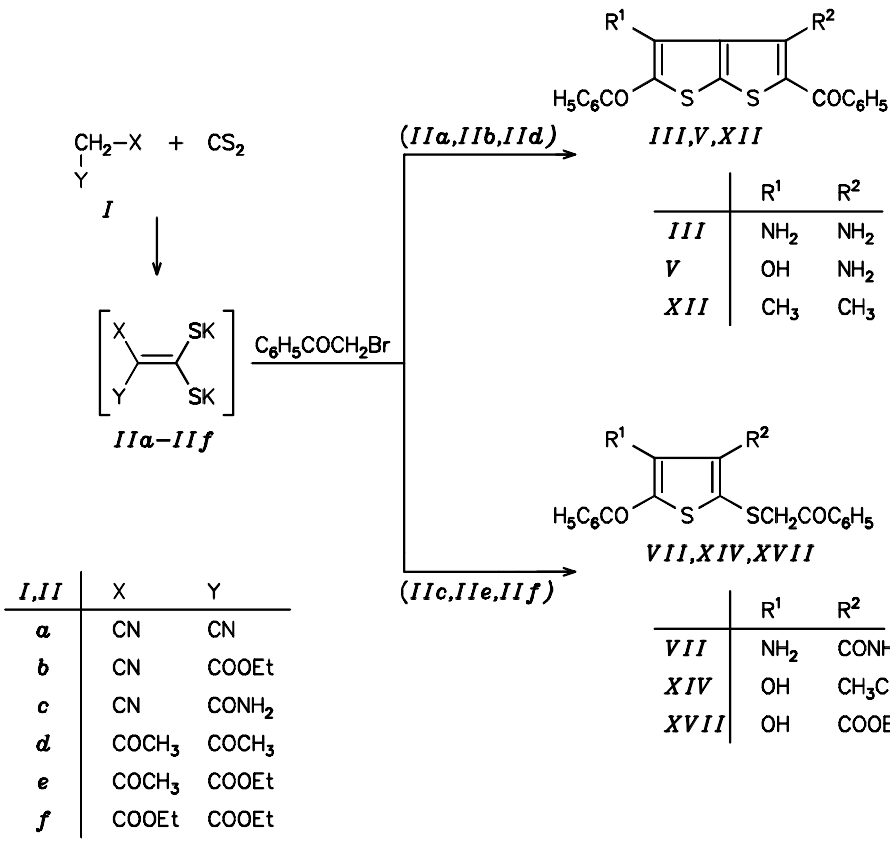
Thiophenes are important substances for the synthesis of pharmacologically active compounds and considered as the fundamental key structure units in sulfur containing heterocycles[1–5]. Recently our research group studied the reaction of active methylene reagents with phenyl isothiocyanate followed by cyclization of the resulted adducts with α-halocarbonyl compounds to give thiophene as well as thiazole derivatives[6–8]. In continuation of this synthetic route we report here the reaction of active methylene compounds with carbon disulfide in basic dimethylformamide solution followed by cyclization of the resulted intermediate adducts with α-halocarbonyl compounds[9–12].

The reaction of the active methylene compounds *Ia–If* with equimolar amount of carbon disulfide in dimethylformamide containing potassium hydroxide afforded the dipotassium disulfide salts *IIa–IIf* which were not isolated. Subsequent treatment of *IIa* with two-fold molar equivalent of phenacyl bromide gave a single product which was identified as compound *III* (Scheme 1). It reacted with two-fold molar equivalent of each of hydrazine hydrate and phenylhydrazine to give the corresponding 1,1′-dihydrobispyrazolo[4,3-*b*]thiophene derivatives *IVa* and *IVb*, respectively.

The reaction of *IIb* with phenacyl bromide gave the thieno[2,3-*b*]thiophene derivative *V*. Compound *V* reacted with two-fold molar equivalent of each of hydrazine hydrate or phenylhydrazine to afford the corresponding dihydrazone derivative *VIa*, *VIb*, respectively. Reaction of disulfide *IIc* with phenacyl bromide gave the thiophene derivative *VII* (Scheme 1). All attempts to further cyclize the compound *VII* under various reaction conditions failed. The reaction of *VII* with ethyl cyanoacetate *Ib* in absolute ethanol containing a catalytic amount of piperidine gave the thieno[3,2-*b*]pyridine derivative *VIII* (Scheme 2). The reaction of *VII* with malononitrile *Ia* gave the thieno[3,2-*b*]-pyridine derivative *IX*. Compound *VII* reacted with acrylonitrile to afford the thieno[3,2-*b*]pyridine derivative *X*. Formation of *X* was assumed to take place through

the intermediate formation of the corresponding cyanoethylated derivative[13], cyclization via water elimination and subsequent autooxidation under the reaction conditions[14,15] (Scheme 2). The reaction of *VII* with equimolar amount of each of hydrazine hydrate or phenylhydrazine gave products *XIa* and *XIb*, respectively. Treatment of *IId* with two-fold molar equivalent of phenacyl bromide gave the thieno[2,3-*b*]thiophene derivative *XII* (Scheme 1). Compound *XII* reacted with hydrazine hydrate and with phenylhydrazine to give the hydrazone derivatives *XIIIa*, *XIIIb*, respectively.

Similarly, the reaction of *IIe* with phenacyl bromide gave the thiophene derivative *XIV*. Compound *XIV* reacted with two-fold molar equivalent of both of hydrazine hydrate or phenylhydrazine to give the thieno[3,2-*c*]pyrazole derivatives *XVa*, *XVb*, respectively. The reaction of *XIV* with malononitrile *Ia*, in dioxane containing a catalytic

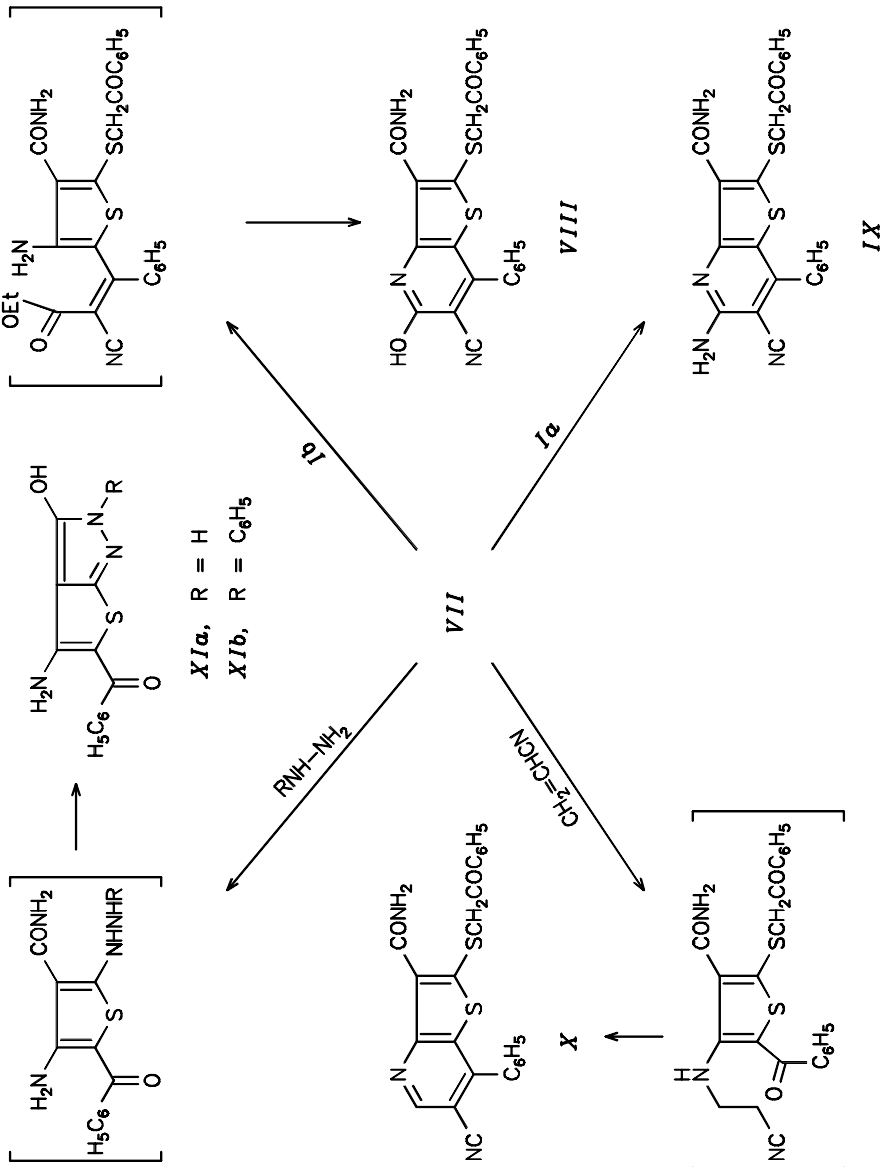


	R¹	R²
III	NH_2	NH_2
V	OH	NH_2
XII	CH_3	CH_3

	R¹	R²
VII	NH_2	$CONH_2$
XIV	OH	CH_3CO
XVII	OH	COOEt

I,II	X	Y
a	CN	CN
b	CN	COOEt
c	CN	$CONH_2$
d	$COCH_3$	$COCH_3$
e	$COCH_3$	COOEt
f	COOEt	COOEt

SCHEME 1

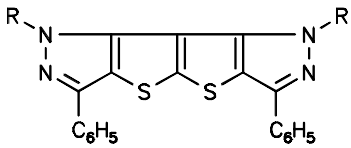

CONH2
SCH2COC6H5
H2N
C6H5
OEt
O
NC
OH
N
R
S
H5C6
NHNHR
XIa, R = H
XIb, R = C6H5
VII
VIII
IX
X
RNH–NH2
CH2=CHCN
HO

SCHEME 2

amount of piperidine, yielded the Knoevenagel condensation product *XVI*. Our attempts to cyclize *XVI* under variety of reaction conditions were unsuccessful.

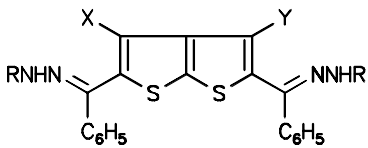
Reaction of *IIf* with phenacyl bromide gave the thiophene derivative *XVII* which reacted with two-fold molar equivalent of each of hydrazine hydrate or phenylhydrazine to give the thieno[2,3-*c*]pyrazole derivatives *XVIIIa*, *XVIIIb*.

Subsequent treatment of the intermediate salt *IIa* with ethyl bromocyanoacetate[16] gave the thieno[2,3-*b*]thiophene derivative *XIX* which proceeds through the intermediate formation of the corresponding dithioether followed by hydrolysis, decarboxylation and intramolecular cyclization[17]. Similarly, the reaction of *IIb* with ethyl bromo-



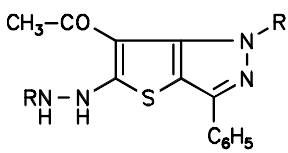
IVa, R = H
IVb, R = C_6H_5

IV



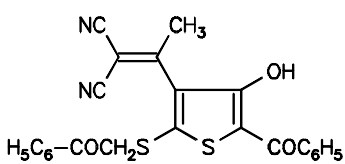
VI, XIII

	X	Y	R
VIa	OH	NH_2	H
VIb	OH	NH_2	C_6H_5
XIIIa	CH_3	CH_3	H
XIIIb	CH_3	CH_3	C_6H_5



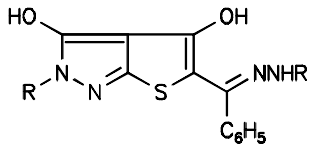
XVa, R = H
XVb, R = C_6H_5

XV



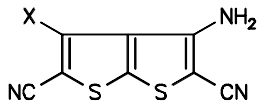
XVI

cyanoacetate gave the thieno[2,3-*b*]thiophene derivative *XX*. The same reaction sequence described above for the formation of *XIX* was proposed.



XVIII

XVIIIa, R = H
XVIIIb, R = C_6H_5



XIX, *XX*

XIX, X = NH_2
XX, X = OH

EXPERIMENTAL

Melting points are uncorrected. IR spectra (KBr) were obtained on a Pye Unicam SP-1000 spectrophotometer. ^{1}H NMR spectra (δ, ppm) were measured on a Varian EM 390 spectrometer (90 MHz) in $(CD_3)_2SO$ as solvent, using TMS as internal standard. Mass spectra were recorded on an AEI MS 30 spectrometer (70 eV). Analytical data were obtained from the Microanalytical Data Unit at Cairo University.

Thiophene Derivatives *III*, *V*, *VII*, *XII*, *XIV*, *XVII*, *XIX* and *XX* (General Procedure)

To a solution of the active methylene compound *Ia–If* (0.01 mol) in dimethylformamide (20 ml) containing finely ground potassium hydroxide (0.01 mol), carbon disulfide (0.76 g, 0.01 mol) was added. The reaction mixture was stirred at 25 °C for 24 h and then treated with an appropriate α-haloketone, phenacyl bromide (4.0 g, 0.02 mol) or ethyl bromocyanoacetate (3.6 g, 0.02 mol). The reaction mixture was stirred for additional 24 h at 25 °C. The solid product formed upon addition of ice/water containing a few drops of hydrochloric acid (till pH 6) was collected by filtration.

1,6-Diamino-2,5-dibenzoylthieno[2,3-b]thiophene (III). Crystallized from ethanol, m.p. 89 °C, yield 2.5 g (65%). IR spectrum: 3 480–3 430 (NH_2); 3 060 (CH aromatic); 1 685, 1 680 (C=O). ^{1}H NMR spectrum: 4.48 s, 4.51 s, 4 H (2 × NH_2); 7.32–7.49 m, 10 H (2 × C_6H_5). Mass spectrum, *m/z*: 378 (M^+). For $C_{20}H_{14}N_2O_2S_2$ (378.5) calculated: 63.47% C, 3.72% H., 7.40% N, 16.94% S; found: 63.02% C, 3.45% H, 7.12% N, 16.80% S.

6-Amino-2,5-dibenzoyl-1-hydroxythieno[2,3-b]thiophene (V). Crystallized from ethanol, m.p. 210 °C, yield 2.4 g (63%). IR spectrum: 3 630–3 380 (OH, NH_2); 3 055 (CH aromatic); 1 690, 1 680 (C=O). ^{1}H NMR spectrum: 4.84 s, 2 H (NH_2); 7.32–7.46 m, 10 H (2 × C_6H_5); 9.93 s, 1 H (OH). Mass spectrum, *m/z*: 379 (M^+). For $C_{20}H_{13}NO_3S_2$ (379.4) calculated: 63.30% C, 3.45% H, 3.69% N, 16.89% S; found: 63.02% C, 3.34% H, 3.52% N, 17.05% S.

3-Amino-2-benzoyl-5-benzoylmethylthio-4-formamidothiophene (VII). Crystallized from dioxane, m.p. 112 °C, yield 2.7 g (69%). IR spectrum: 3 460–3 370 (NH_2); 3 050 (CH aromatic); 1 710, 1 690,

1 680 (C=O). ^{1}H NMR spectrum: 4.63 s, 2 H (CH_2); 5.34 s, 5.62 s, 4 H (2 × NH_2); 7.32–7.48 m, 10 H (2 × C_6H_5). Mass spectrum, *m/z*: 296 (M^+). For $C_{20}H_{16}N_2O_3S_2$ (396.5) calculated: 60.58% C, 4.06% H, 7.06% N, 16.17% S; found: 60.34% C, 4.03% H, 7.41% N, 16.05% S.

2,5-Dibenzoyl-1,6-dimethylthieno[2,3-b]thiophene (XII). Crystallized from dioxane, m.p. 125 °C, yield 2.4 g (66%). IR spectrum: 3 060 (CH aromatic); 1 690, 1 685 (C=O); 1 655 (C=C). ^{1}H NMR spectrum: 2.22 s, 2.24 s, 6 H (2 × CH_3); 7.29–7.42 m, 10 H (2 × C_6H_5). Mass spectrum, *m/z*: 376 (M^+). For $C_{22}H_{16}O_2S_2$ (376.5) calculated: 70.18% C, 4.28% H., 17.03% S; found: 70.02% C, 4.64% H, 17.22% S.

4-Acetyl-2-benzoyl-5-benzoylmethylthio-3-hydroxythiophene (XIV). Crystallized from ethanol, m.p. 186 °C, yield 2.8 g (72%). IR spectrum: 3 550–3 340 (OH); 3 055 (CH aromatic); 2 985 (CH_3); 1 700, 1 690, 1 680 (C=O); 1 655 (C=C). ^{1}H NMR spectrum: 2.23 s, 3 H (CH_3); 4.52 s, 2 H (CH_2); 7.29–7.48 m, 10 H (2 × C_6H_5); 9.23 s, 1 H (OH). Mass spectrum, *m/z*: 396 (M^+). For $C_{21}H_{16}O_4S_2$ (396.3) calculated: 63.59% C, 4.06% H, 16.18% S; found: 63.20% C, 3.80% H, 16.01% S.

2-Benzoyl-6-benzoylmethylthio-4-ethoxycarbonyl-3-hydroxythiophene (XVII). Crystallized from ethanol, m.p. 178 °C, yield 3.0 g (71%). IR spectrum: 3 520–3 320 (OH); 3 050 (CH aromatic); 1 710, 1 690–1 675 (C=O); 1 650 (C=C). ^{1}H NMR spectrum: 1.34 t, 3 H, J = 8.0 Hz (CH_3); 4.42 s, 2 H (CH_2); 4.54 s, 2 H (CH_2); 7.31–7.49 m, 10 H (2 × C_6H_5); 10.13 s, 1 H (OH). For $C_{22}H_{18}O_5S_2$ (426.5) calculated: 61.95% C, 4.25% H, 15.03% S; found: 61.66% C, 3.79% H, 14.76% S.

1,6-Diamino-2,5-dicyanothieno[2,3-b]thiophene (XIX). Crystallized from ethanol, m.p. 121 °C, yield 1.5 g (68%). IR spectrum: 3 450–3 380 (NH_2); 2 225, 2 220 (CN). ^{1}H NMR spectrum: 4.28 s, 4.39 s, 4 H (2 × NH_2). Mass spectrum, *m/z*: 220 (M^+). For $C_8H_4N_4S_2$ (220.3) calculated: 43.62% C, 1.83% H, 25.43% N, 29.11% S; found: 43.28% C, 1.86% H, 25.18% N, 28.69% S.

1-Amino-2,5-dicyano-6-hydroxythieno[2,3-b]thiophene (XX). Crystallized from dimethylformamide, m.p. 197 °C, yield 1.4 g (62%). IR spectrum: 3 650–3 370 (OH, NH_2); 2 225, 2 220 (CN). ^{1}H NMR spectrum: 4.51 s, 2 H (NH_2); 9.35 s, 1 H (OH). Mass spectrum, *m/z*: 221 (M^+). For $C_8H_3N_3OS_2$ (221.2) calculated: 43.42% C, 1.36% H, 18.99% N, 28.98% S; found: 43.48% H, 1.51% H, 18.58% N, 28.68% S.

Thieno[2,3-*c*]pyrazoles *IV*, *XI*, *XV*, *XVIII* and the Thieno[2,3-*b*]thiophenes *VI*, *XIII* (General Procedure)

To a solution of *III*, *V*, *VII*, *XII*, *XIV* or *XVII* (0.01 mol) in ethanol (50 ml), hydrazine hydrate (1.0 g, 0.02 mol) or phenylhydrazine (2.2 g, 0.02 mol except of the compound *VII*, when 0.01 mol was used) was added. The reaction mixture was heated under reflux for 12 h and then evaporated in vacuo. The residue was triturated with diethyl ether and the crystals were collected by filtration.

1,1′-Dihydro[5,6:5′,6′]bisthieno[2,3-c]bipyrazole (IVa). Crystallized from dioxane, m.p. 148 °C, yield 2.8 g (75%). IR spectrum: 3 430–3 380 (NH); 3 050 (CH aromatic); 1 655 (C=C). ^{1}H NMR spectrum: 7.32–7.52 m, 10 H (2 × C_6H_5); 8.82 s, 9.21 s, 2 H (2 × NH). For $C_{20}H_{12}N_4S_2$ (372.5) calculated: 64.49% C, 3.24% H, 15.05% N, 17.21% S; found: 64.19% C, 3.02% H, 14.76% N, 17.48% S.

1,1′-Diphenyl[5,6:5′,6′]bisthieno[2,3-c]bipyrazole (IVb). Crystallized from dioxane, m.p. 124 °C, yield 3.3 g (64%). IR spectrum: 3 050 (CH aromatic); 1 655 (C=C). ^{1}H NMR spectrum: 7.30–7.59 m, 20 H (4 × C_6H_5). For $C_{32}H_{20}N_4S_2$ (524.6) calculated: 73.25% C, 3.84% H, 10.67% N, 12.2% S; found: 72.98% C, 3.86% H, 10.77% N, 12.50% S.

6-Amino-2,5-dibenzoylhydrazono-1-hydroxythieno[2,3-b]thiophene (VIa). Crystallized from dimethylformamide, m.p. 105 °C, yield 3.6 g (90%). IR spectrum: 3 620–3 380 (OH, NH_2); 3 350 (CH aromatic); 1 655 (C=C). ^{1}H NMR spectrum: 4.82 s, 2 H (NH_2); 5.23 s, 5.30 s, 4 H (2 × NH_2); 7.32–7.48 m, 10 H (2 × C_6H_5); 10.13 s, 1 H (OH). For $C_{20}H_{17}N_5OS_2$ (407.5) calculated: 58.94% C, 4.20% H, 17.18% N, 15.73% S; found: 58.67% C, 4.08% H, 17.28% N, 16.02% S.

6-Amino-2,5-dibenzoylphenylhydrazono-1-hydroxythieno[2,3-b]thiophene (VIb). Crystallized from dimethylformamide, m.p. 83 °C, yield 4.0 g (72%). IR spectrum: 3 620–3 302 (OH, NH_2, NH); 3 060 (CH aromatic); 1 655 (C=C). ^{1}H NMR spectrum: 4.84 s, 2 H (NH_2); 7.32–7.59 m, 20 H ($4 \times C_6H_5$); 8.28 s, 8.32 s, 2 H ($2 \times$ NH); 10.21 s, 1 H (OH). For $C_{32}H_{25}N_5OS_2$ (559.7) calculated: 68.74% C, 4.50% H, 12.51% N, 11.45% S; found: 69.04% C, 4.24% H, 12.37% N, 11.18% S.

1-Amino-2-benzoyl-(5H)-6-hydroxythieno[2,3-c]pyrazole (XIa). Crystallized from ethanol, m.p. 146 °C, yield 1.9 g (77%). IR spectrum: 3 580–3 320 (OH, NH_2, NH); 3 050 (CH aromatic); 1 695 (C=O); 1 650 (C=C). ^{1}H NMR spectrum: 5.36 s, 2 H (NH_2); 7.32–7.46, 5 H (C_6H_5); 8.26 s, 1 H (NH); 9.81 s, 1 H (OH). For $C_{12}H_9N_3O_2S$ (259.4) calculated: 55.63% C, 3.52% H, 16.54% N, 12.36% S; found: 55.42% C, 3.80% H, 16.46% N, 12.39% S.

1-Amino-2-benzoyl-6-hydroxy-5-phenylthieno[2,3-c]pyrazole (XIb). Crystallized from ethanol, m.p. 146 °C, yield 2.0 g (77%). IR spectrum: 3 570–3 390 (OH, NH_2, NH); 3 060 (CH aromatic); 1 695 (C=O); 1 655 (C=C). ^{1}H NMR spectrum: 5.31 s, 2 H (NH_2); 7.32–7.46 m, 5 H (C_6H_5); 8.26 s, 1 H (NH); 9.47 s, 1 H (OH). Mass spectrum, *m/z*: 335 (M^+). For $C_{18}H_{13}N_3O_2S$ (335.4) calculated: 64.46% C, 3.90% H, 12.52% N, 9.55% S; found: 64.24% C, 4.02% H, 12.38% N, 9.71% S.

2,5-Dibenzoylhydrazono-1,6-dimethylthieno[2,3-b]thiophene (XIIIa). Crystallized from ethanol, m.p. 215 °C, yield 2.8 g (71%). IR spectrum: 3 440–3 380 (NH_2); 3 050 (CH aromatic); 1 660 (C=C). ^{1}H NMR spectrum: 2.24 s, 2.26 s, 6 H ($2 \times CH_3$); 4.38 s, 4.40 s, 4 H ($2 \times NH_2$); 7.32–7.41 m, 10 H ($2 \times C_6H_5$). Mass spectrum, *m/z*: 404 (M^+). For $C_{22}H_{20}N_4S_2$ (404.6) calculated: 65.31% C, 4.98% H, 13.84% N, 15.84% S; found: 64.89% C, 4.68% H, 13.56% N, 15.88% S.

2,5-Dibenzoylphenylhydrazono-1,6-dimethylthieno[2,3-b]thiophene (XIIIb). Crystallized from dimethylformamide, m.p. 90 °C, yield 3.3 g (90%). IR spectrum: 3 440–3 340 (NH); 3 050 (CH aromatic); 2 980 (CH_3); 1 660 (C=C). ^{1}H NMR spectrum: 2.24 s, 6 H ($2 \times CH_3$); 7.28–7.52 m, 20 H ($4 \times C_6H_5$); 8.28 s, 8.35 s, 2 H ($2 \times$ NH). For $C_{34}H_{28}N_4S_2$ (556.7) calculated: 73.35% C, 5.06% H, 10.06% N, 11.51% S; found: 72.96% C, 4.91% H, 9.87% N, 11.36% S.

6-Acetyl-5-hydrazino-(1H)-3-phenylthieno[3,2-c]pyrazole (XVa). Crystallized from dimethylformamide, m.p. 87 °C, yield 1.9 g (70%). IR spectrum: 3 410–3 370 (NH_2, NH); 3 050 (CH aromatic); 2 975 (CH_3); 1 690 (C=O); 1 650 (C=C). ^{1}H NMR spectrum: 2.25 s, 3 H (CH_3); 4.55 s, 2 H (NH_2); 7.32–7.49 m, 5 H (C_6H_5); 9.29 s, 8.52 s, 2 H ($2 \times$ NH). Mass spectrum, *m/z*: 272 (M^+). For $C_{13}H_{12}N_4OS$ (272.3): 57.33% C, 4.44% H, 20.57% N, 11.77% S; found: 57.21% C, 4.56% H, 20.57% N, 11.96% S.

6-Acetyl-1,3-diphenyl-5-phenylhydrazinothieno[2,3-c]pyrazole (XVb). Crystallized from dimethylformamide, m.p. 92 °C, yield 3.0 g (72%). IR spectrum: 3 400–3 380 (NH); 3 050 (CH aromatic); 2 975 (CH_3); 1 690 (C=O); 1 660 (C=C). ^{1}H NMR: 2.32 s, 3 H (CH_3); 7.32–7.59 m, 15 H ($3 \times C_6H_5$); 8.31 s, 8.51 s, 2 H ($2 \times$ NH). For $C_{25}H_{20}N_4OS$ (424.5) calculated: 70.73% C, 4.74% H, 13.19% N, 7.55% S; found: 70.50% C, 4.56% H, 13.37% N, 7.37% S.

2-Benzoylhydrazono-3,4-dihydroxy-(5H)-thieno[2,3-c]pyrazole (XVIIIa). Crystallized from ethanol, m.p. 117 °C, yield 1.8 g (67%). IR spectrum: 3 570–3 320 (OH, NH_2); 3 060 (CH aromatic); 1 660 (C=C). ^{1}H NMR spectrum: 4.22 s, 2 H (NH_2); 7.32–7.43 m, 5 H (C_6H_5); 8.31 s, 1 H (NH); 9.21 s, 9.24 s, 2 H ($2 \times$ OH). For $C_{12}H_{10}N_4O_2S$ (274.3) calculated: 52.54% C, 3.67% H, 20.42% N, 11.68% S; found: 52.44% C, 3.48% H, 20.22% N, 11.53% S.

2-Benzoylphenylhydrazono-3,4-dihydroxy-5-phenylthieno[2,3-c]pyrazole (XVIIIb). Crystallized from ethanol, m.p. 188 °C, yield 2.8 g (65%). IR spectrum: 3 590–3 340 (OH, NH); 3 070 (CH aromatic); 1 660 (C=C). ^{1}H NMR spectrum: 5.22 s, 1 H (NH); 7.32–7.41 m, 15 H ($3 \times C_6H_5$); 9.32 s, 9.34 s, 2 H ($2 \times$ OH). For $C_{24}H_{18}N_4O_2S$ (426.5) calculated: 67.58% C, 4.25% H, 13.13% N, 7.51% S; found: 67.37% C, 3.97% H, 13.28% N, 7.27% S.

6-Benzoylmethylthio-3-cyano-7-formamido-2-hydroxy-4-phenylthieno[3,2-*b*]pyridine (*VIII*)

To a solution of *VII* (3.9 g, 0.01 mol) in absolute ethanol (40 ml) containing piperidine (0.5 ml), ethyl cyanoacetate (1.1 g, 0.01 mol) was added. The reaction mixture was heated under reflux for 4 h then evaporated in vacuo. The remaining product was triturated with ether and the formed solid product was collected by filtration. Crystallization from dioxane afforded 2.7 g (62%) of compound *VIII*, m.p. 180 °C. IR spectrum: 3 590–3 300 (OH, NH_2); 3 050 (CH aromatic); 2 890 (CH_2); 2 220 (CN); 1 700, 1 680 (C=O); 1 650 (C=C). ^{1}H NMR spectrum: 4.92 s, 2 H (CH_2); 5.72 s, 2 H (NH_2); 7.32–7.52 m, 10 H (2 × C_6H_5); 9.82 s, 1 H (OH). For $C_{23}H_{15}N_3O_3S_2$ (445.5) calculated: 62.00% C, 3.39% H, 9.43% N, 14.39% S; found: 61.77% C, 3.39% H, 9.26% N, 14.54% S.

2-Amino-6-benzoylmethylthio-3-cyano-7-formamido-4-phenylthieno[3,2-*b*]pyridine (*IX*)

To a solution of *VIII* (3.9 g, 0.01 mol) in dioxane (40 ml) containing piperidine (0.5 ml), malononitrile *Ia* (0.66 g, 0.01 mol) was added. The reaction mixture was heated under reflux for 3 h. The solid product formed upon pouring into ice/water containing few drops of hydrochloric acid was collected by filtration. Crystallization from dioxane afforded 2.9 g (66%), m.p. 108 °C. IR spectrum: 3 460–3 350 (NH_2); 3 050 (CH aromatic); 2 890 (CH_2); 2 220 (CN); 1 690, 1 680 (C=O). ^{1}H NMR spectrum: 4.49 s, 2 H (CH_2); 4.82 s, 5.28 s, 4 H (2 × NH_2); 7.32–7.41 m, 10 H (2 × C_6H_5). For $C_{23}H_{16}N_4O_2S_2$ (444.5) calculated: 62.14% C, 3.62% H, 12.60% N, 14.4% S; found: 62.32% C, 3.33% H, 12.78% N, 14.03% S.

6-Benzoylmethylthio-3-cyano-7-formamido-4-phenylthieno[3,2-*b*]pyridine (*X*)

To a solution of *VII* (3.9 g, 0.01 mol) in dioxane (30 ml) containing acetic acid (2 ml), acrylonitrile (0.53 g, 0.01 mol) was added. The reaction mixture was heated under reflux for 10 h, then evaporated in vacuo. The solid product formed upon triturating the remaining product with ether was collected by filtration. Crystallization from dimethylformamide afforded 2.8 g (66%), m.p. 167 °C. IR spectrum: 3 410–3 750 (NH_2); 3 050 (CH aromatic); 2 896 (CH_2); 2 220 (CN); 1 690, 1 685 (C=O). ^{1}H NMR spectrum: 4.45 s, 2 H (CH_2); 5.28 s, 2 H (NH_2); 7.28–7.51 m, 11 H (2 × C_6H_5, pyridine H-2). For $C_{23}H_{15}N_3O_2S_2$ (429.5) calculated: 64.31% C, 3.51% H, 9.78% N, 14.92% S; found: 64.05% C, 3.55% H, 9.87% N, 15.11% S.

2-Benzoyl-5-benzoylmethylthio-3-hydroxy-4-(2′-cyanocrotononitrilo-3′-yl)thiophene (*XVI*)

To a solution of *XIV* (3.9 g, 0.01 mol) in dioxane (20 ml) containing piperidine (0.5 ml), malononitrile *Ia* (0.66 g, 0.01 mol) was added. The reaction mixture was heated under reflux for 6 h and the solid product, so formed upon dilution with ice/water, was collected by filtration. Crystallization from dioxane afforded 3.4 g (78%) from compound *XVI*, m.p. 138 °C. IR spectrum: 3 480–3 320 (OH); 3 050 (CH aromatic); 2 985 (CH_3); 2 225, 2 220 (CN); 1 685–1 680 (C=O); 1 660 (C=C). ^{1}H NMR spectrum: 2.34 s, 3 H (CH_3); 4.41 s, 2 H (CH_2); 7.49–7.54 m, 10 H (2 × C_6H_5); 10.21 s, 1 H (OH). For $C_{24}H_{16}N_2O_3S_2$ (444.5) calculated: 64.84% C, 3.62% H, 6.30% N, 14.42% S; found: 64.63% C, 3.50% H, 6.02% N, 14.26% S.

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