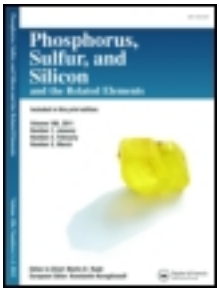

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SOME RING CLOSURE REACTIONS WITH CYANOTHIOFORMAMIDES: NEW ROUTE FOR THE SYNTHESIS OF (IMIDAZOLIDINE, OXAZOLIDINE & PYRROLINE)-IMINOTHIONES, BENZOTHIAZOLOQUINAZOLINONES AND IMIDAZOQUINOXALINES

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SOME RING CLOSURE REACTIONS WITH CYANOTHIOFORMAMIDES: NEW ROUTE FOR THE SYNTHESIS OF (IMIDAZOLIDINE, OXAZOLIDINE & PYRROLINE)-IMINOTHIONES, BENZOTHIAZOLOQUINAZOLINONES AND IMIDAZOQUINOXALINES

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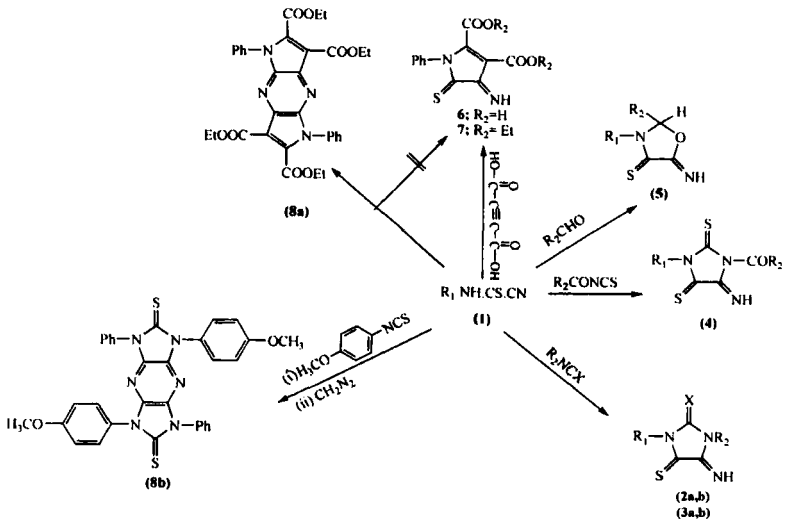
Cyanothioformamides were reacted with isocyanates, isothiocyanates, aldehydes, acetylenedicarboxylic acid and anthranilic acids to produce imidazolidines, oxazolidines pyrroline, quinazolinones and benzothiazoloquinazolinones, respectively. Interaction of imidazolidineimino(thiones and dithiones) with o-phenylenediamines gave rise to imidazoquinoxalines and imidazoquinoxalinethiones, respectively.

Keywords: Cyanothioformamides; Imidazolidineiminothiones; Oxazolidineiminothiones; Benzothiazoloquinazolinones; Imidazoquinoxalines

A variety of heterocyclic ring closure reactions with cyanothioformamides[1–3] gave rise to imidazoles[4], oxazoles[5] and thiazoles[6,7]. A part of our programme in ring closure reactions[8], activated nitriles[9], and the chemistry of cyanothioformamides[10–13], led us to investigate the behaviour of the latter towards some electrophilic and nucleophilic reagents.

Thus, interaction of substituted cyanothioformamides (**1**) with 3-chlorophenyl isocyanate and phenyl isothiocyanate furnished 1-(3′-chlorophenyl)-3-aryl-5-imino-4-thioxo-2-imidazolidinones (**2a,b**) and 1-phenyl-3-aryl-5-imino-2,4-imidazolidinedithiones (**3a,b**), respectively (scheme-1).

* Correspondence Author.



SCHEME 1

Benzoyl and p-chlorobenzoyl isothiocyanate were reacted successfully with substituted cyanothioformamides (**1**) to give 3-aryl-1-aroyl-5-imino-2,4-imidazolidinedithiones (**4a-c**) (scheme-1).

Acetaldehyde was also reacted with substituted cyanothioformamides (**I**) to produce 5-imino-4-oxazolidinethiones (**5a-c**) (scheme-1).

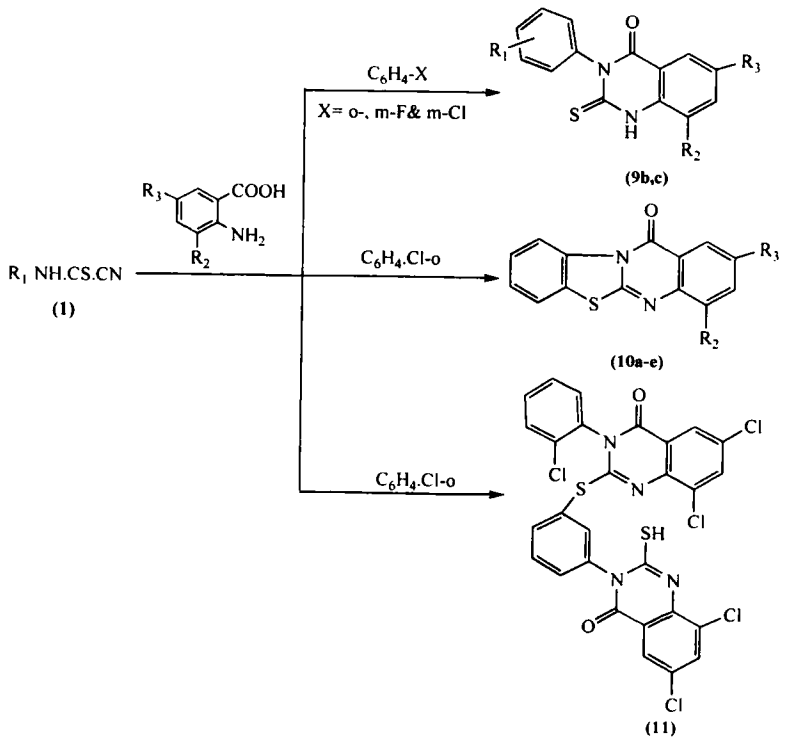
Acetylenedicarboxylic acid was also reacted with cyanothioformanilide to give 3-imino-1-phenyl-2-thioxopyrroline-4,5-dicarboxylic acid (**6**) (scheme-1).

Similarly, interaction of ethyl acetylenedicarboxylate with cyanothioformanilide was expected to produce (**7**) but instead (**8a**; scheme-1) was obtained depending on analytical and spectral data. The mechanism of formation of (**8a**) can be passed through a pyrrole of type (**7**) which loss sulphur to give an iminocarbene[6], then dimerized to produce (**8a**) (the trans isomer). This isomer was favoured by the authors over the other cis form on bases similar to those discussed earlier[6].

The formation of iminocarbene could also be observed through interaction of imidazolidineiminodithione (**3b**) with diazomethane. Thus, diimidazo [4,5-b:4′,5′-e]pyrazin-2,6-dithione (**8b**) was the only product which could be isolated from the reaction of (**3b**) with diazomethane. The forma-

tion of **(8b)** showed that diazomethane was not included, but disulphurization was took place to give iminocarbene, which dimerized then aromatized to give **(8b)**.

In continuation to our cyclization reactions with cyanothioformamides, we investigated here the reaction of different anthranilic acid derivatives with various halogenated cyanothioformanilides **(1)**. Thus, interaction of m-flouro or m-chlorophenyl cyanothioformamides with anthranilic acid produced the 2-thioxo-3-(3′-halophenyl)quinazolin-4-ones **(9b,c)** respectively (scheme-2).



SCHEME 2

The reaction between cyanothioformanilides and anthranilic acids was extented to the o-halogenated cyanothioformanilides in order to examine

the reactivity of this halo atom for further cyclization reactions. Thus, interaction of N-(2′-chlorophenyl)-cyanothioformamide with anthranilic acid and its halogenated derivatives (5-chloro, 5-bromo, 5-iodo and 3, 5-dibromo)anthranilic acid furnished in each case one isolated product which was given structure **(10a-e)** (scheme-2) as benzothiazoloquinazolinone derivatives on bases of elemental and spectral data. The mechanism of formation of **(10)** can be rationalized as described in (scheme-5).

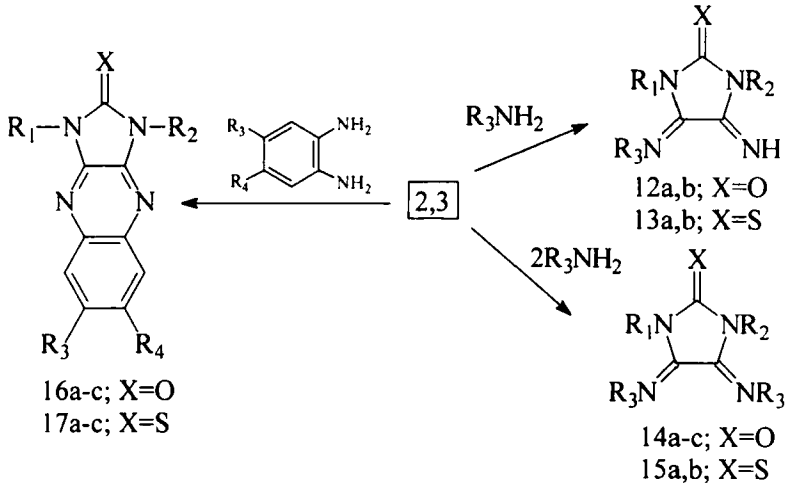
Interaction of N-(2′-chlorophenyl)cyanothioformamide with 3,5-dichloro anthranilic acid furnished a mixture which on GLC mass exhibited two different mass spectra corresponding to two different products. The first one, showed a molecular ion peak at m/e 321 (7%) together with a base peak at m/e 289 (100%). Other significant peaks were observed; (111; 21.9%), 93 (10.3%) and 75 (19.5%) which fitted with structure (**10f**; R_2=R_3=Cl; scheme-2) as benzothioazoloquinazolinone derivative. The second mass spectrum was fitted with structure (**11**; scheme-2) which showed a molecular ion peak at 712 (3%) and other significant peaks at 681 (1%) & 355 (2.2%). The base peak 321 (100%) was corresponding to structure **(10f)** which could be resulted by fission of the sulphide linkage and elimination of HCl molecule.

Attempted interaction of N (2′-flourophenyl) cyanothioformamide with 5-iodoanthranilic acid to produce a benzothiazoloquinazolone **(10d)** was unsuccessful and 2-thioxo-3-(2′-fourophenyl)quinazoline-4-one (**9a**; scheme-2) was obtained. The noncyclization of **(9a)** can be attributed to the flourine atom, which is highly tided to the aromatic ring. It is of great interest that the base peak in the mass spectrum of **(9a)** (379; 100%) was corresponding to the required **(10d)**.

Now, the authors tried to make a comparison between imidazolidineiminothiones **(2,3)** & **(4)** and oxazolidineiminothiones **(5)** towards some nucleophilic reagents as amines, o-phenylenediamines and anthranilic acids.

Thus **(2)** was reacted readily with one mole of amine in boiling ethanol through elimination of one molecule of H_2S to give (**12**; scheme-3). Attempted interaction of **(3)** with one mole of amine under the same conditions to produce **(13)** was unsuccessful and no identified product could be isolated.

The imidazolidineiminothiones **(2&3)** could be also reacted easily with two moles or excess of amines to produce **(14&15)** respectively (scheme-3) through elimination of one mole of both H_2S & NH_3. Simi-



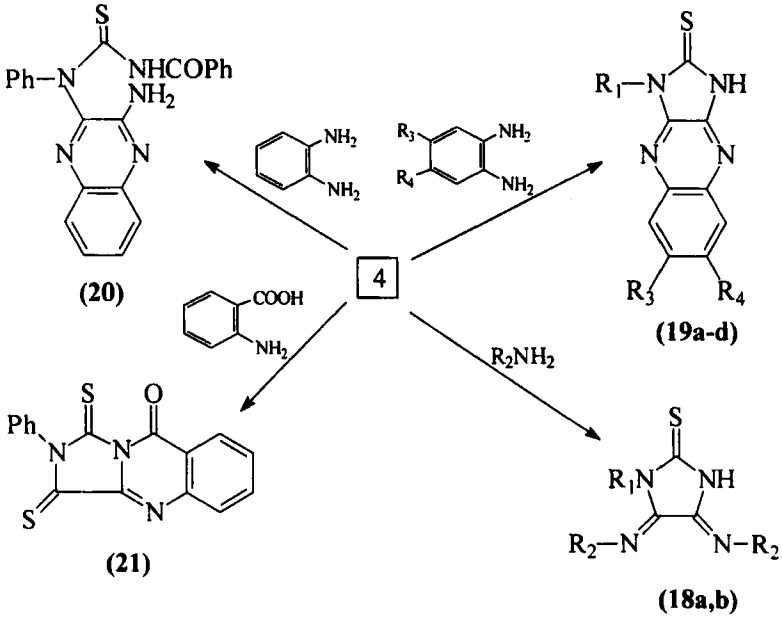
SCHEME 3

larly **(2&3)** reacted with o-phenylenediamines to furnish imidazoquinoxalines **(16&17)** respectively (scheme-3)

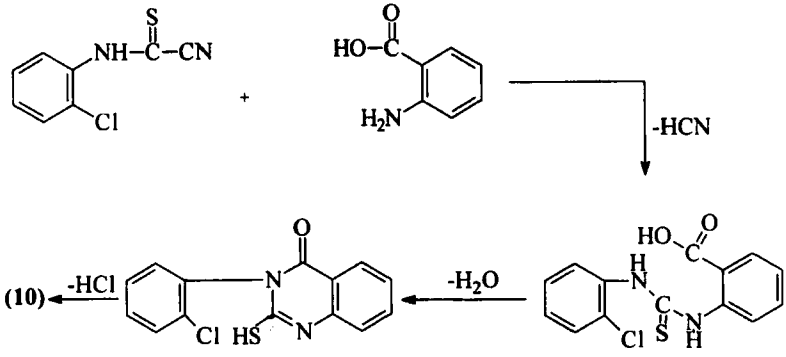
It is obvious that **(2&3)** took the same lines through reactions with these reagents.

Interaction of 3-aroyl-4-imino-2,5-imidazolidinedithiones **(4)** with amines was found to have different lines. Thus, when **(4)** was reacted with p-chloroaniline, the obtained product exhibited analytical figures compatible with **(18a)** as 4,5-bis(4′-chlorophenyl)-2-thioxo-1-phenyl imidazolidine (scheme-4), IR measurements showed the disappearance of νCO and no benzoyl group fragment could be observed in the mass spectrum fragmentation. The mechanism of formation of **(18a)** can be rationalized as described in (scheme-6). p-Anisidine could be also reacted with **(4)** by the same mechanism to produce 4,5-bis(4′-methoxyphenyl)-2-thioxo-1-phenyl-imidazolidine (**18b**; Scheme-4).

Interaction of **(4)** with o-phenylenediamine derivatives path through the same mechanism (scheme-6) to produce 2-thioxoimidazoquinoxaline derivatives **(19a-d)** (scheme-4). Mass spectra of these products **(19)** exhibited the molecular ion peak as the pase peak which through some light on the stability of these compounds.

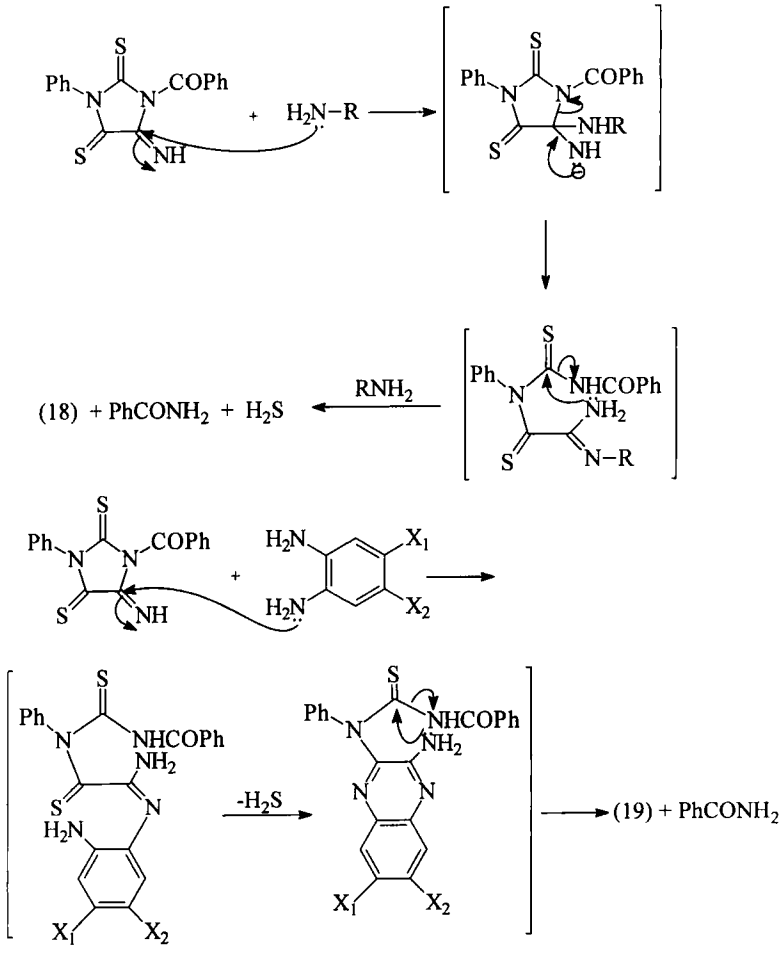


SCHEME 4



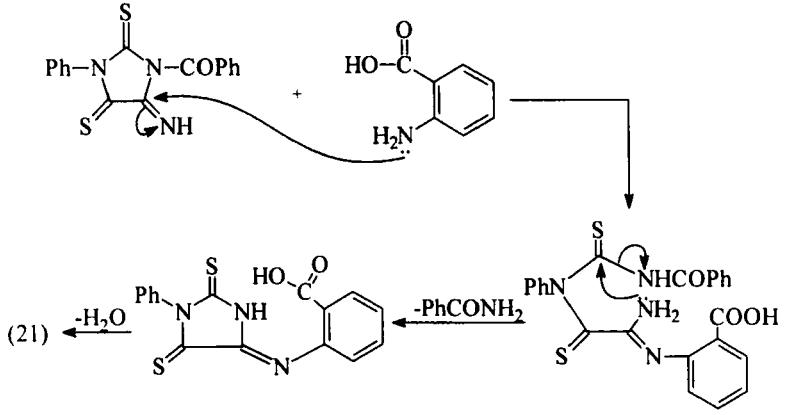
SCHEME 5

A strong evidence for this mechanism was arrived at from isolation of the intermediate (**20**, scheme-3) through interaction of (**4**) with o-phenylenediamine; νNH_2 was observed at 3400& 3350 cm^{-1} and PhCO could be easily observed at the mass spectrum (105; 100%). The mechanism was also demonstrated by interaction of (**4**) with anthranilic acid, which resulted in the formation of dithioxoimidazoquinazolinone (**21**) (scheme-4).



SCHEME 6

The formation of **(21)** took the same lines through nucleophilic attack on the imino group, opining of the imidazole ring, elimination of a benzamide molecule then recyclization took place by loosing one molecule of water (scheme-7).



SCHEME 7

It is obvious that the behaviour of **(4)** towards various nucleophilic reagents is the same, but differ than that of **(2&3)** towards the same reagents. In case of **(4)** fission of the imidazole ring was took place which can be attributed to the benzoyl group which attached directly to the imidazoline nitrogen, but with **(2&3)** no opening of the imidazole ring was occured.

The behaviour of 3-aroyl-4-imino-2,5-imidazolidinedithiones **(4)** towards nucleophilic reagents was found to be identical with our recent work[13] on the behaviour of 5-iminoxazolidine-4-thiones **(5)** towards the same reagents.

It was found that[14] interaction of the oxazolidineiminothione **(5)** with amines or o-phenylenediamines caused nucleophilic attack on the imino group, fission of the oxazolidine ring followed by elimination of the aldehyde molecule, then recyclized again (in case of o-phenylenediamines) to give quinoxaline derivative.

EXPERIMENTAL

M.p.'s reported were uncorrected. IR spectra (KBr) were recorded on Pye Unicam (UK) SP 1000 instrument. ^{1}H NMR spectra were recorded on a

Varian Gemini instrument, 200 MHz, using DMSO-d_6 as a solvent and TMS as internal standard. Chemical shifts are expressed as δppm units. Mass spectra were recorded on gas chromatographic GC-MSq p1000 (Shimadzu, Japan) instrument. Microanalytical data were obtained from the microanalytical data unit at the Cairo University

Cyanothioformamides (1)

Were prepared as described in the literature[1,2].

3-aryl-1-(3'-chlorophenyl)-5-imino-4-thioxo-2-imidazolidinones (2a,b)

A mixture of m-chlorophenyl isocyanate (0.01 mol), the appropriate cyanothioformamide (1, 0.01 mol) in dry ether (30 ml) and TEA. (0.5 ml) was stirred at room temperature for half an hour. The obtained product was recrystallized from ethanol to give **(2a,b)** (Table-1). IR ν_{max}/cm^{-1}: **2a**; 3270 (NH), 1728 (C=O); 1650 (C=N); 1472, 1161 (-CS-N). MS: **2a**; 315 (M^+; 10.4%); 317 (4%); 163 (22%); 135 (100%; base peak; C_6H_5NCS) and 77 (53%).

3-Aryl-1-phenyl-5-imino-2,4-imidazolidinedithiones (3a,b)

A mixture of phenyl isothiocyanate (0.01 mol), the requisite cyanothioformamide (1; 0.01 mol) in dry ether (20 ml) and TEA. (0.5 ml) was stirred at room temperature for 2 hr. The reaction mixture was triturated with n-hexane to give a product which recrystallized from ethanol to produce **(3a,b)** (Table-1). IR ν_{max}/cm^{-1}: **3a**; 3235 (NH); 1632 (C=N); 1483, 1208 (-CS-N). **3b**; 3245 (NH), 1645 (C=N); 1487, 1209 (-CS-N). ^{1}Hnmr (**3a**; $CDCl_3$), 1.2[6H,dd,$(CH_3)_2CH$], 2.8[1H,m,$CH(CH_3)_2$], 6.9–7.4 (9H,m,Ar-H), 8.2(1H,hump,NH,disappeared by D_2O). MS: **3a**; 339 (M^+; 48%); 340 (M+1; 15.7%); 296 (88.7%; M-$CH(CH_3)_2$); 262 (27.8%); 189(12%); 135(59.9%; PhNCS), 77(100%). **3b**; 327 (M^+; 23.8%) and 77 (100%).

1-Aroyl-3-aryl-5-imino-2,4-imidazolidinedithiones (4a-c)

A mixture of the requisite cyanothioformamide (1; 0.01 mol), aroyl isothiocyanate (0.01 mol) in dry ether (30 ml) and TEA. (0.5 ml) was stirred at room temperature for 0.5 hr. The obtained product was recrystallized from chloroform/n-hexane to give **(4a-c)** (Table-1). IR ν_{max}/cm^{-1}: **4a**; 3200 (NH), 3050 (Ar-CH), 1700 (C=O), 1650 (C=N), 1450, 1190 (-CS-N); **4b**;

3245 (NH), 3062 (Ar-CH), 1720 (C=O), 1660 (C=N), 1470, 1200 (-CS-N). MS: **4a**; 325 (M^+; 3.2%), 256 (25%), 224 (10.9%), 180 (13%), 164 (11%; PhCONCS+1) & 105 (100%; base peak; PhCO); **4c**: 359.5 (M+; 23%), 361 (27%), 362 (7%), 165 (53%) & 77 (100%).

5-Imino-4-oxazolidinethiones (5a-c)

A solution of substituted cyanothioformamide (**1**; 0.01 mol) in dry ether (20 ml) was treated with acetaldehyde (0.01 mol) and TEA. (0.5 ml). The mixture was stirred at room temperature for 0.5 hr then triturated with n-hexane to give a product, which recrystallized from ethanol to furnish (**5a-c**) (Table-1). IR ν_{max}/cm^{-1}: **5a**; 3255 (NH), 1638 (C=N), 1450, 1150 (-CS-N); **5b**; 3270 (NH), 1633 (C=N), 1499, 1175 (-CS-N) ^{1}Hnmr ($CDCl_3$) (δ, ppm): **5a**; 1.7 (3H,d,CH_3), 5.6 (1H,q,CH), 6.5–8.0(4H,m,Ar-H), 10(1H,s,NH, disappeared by D_2O). MS: **5a**; 225 (M+1; 42.9%), 199 (17.3%), 181 (18%; M-CH_3CO), 153 (100%; base peak; F.C_6H_4.NCS) & 111 (73.8%; m-F.C_6H_4.NH_2); **5b**; 224 (M^+; 52%), 225 (M+1; 22%), 179 (7%) & 153 (100%).

1-Phenyl-3-imino-2-thioxopyrroline-4,5-dicarboxylic acid (6)

A solution of cyanothioformanilide (0.01 mol) in dry benzene (30 ml) was treated with an ethereal solution of acetylenedicaboxylic acid (0.01 mol) and TEA (0.5 ml). The reaction mixture was stirred at room temperature for 2 hr, then treated with n-hexane. The obtained product was recrystallized from benzene/n-hexane to give (**6**; Table-1). IR: 3250–2500 (NH overlapped with OH of (CO_2H), 1667(CO), 1650 (C=N) & 1490, 1204 (-CS-N). MS: 276 (M+; 15%), 249 (31%), 222 (12%), 180 (5%), 161 (41%, PhNCSCN), 120 (91.8%) & 77 (100%).

Tetraethyl-1,5-diphenyldipyrrolo[2,3-b:2',3'-e]pyrazin-2,3,6,7-carboxylate (8a)

A solution of cyanothioformanilide (0.01 mol) in dry benzene (30 ml) was treated with diethyl acetylenedicarboxylate (0.01 mol) and TEA. (0.5 ml). The reaction mixture was stirred at 70°C for 2hr, triturated with ether and the obtained product was recrystallized from benzene/light pet. 60–80 to give (**8a**; Table-1). IR ν_{max}/cm^{-1} 2950 (CH aliph.), 1762, 1734 (C=O) & 1650 (C=N). MS: 598 (M+; 14.3%), 563 (5%), 538 (10%), 503 (13%), 435 (23%), 314 (14.1%;) & 77 (100%).

TABLE I Physical and analytical data of the synthesized compounds

R_1	R_2	R_3	R_4	M.P. °C	Yield %	TLC		Mol. Formula	Elemental and Calculate/Fo	
						Eluent	R_f		C	
									%	%
C_6H_5	C_6H_4Cl-m			138	75	E/H	0.71	$C_{15}H_{10}N_3OSCl$	57.05	3.17
						(1:3)		(315.5)	57.10	3.20
C_6H_4F-m	C_6H_4Cl-m			102	78	E/H	0.68	$C_{15}H_9N_3OSFCl$	53.07	2.70
						(1:3)		(333.5)	53.20	2.80
$C_6H_4CH(CH_3)_2$-p	C_6H_5			125	65	E/H	0.56	$C_{18}H_{17}N_3S_2$	63.72	5.02
						(1:3)		(339)	63.70	5.10
$C_6H_4OCH_3$-p	C_6H_5			135	75	E/H	0.70	$C_{16}H_{16}N_3OS_2$	58.72	3.98
						(1:3)		(327)	58.50	4.00
C_6H_5	C_6H_5			140	78	E/H	0.68	$C_{16}H_{11}N_3OS_2$	59.08	3.38
						(1:3)		(325)	59.10	3.30
C_6H_5	C_6H_4Cl-p			125	71	E/H	0.79	$C_{16}H_{10}N_3OS_2Cl$	53.48	2.79
						(1:3)		(359.5)	53.50	2.80
C_6H_4Cl-p	C_6H_5			320	75	E/H	0.65	$C_{16}H_9N_3OS_2Cl$	53.48	2.79
						(1:3)		(359.5)	53.50	2.80
C_6H_4F-m	CH_3			115	78	E/H	0.57	$C_{10}H_9N_2OSF$	53.57	4.02
						(1:4)		(224)	53.40	4.10

R_1	R_2	R_3	R_4	M.P. °C	Yield %	TLC		Mol. Formula	Elemental an Calculate/F	
						Eluent	R_f		C	
									%	%
C_6H_4F-p	CH_3			118	72	E/H	0.62	$C_{10}H_9N_2OSF$	53.57	4.02
						(1:4)		(224)	53.30	4.10
C_6H_4Cl-p	CH_3			137	75	E/H	0.56	$C_{10}H_9N_2OSCl$	50.00	3.75
						(1:2)		(240.5)	49.98	3.70
				125	40	E/H	0.53	$C_{12}H_8N_2O_4S$	52.17	2.90
						(1:3)		(276)	52.10	2.80
				130	67	E/H	0.48	$C_{32}H_{30}N_4O_8$	64.21	5.02
						(1:3)		(598)	64.10	5.00
				165	27	E/H	0.48	$C_{32}H_{24}N_6O_2S_2$	65.31	4.08
						(1:3)		(588)	65.20	4.10
-F	I			280	60	E/H	0.55	$C_{14}H_8N_2OSFI$	42.21	2.01
						(1:3)		(398)	42.20	2.00
n-F	H			263	80	E/H	0.47	$C_{14}H_9N_2OSF$	61.76	3.31
						(1:3)		(272)	61.70	3.20
n-Cl	H			235	75	E/H	0.65	$C_{14}H_9N_2OSCl$	58.33	3.13
						(1:3)		(288.75)	58.40	3.00
	H	H		243	70	E/H	0.56	$C_{14}H_8N_2OS$	66.67	3.17

R_1	R_2	R_3	R_4	M.P. °C	Yield %	TLC		Mol. Formula	Elemental an Calculate/F	
						Eluent	R_f		C	
									%	%
						(1:3)		(252)	66.70	3.20
	Cl	H		240	77	E/H	0.80	$C_{14}H_7N_2OSCl$	58.64	2.44
						(1:3)		(286.5)	58.60	2.40
	Br	H		265	85	E/H	0.78	$C_{14}H_7N_2OSBr$	50.76	2.12
						(1:3)		(331)	50.80	2.10
	I	H		260	86	E/H	0.50	$C_{14}H_7N_2OSI$	44.44	1.85
						(1:3)		(378)	44.30	1.90
	Br	Br		195	80	E/H	0.65	$C_{14}H_6N_2OSBr_2$	40.98	1.46
						(1:3)		(410)	40.90	1.50
C_6H_5	C_6H_4Cl-m	C_6H_4Cl-p		70	82	E/H	0.71	$C_{21}H_{14}N_4OCl_2$	61.61	3.42
						(1:3)		(409)	61.60	3.40
C_6H_4F-m	C_6H_4Cl-m	C_6H_4Cl-p		75	75	E/H	0.78	$C_{21}H_{13}N_4OFCl_2$	59.02	3.05
						(1:3)		(427)	59.00	3.00
C_6H_5	C_6H_4Cl-m	C_6H_4Cl-p		90	70	E/H	0.6	$C_{27}H_{17}N_4OCl_3$	62.37	3.28
						(1:3)		(519.5)	62.40	3.30
C_6H_4F-m	C_6H_4Cl-m	$C_6H_4CH_3$-p		85	72	E/H	0.65	$C_{29}H_{22}N_4OFCl$	70.09	4.43
						(496.5)		(496.5)	70.10	4.50

R_1	R_2	R_3	R_4	M.P. °C	Yield %	TLC		Mol. Formula	Elemental an Calculate/F	
						Eluent	R_f		C	
									%	%
C_6H_4F-m	C_6H_4Cl-m	$C_6H_4OCH_3$-p		95	68	E/H	0.55	$C_{29}H_{22}N_4O_3FCl$	65.84	4.16
						(1:3)		(528.5)	65.80	4.10
$C_6H_4OCH_3$-p	C_6H_5	$C_6H_4CH_3$-p		90	70	E/H	0.60	$C_{30}H_{26}N_4OS$	73.47	5.31
						(1:3)		(490)	73.40	5.30
$C_6H_4OCH_3$-p	C_6H_5	C_6H_4Cl-p		109	75	E/H	0.55	$C_{28}H_{20}N_4SOCl_2$	63.28	3.77
						(1:3)		(531)	63.30	3.80
C_6H_4F-m	C_6H_4Cl-m	H	H	280	82	E/H	0.61	$C_{21}H_{12}N_4OFCl$	64.53	3.70
						(1:3)		(390.5)	64.60	3.60
C_6H_4F-m	C_6H_4Cl-m	H	CH_3	240	75	E/H	0.73	$C_{22}H_{14}N_4OFCl$	65.27	3.36
						(1:3)		(404.5)	65.30	3.40
C_6H_4F-m	C_6H_4Cl-m	CH_3	CH_3	260	65	E/H	0.65	$C_{23}H_{16}N_4OFCl$	65.94	3.82
						(1:3)		(418.5)	65.90	3.70
$C_6H_4OCH_3$-p	C_6H_5	H	H	250	85	E/H	0.67	$C_{22}H_{16}N_4OS$	68.75	4.17
						(1:3)		(384)	68.70	4.20
$C_6H_4OCH_3$-p	C_6H_5	H	CH_3	305	74	E/H	0.58	$C_{23}H_{18}N_4OS$	69.35	4.53
						(1:3)		(398)	69.50	4.60
$C_6H_4OCH_3$-p	C_6H_5	CH_3	CH_3	315	80	E/H	0.60	$C_{24}H_{20}N_4OS$	69.90	4.85

R_1	R_2	R_3	R_4	M.P. °C	Yield %	TLC		Mol. Formula	Elemental and Calculate/Fo	
						Eluent	R_f		C	
									%	%
						(1:3)		(412)	69.90	4.80
C_6H_5	C_6H_4Cl-p			110	65	E/H	0.55	$C_{21}H_{14}N_4SCl_2$	59.29	3.29
						(1:3)		(425)	59.30	3.10
C_6H_5	$C_6H_4OCH_3$-p			105	70	E/H	0.58	$C_{23}H_{20}N_4SO_2$	66.35	4.81
						(1:3)		(416)	66.30	4.70
C_6H_5		CH_3	H	>300	65	E/H	0.44	$C_{16}H_{12}N_4S$	65.75	4.11
						(1:3)		(292)	65.70	4.20
C_6H_4Cl-p		H	H	>300	61	E/H	0.56	$C_{15}H_9N_4SCl$	57.60	2.88
						(1:3)		(312.5)	57.70	2.90
C_6H_4Cl-p		CH_3	H	>300	66	E/H	0.74	$C_{16}H_{11}N_4SCl$	58.81	3.37
						(1:3)		(326.5)	58.90	3.40
C_6H_4Cl-p		CH_3	CH_3	>300	69	E/H	0.37	$C_{17}H_{13}N_4SCl$	59.91	3.82
						(1:3)		(340.5)	59.80	3.80
				96	65	E/H	0.40	$C_{22}H_{17}N_3OS$	66.17	4.26
						(1:3)		(399)	66.20	4.30
				285	65	E/H	0.47	$C_{16}H_9N_3OS_2$	59.44	2.79
						(1:3)		(323)	59.40	2.80

Diimidazo[4,5-b:4′,5′-e]pyrazin-2,6-dithione (8b)

A solution of (**3b**; 0.01 mol) in benzene (20 ml) was treated with ethereal solution of diazomethane and stirred at room temperature for one hour. Trituration with n-hexane furnised a product which recrystallized from benzene/n-hexane to give (**8b**; 27%). IR ν_{max}/cm^{-1}; 2930 (CH aliph.), 1650 (C=N), 1510, 1120 (-CS-N; amide II & amide I). ^{1}Hnmr ($CDCl_3$); 4.2 (6H,s,2XOCH_3), 6.8–8.0 (18H,m,Ar-H). Ms; 588 (M^+, 15.3%), 77 (100%), 455 (20.7%,), 294 (15.8%, M/2; the iminocarbene), 135 (62%, PhNCS).

3-Aryl-2-thioxoquinazolin-4-ones (9a-c)

A mixture of the requisite cyanothioformamide (**1**; 0.01 mol), anthranilic acids (0.01 mol) in ethanol (25 ml) and TEA. (0.5 ml) was heated under reflux for 2 hrs. The obtained product was recrystallized from ethanol to give (**9a-c**; Table-1). IR ν_{max}/cm^{-1}: 9a; 3250 (NH), 1700 (C=O), 1487, 1187 (-CS-N); **9b**, 3205 (NH), 1693 (C=O) & 1490, 1170 (-CS-N). MS: **9a**, 398 (M+; 90%), 378 (16%) & 379 (100%, base peak; M-HF); **9b**: 272 (M^+; 46%) & 253 (100%; M-F) and 9c 288 (M^+; 100%; base peak).

Benzothiazolo[2,3-b]quinazolinones (10a-e)

A mixture of N (2′-chlorophenyl)cyanothioformamide (0.01 mol), anthranilic acid derivatives (0.01 mol) and TEA. (0.5 ml) in ethanol (20 ml) was heated under reflux for 3 hrs. The obtained product was recrystallized from ethanol to give (**10a-e**) (Table-1). IR ν_{max}/cm^{-1}: **10a**; showed the absence of νNH and the presence of νCO at 1673 & νC=N at 1578. MS: **10a**; 252 (M^+; 100%, base peak), 224 (6%), 192 (1.7%), 144 (2.2%) & 98 (1.7%); **10d**; 379 (M^+; 100%), 252 (30%) & 63 (17%).

1,3-Diaryl-4-arylimino-5-imino-2-imidazolidinones (12a,b)

A solution of (**2a or b**; 0.01 mol) and p-chloroaniline (0.01 mol) in ethanol (30 ml) was refluxed for 3 hrs. The reaction mixture was concentrated and the obtained product was recrystallized from ethanol to furnish **12a** or **b** respectively (Table-1). IR ν_{max}/cm^{-1}: **12b**; 3245 (NH), 3077 (Ar-H), 1679 (C=O), 1567& 1550 (C=N). MS: **12a**; 409 (M^+; 40%), 410 (M+1; 11%), 228 (52%), 127 (100%; base peak; p-ClC_6H_4NH) and 77 (42%).

1,3-Diaryl-4,5-bis(arylimino)-2-imidazolinones (14a-c and 15a,b)

A solution of (**2** or **3**; 0.01 mol) and the aromatic amine (0.02 mol) in ethanol (30 ml) was refluxed for 5 hrs. The reaction mixture was concentrated and the obtained product was recrystallized from ethanol to give **14a-c** or **15a,b** respectively (Table-1). IR ν_{max}/cm^{-1}: **14a**; 3062 (Ar-H), 1718 (C=O), 1636& 11590 (C=N); **14b**; 3047 (Ar-H), 2936 (aliph-H), 1716 (C=O), 1638, 1595 (C=N); **14c**, 3050 (Ar-H), 2910 (alip-H), 1720 (C=O), 1645, 1607 (C=N). ^{1}Hnmr (**14c**; $CDCl_3$), 3.8(6H,s,2xOCH_3), 6.9&7.8 (8H,AB quartet, Ar-H, p-substituted), 7.3–7.7 (8H,m,Ar-H, m-substituted). ^{1}Hnmr (**15a**; $CDCl_3$), 2.3 (6H,s,2CH_3), 4.0 (3H,s,OCH_3), 6.8–7.8 (17H, m,Ar-H).MS: **14a**, 519.5 (M^+; 20.4%), 442 (26.2%; M-C_6H_6), 407 (30.1%; M-p-Cl.C_6H_5), 229 (15.5%; p-ClC_6H_4.N:C:N.C_6H_5) & 77 (100%); **14b**, 497 (M^+; 10%); 406 (32.7%; M-p-CH_3.C_6H_4), 260 (21.6%), 227 (17%) & 107 (100%; p-CH_3.C_6H_4.NH_2); **15a**; 490 (M^+; 22%), 399 (100%; M-p-CH_3.C_6H_4), 234 [29%; 2(CH_3.C_6H_4NC)]; 118 (16.8%; CH_3.C_6H_4.NC+H) & 91 (31.6%, CH_3.C_6H_4).

Imidazo[4,5-b]quinoxalines (16a-c and 17a-c)

A solution of (**2b** or **3b**; 0.01 mol) and the requisite o-phenylenediamine (0.01 mol) in absolute ethanol (30 ml) was refluxed for 24 hrs. The solid that obtained was recrystallized from ethanol to give **16a-c** and **17a-c** respectively (Table-1). IR ν_{max}/cm^{-1}: **16b**; 1742 (C=O), 1590 (C=N). ^{1}Hnmr (**16b**; $CDCl_3$), 2.5(3H,s,CH_3), 7.15–7.95(11H,m,Ar-H). ^{1}Hnmr (**17c**; $CDCl_3$): 2.4 (6H,s,2CH_3), 4.1 (3H,s,OCH_3), 7.3–8.4 (11H,m,Ar-H). MS: **16a**; 390.5 (M^+, 52%), 296 (34%), 279 (100%; M-m-Cl.C_6H_4) & 95(27%; F.C_6H_4), **16b**; 404.5 (87%), 293 (100%; M-m-Cl.C_6H_4); 17a; 384 (M^+; 100%; base peak).

4,5-Bis(arylimino)-3-phenyl-2-imidazolidinethione (18a,b)

A solution of (**4a**; 0.01 mol) and p-chloroaniline or p-anisidine (0.02 mol) in ethanol (30 ml) was refluxed for 3 hrs. The reaction mixture was concentrated and the obtained product was recrystallized from ethanol to furnish **18a,b** (Table-1). IR ν_{max}/cm^{-1}: **18a**; 3290 (NH), 1663, 1614 (C=N); **18b**, 3300 (NH), 1666, 1615 (C=N). ^{1}Hnmr (**18b**; $CDCl_3$), 3.8, 3.9 (6H,2s, 2xOCH_3), 6.9&7.9 (8H,AB quartet, 2x p-substituted) and 7.5–7.7 (6H,m,Ar-H + NH which disappeared by D_2O). MS: **18a**, 425 (M^+; 18%), 358 (26%), 315 (50%; M-p-Cl.C_6H_4) and 138 (100%; p-Cl-C_6H_4..NC).

Imidazo[4,5-b]quinoxalines (19a-d)

A solution of (**4a** or **c**; 0.01 mol) and o-phenylenediamine derivative (0.01 mol) in absolute ethanol (30 ml) was refluxed for 24 hrs., the solid that obtained was recrystallized from ethanol to give (**19a-d**) (Table-1).). IR ν_{max}/cm^{-1}: **19a**; 3255 (NH), 1628 (C=N), 1472 & 1161 (-CS-N). MS: 19a; 292 (M^+, 15.8%), 291 (100%; base peak; M-1) & 77 (29.8%); **19b**; 312.5 (M^+; 100%; base peak); **19c**; 340.5 (M^+, 100%, base peak).

N^1-Benzoyl-N^2-phenyl-N^2(2'-aminoquinoxalin-3'-yl)thiourea (20)

A mixture of (**4a**; 0.01 mol) and o-phenylenediamine (0.01 mol) in absolute ethanol (30 ml) was refluxed for 3hrs. The solid that obtained was recrystallized from ethanol to give (**20**; Table-1).). IR ν_{max}/cm^{-1}: 3220 (NH), 1677 (C=O). MS: 399 (M^+; 19%), 398 (1.4%), 397 (6.5%), 105 (100%; PhCO, base peak) & 77 (44%).

1-Phenyl-8-oxo-imidazo[3,4-b]quinazoline-2,9-dithione (21)

A mixture of (**4a**; 0.01 mol) anthranilic acid (0.01 mol) in ethanol (25 ml) and TEA. (0.5 ml) was heated under reflux for 2 hrs. The obtained product was recrystallized from ethanol to give (**21**; Table-1).). IR ν_{max}/cm^{-1}: exhibited the absence of νNH; MS: 323 (M^+; 2.4%), 122 (16.2%; o-aminobenzaldehyde or benzamide+H) & 77 (100%).

References

[1] A. Reissert and K. Brüggemann, Ber., 57 (1924) 981.
[2] W. Walter and K.D. Bode, leibigs Ann. 131 (1966) 698.
[3] E.P. Papadopoulos. J. Org. Chem. 44 (1979) 3858.
[4] R. Ketcham and E. Schaumann, J. Org. Chem., 45 (1980) 3748.
[5] R. Ketcham, Synthesis, 11 (1980) 869.
[6] I. Khattak, R. Ketcham, E. Schaumann, and G. Adiwidjaja, J. Org. Chem., 50, 19 (1985) 3432.
[7] J. Huang and M.D. Graves, Heterocyclic Chemistry, 24 (1987) 1781.
[8] Y.A. Ammar, I.M. Ismail, A.M.Sh. El-Sharief, Y.A. Mohamed and R.A. Amer, J. Prakt. Chemie, Band 330, Heft 3 (1988) 421–427.
[9] Y.A. Ammar, A.M.Sh. EJ-Sharief, M.A. Zahran, M.Z. El-Said and U.H. El-Said, J. Chem. Research(s) (1995) 325.
[10] A.M.Sh. El-Sharief, R. Ketcham, and E. Schaumann, Phosphorus, Sulfur, and Silicon, 46 (1989) 83–86.
[11] A.M. Mohamed, A.M.Sh. El-Sharief, Y.A. Ammar and M.M. Aly, Pharmazie, 44, H. 11 (1989), 765–767.
[12] Y.A. Mohamed, Y.A. Ammar, A.M.Sh. El-Sharief and M.M. Aly, J. Chiense Chem. Soc., 37 (1990) 511–516.
[13] A.M.Sh. El-Sharief, Y.A. Ammar, Y.A. Mohamed and M.S.A. El-Gaby, Phosphorus, Sulphur and Silicon, 1999, 148, 117–130.