Mass Spectra of Thiazoloquinolines (1).

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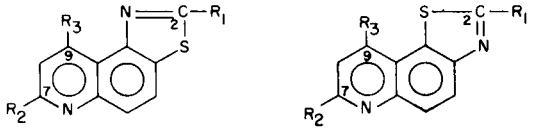
The behaviour under electron impact of sixteen thiazoloquinolines, unsubstituted and containing methyl substituents in both the pyridine and the thiazole rings, was investigated. Some decomposition schemes related to the main fragmentations in these fused heteroaromatic systems are proposed on the basis of available results on simpler related structures like thiazoles, benzothiazoles and quinolines.

The mass spectra of thiazoles (2), benzothiazoles (3) and quinolines (4,5,6) have recently been investigated, but no survey of thiazoloquinolines has been reported. In previous works we described the synthesis and structure of substituted thiazoloquinolines (7) which now are available to us. This paper is concerned with the mass spectra of the thiazoloquinolines (I-XVI), which are recorded in Table I.

TABLE I



	R_1=	R_2=	R_3=		R_1=	R_2=	R_3=
I	H	H	H	IX	H	H	H
II	CH_3	H	H	X	CH_3	H	H
III	H	CH_3	H	XI	H	CH_3	H
IV	H	H	CH_3	XII	H	H	CH_3
V	CH_3	CH_3	H	XIII	CH_3	CH_3	H
VI	CH_3	H	CH_3	XIV	CH_3	H	CH_3
VII	H	CH_3	CH_3	XV	H	CH_3	CH_3
VIII	CH_3	CH_3	CH_3	XVI	CH_3	CH_3	CH_3

Table II reports the related spectral data.

In Table III the metastable transitions are collected.

Clarke *et al.* (2) and Millard *et al.* (3) elucidated the fragmentation processes of some thiazoles and benzothiazoles. Recently Draper *et al.* (5,6) in their labelling experiments completely clarified the fragmentation mechanism of methyl substituted quinolines. Taking into account the results reported by the above authors we investigated the behaviour under electron impact of the condensed thiazoloquinoline system.

As a general rule we did not observe any appreciable differences between the two types of condensation. Consequently, the results regarding the [4,5-*f*] isomers (I-VIII) can be extended to the parent [5,4-*f*] isomers (IX-XVI).

The parent compounds of the two series, the thiazoloquinolines I and IX, show two important decomposition

SCHEME I

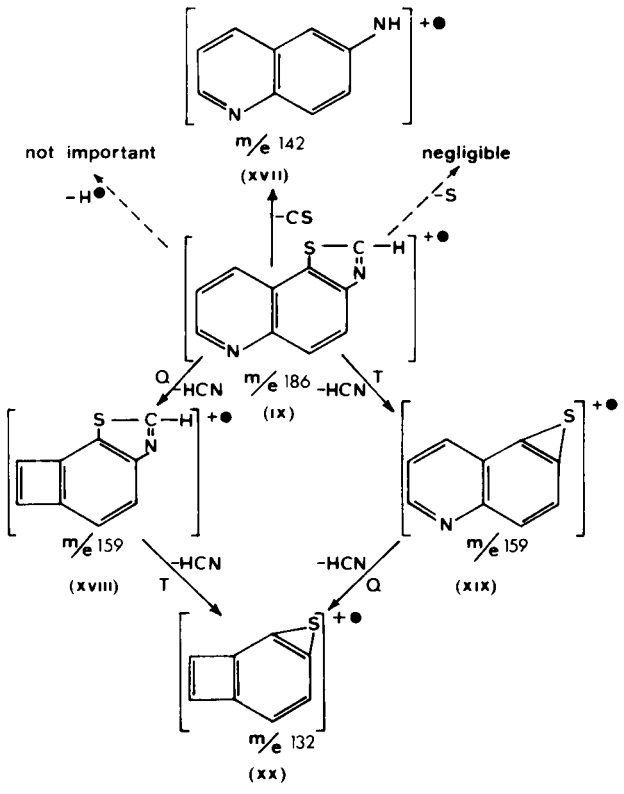


TABLE II

Mass Spectra of Thiazoloquinolines

I		IX	II		X	III		XI	IV		XII
I %	m/e	I %	I %	m/e	I %	I %	m/e	I %	I %	m/e	I %
5.2	188	5.4	5.4	202	5.5	5.1	202	5.2	5.1	202	5.2
12.8	187	12.7	13.8	201	14.0	13.6	201	13.6	13.8	201	13.7
100.0	186	100.0	100.0	200	100.0	100.0	200	100.0	100.0	200	100.0
4.8	185	3.4	14.8	199	12.5	8.2	199	6.2	19.2	199	11.5
3.8	160	3.2	2.6	173	2.0	2.2	185	2.0	1.6	174	2.5
23.8	159	23.0	1.8	172	2.9	2.5	174	2.0	4.0	173	11.9
2.7	158	3.1	1.4	168	1.5	7.3	173	6.3	12.4	172	23.8
0.5	154	1.0	5.0	160	6.0	10.1	172	6.4	0.5	171	3.8
10.5	142	9.0	22.0	159	24.0	8.2	168	3.5	4.3	168	0.8
3.4	133	3.1	3.5	158	3.5	4.4	167	2.0	2.7	167	0.5
6.8	132	6.2	1.7	155	1.8	5.3	159	2.5	2.1	156	0.7
2.1	127	2.0	3.0	154	2.4	3.2	158	3.9	3.5	155	1.0
8.2	115	6.2	1.9	133	3.6	3.6	156	2.0	2.8	145	3.8
6.8	114	5.0	3.7	132	4.5	3.6	155	2.2	2.2	129	2.2
2.6	106	2.5	1.8	129	3.2	4.4	146	2.0	2.6	128	2.8
			2.4	127	2.4	6.2	145	2.6	2.4	102	2.0
			3.5	115	6.4	3.0	141	2.1	3.6	100	3.2
			2.5	114	5.4	5.0	140	2.5			
			4.1	100	3.8	4.2	129	2.2			
						5.0	128	3.0			
						7.8	114	4.3			
						7.2	102	2.8			

V		XIII	VI		XIV	VII		XV	VIII		XVI
5.6	216	5.8	5.3	216	5.7	6.0	216	5.5	5.6	230	5.5
14.8	215	14.9	14.8	215	15.1	14.7	215	14.8	15.5	229	15.3
100.0	214	100.0	100.0	214	100.0	100.0	214	100.0	100.0	228	100.0
8.0	213	7.8	12.8	213	15.2	13.7	213	10.1	7.0	227	8.2
3.0	199	2.5	5.8	199	7.4	8.5	199	8.2	4.8	213	6.4
1.0	186	1.2	1.5	186	2.2	4.8	198	3.6	3.9	187	4.6
3.0	174	3.0	2.4	174	2.8	4.0	187	2.2	9.4	186	13.2
8.4	173	8.6	5.4	173	9.8	6.8	186	4.1	1.8	173	2.9
7.2	172	8.6	20.2	172	20.2	2.2	185	1.4	3.0	172	3.1
2.3	146	2.6	2.1	146	2.4	4.4	182	2.2	2.0	154	2.0
3.0	145	3.0	3.2	145	4.3	2.8	181	2.0	2.2	146	2.4
2.7	140	2.2	1.6	140	2.3	4.9	173	3.8	2.6	145	3.4
3.6	129	3.0	2.6	129	2.1	4.6	172	6.2	2.4	128	2.6
2.6	128	2.9	2.7	128	3.5	2.0	169	2.8	3.2	115	3.4
2.2	114	2.4	2.0	114	2.0	0.8	155	3.5	7.8	114	4.3
3.5	107	3.3	6.0	107	3.8	3.2	154	5.8	2.0	107	2.2
2.8	102	2.7	3.6	102	3.5	2.0	153	4.2	2.3	102	2.6
						2.8	146	5.2			
						3.8	145	4.6			
						2.8	128	4.8			
						2.6	127	4.2			
						4.2	115	6.4			
						3.6	107	3.6			
						3.3	102	4.2			

All peaks having an abundance greater than 2% (base peak taken as 100%) are recorded in the Table. Peaks of lesser abundance are included if they have obvious diagnostic significance or if they are discussed in the text.

pathways from the molecular ion (Scheme I. Compound IX is used as an example. T and Q indicate loss from the thiazole and quinoline nuclei respectively): loss of hydrogen cyanide and of carbon monosulphide. The most important peak at M-27 is due to both the loss of HCN from the thiazole ring and the loss of HCN from the quinoline ring the latter contribution apparently being very small in the case of compounds II and X. In these compounds in which the presence of the 2-methyl substituents makes rather insignificant the loss of hydrogen

TABLE III

Metastable Transitions in the Mass Spectra of Thiazoloquinolines

m_1	m_2	m_{lost}	$m_{calcd.}$	$m_{obsd.}$ in compounds:	
				I	IX
186	185	1	184.0	184.0	184.0
186	159	27	135.9	136.0	136.0
186	142	44	108.4	108.4	108.5
159	132	27	109.6	109.6	109.5
				II	X
200	199	1	198.0	198.0	198.0
200	159	41	126.4	126.4	126.4
159	132	27	109.6	109.6	109.6
				III	XI
200	199	1	198.0	198.0	198.0
200	185	15	171.1	171.0	171.0
200	173	27	149.6	149.6	149.7
199	172	27	148.7	148.7	148.7
173	172	1	171.0	171.0	171.0
				IV	XII
200	199	1	198.0	198.0	198.0
200	173	27	149.6	149.6	149.7
199	172	27	148.7	148.7	148.7
173	172	1	171.0	171.0	171.0
				V	XIII
214	213	1	212.0	212.0	212.0
214	199	15	185.1	185.0	185.0
214	173	41	139.9	140.0	140.0
173	172	1	171.0	171.0	171.0
213	172	41	138.9	139.0	139.0
				VI	XIV
214	213	1	212.0	212.0	212.0
214	199	15	185.1	185.0	185.0
214	173	41	139.9	140.0	140.0
173	172	1	171.0	171.0	171.0
213	172	41	138.9	139.0	139.0
				VII	XV
214	213	1	212.0	212.0	212.0
214	199	15	185.1	185.0	185.0
214	187	27	163.4	163.5	163.4
213	186	27	162.4	162.5	162.5
187	186	1	185.0	185.0	185.0
199	172	27	148.7	148.7	148.8
				VIII	XVI
228	227	1	226.0	226.0	226.0
228	213	15	199.0	199.0	199.0
228	187	41	153.4	153.3	153.4
227	186	41	152.4	152.4	152.4
213	172	41	138.9	139.0	139.0
187	186	1	185.0	185.0	185.0

cyanide from the thiazole ring, the peak at M-27, which mainly originates from the loss of quinoline HCN, is very small. The preferential loss of HCN from the thiazole portion instead of from the quinoline part could be due to the formation of the thiiren type ion-radical (XIX). In compounds I and IX the M-27 ion can lose a second molecule of hydrogen cyanide to give the peak at m/e 132 (XX). The loss of hydrogen from the molecular ion is not important and the loss of sulphur from the molecular ion is quite negligible.

Compounds II and X containing a methyl substituent in the thiazole ring have two important fragmentation pathways which are different from the parent ion: the loss of a hydrogen radical with formation of the M-1 ion and the loss of a neutral molecule of acetonitrile to give again the thiiren type ion-radical (XIX), which by loss of a neutral molecule of HCN gives the peak at m/e 132 (XX). A minor fragmentation pathway from the molecular ion arises by loss of sulphur, while the loss of carbon monosulphide is negligible.

Proceeding through the series the behaviour of thiazoloquinolines unsubstituted in the thiazole ring and bearing methyl substituents in the pyridine ring was investigated.

The main fragmentations of 7-methyl and 9-methyl thiazoloquinolines (III, XI, IV, XII) are outlined in Scheme II (compound XI is used as an example).

Draper *et al.* (4) established the sequence M → M-H → M-(H+HCN) in the fragmentation of methylquinolines. The M-H ion in our molecules can lose a molecule of hydrogen cyanide either from the quinoline ring giving the m/e 172 ion (XXII) or from the thiazole ring giving the m/e 172 ion (XXIV). Both XXII and XXIV can further lose HCN to give an ion at m/e 145 (XXV) and CS to give a species at m/e 128. These thiazoloquinolines can also lose a molecule of HCN from the thiazole portion directly from the molecular ion to form an ion at m/e 173 (XXIII) which in turn by loss of a hydrogen radical gives a species at m/e 172 (XXIV). Loss of S and CS from the molecular ion, although not intense, is observed in these compounds. A characteristic difference in the behaviour of compounds containing a 7-methyl substituent (III, XI) compared with compounds containing a 9-methyl substituent (IV, XII) is the direct loss of a methyl radical from the parent ion: this behaviour is not unexpected being typical for 2-methylquinolines (4).

The main fragmentations of 7,9-dimethylthiazoloquinolines (VII, XV) are outlined in Scheme III (compound XV is used as an example).

The behaviour of these compounds is closely related to the fragmentation of the parent 2,4-dimethylquinoline (5). It can be reasonably postulated as a first step, the quinoline ring expansion involving preferentially the 9-methyl group: subsequently from the methylene position either loss of a methyl radical or a hydrogen radical may occur giving m/e 199 (XXI) and m/e 213 (XXVI) ions, respectively. From the first ion (to which simple α cleavage of the 7-methyl group may also contribute) a neutral molecule of hydrogen cyanide from the quinoline ring is lost to give the m/e 172 ion (XXII). From the latter a

SCHEME II

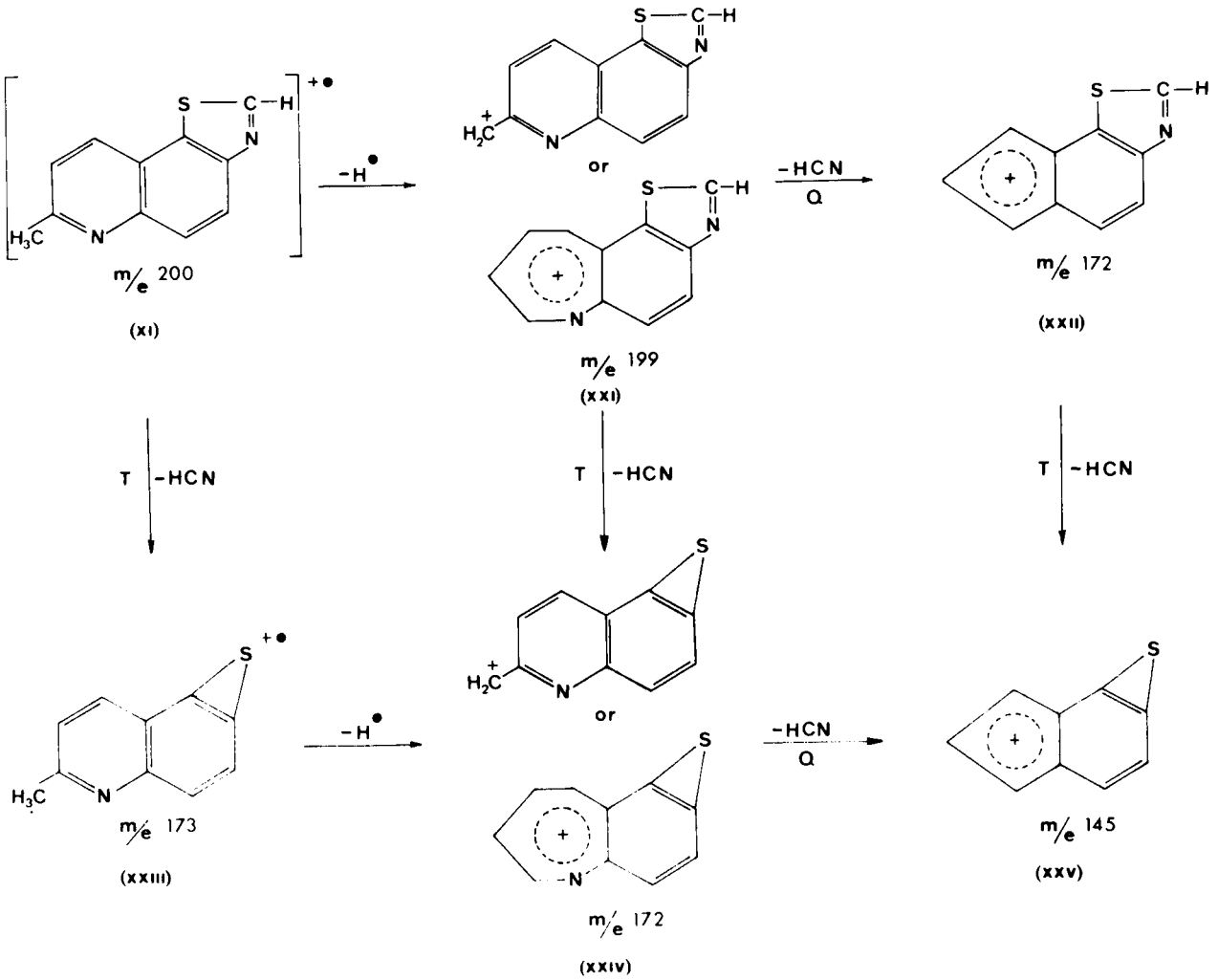
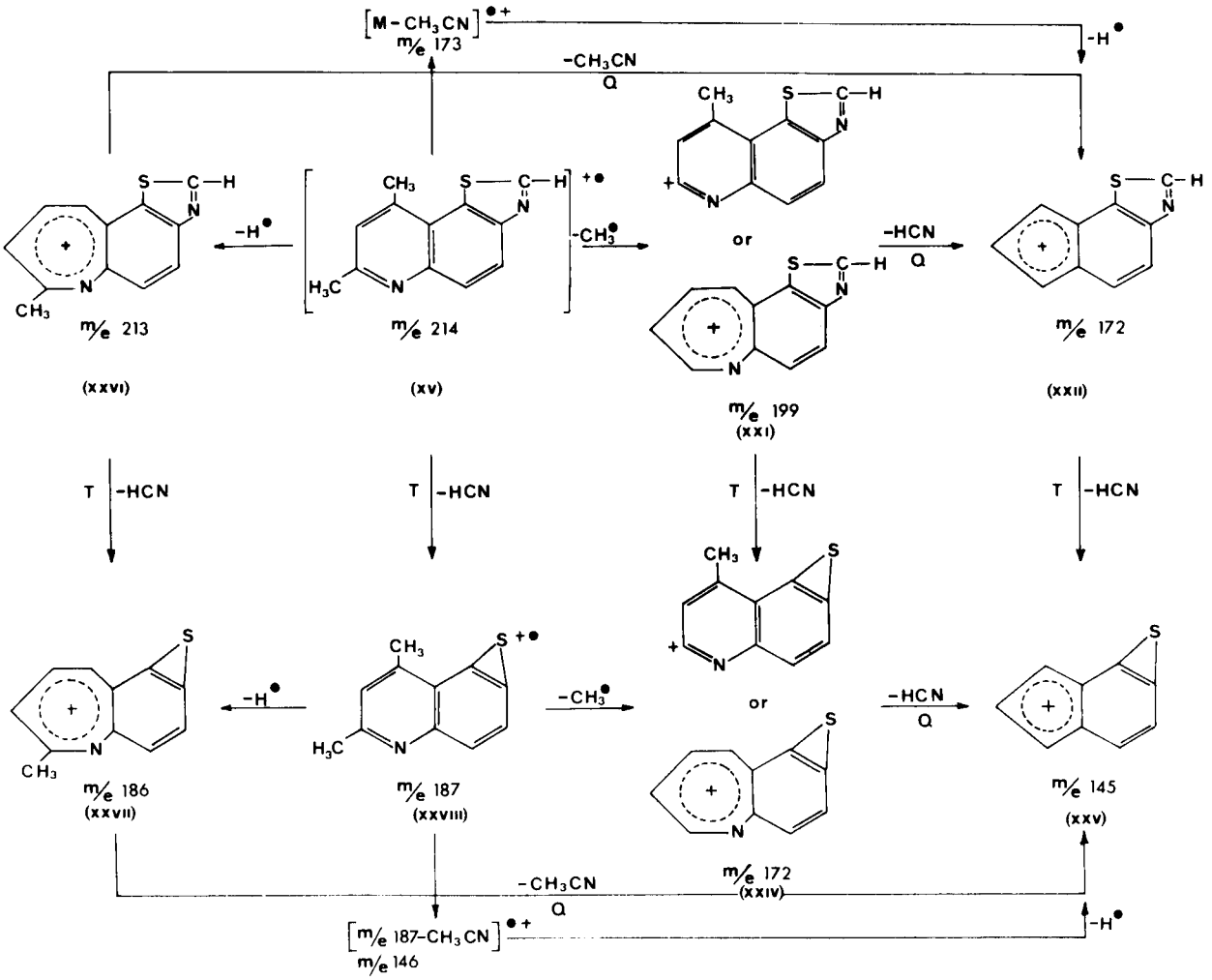


TABLE IV

Compound Number	M.p., °C	Formula	C % Calcd.	C % Found	H % Calcd.	H % Found	N % Calcd.	N % Found
I	136-137	$C_{10}H_6N_2S$	64.49	64.73	3.22	3.14	15.05	15.01
X	91-92	$C_{11}H_8N_2S$	65.97	66.14	4.02	4.16	13.98	13.75
VII	143-144	$C_{12}H_{10}N_2S$	67.26	67.10	4.70	4.58	13.07	13.05
VIII	113-114	$C_{13}H_{12}N_2S$	68.39	68.60	5.30	5.39	12.27	12.40
XV	172-173	$C_{12}H_{10}N_2S$	67.26	67.41	4.70	4.66	13.07	13.19
XVI	169-170	$C_{13}H_{12}N_2S$	68.39	68.57	5.30	5.17	12.27	12.39

neutral molecule of acetonitrile is lost to give again the m/e 172 ion (XXII) (such a decomposition is typical for dimethylquinolines having an α methyl substituent). A third route to the m/e 172 ion (XXII) is the direct loss of a neutral molecule of acetonitrile from the parent ion followed by loss of a hydrogen radical. From the parent ion and from m/e 213 (XXVI), m/e 199 (XXI) and m/e 172 (XXII) ions a molecule of thiazole hydrogen

SCHEME III



cyanide is systematically lost giving m/e 187 (XXVIII), m/e 186 (XXVII), m/e 172 (XXIV) and m/e 145 (XXV) ions, respectively. Regarding the quinoline portion of the molecule, the further decomposition of the m/e 187 ion (XXVIII) is the same as in the molecular ion.

The behaviour of the remaining compounds of the series, (V), (VI), (VIII), (XIII), (XIV), (XVI) *i.e.* thiazoloquinolines with methyl substituents in both the thiazole and in the pyridine ring was investigated. The behaviour of these compounds in comparison with the corresponding derivatives unsubstituted in the 2-position is closely related to the above reported behaviour of compounds II and X in comparison with compounds I and IX; the main differences are: (a) a major intensity due to the loss of a hydrogen radical from the molecular ion; (b) loss of acetonitrile instead of hydrogen cyanide from the thiazole ring as is shown in Schemes I, II, and III.

EXPERIMENTAL

Apparatus, Methods and Materials.

Mass spectra were determined on a Hitachi Perkin-Elmer RMU-6H mass spectrometer at an ionizing potential of 75 eV and an ionizing current of 50 μA. Samples were introduced through an all-glass inlet system maintained at 160°.

Thiazoloquinolines II and IX were prepared by the methods of K. Fries and A. Wolter (8) and W. A. Boggust and W. Cocker (9).

Thiazoloquinolines III, XI, IV, XII, V, XIII, VI, XIV were prepared in previous work (7).

Thiazoloquinoline I was prepared by the method of H. Erlenmayer and H. Ueberwasser (10). The base was crystallized from ligroin. The analytical data are reported in Table IV.

Table IV

Thiazoloquinoline X was prepared by the method of W. A. Boggust and W. Cocker (9). The product was isolated by steam distillation of the reaction mixture previously made alkaline with 10% sodium hydroxide. The base was crystallized from ligroin.

The analytical data are reported in Table IV.

Thiazoloquinolines VII, XV, VIII, XVI were prepared following the general procedure indicated in reference (11). The analytical data are summarized in Table IV.

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