

Amidinoyl isothiocyanates and their dimers

Š. STANKOVSKÝ and A. MARTVOŇ

Department of Organic Chemistry, Slovak Technical University,
880 37 Bratislava

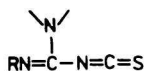
Received 23 January 1979

Accepted for publication 25 September 1979

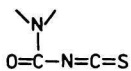
The synthesis and spectral properties of some amidinoyl isothiocyanates and their dimers are described.

Описывается синтез и спектральные свойства избранных амидиноил-изотиоцианатов и их димеров.

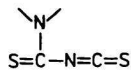
The high reactivity of acyl isothiocyanates [1] is mainly utilized in cycloaddition reactions. Analogously, carbamoyl *XII* [2], thiocarbamoyl *XIII* [3] or imidoyl isothiocyanates *XIV* [4—8] were shown to be even more reactive compounds for this application. Amidinoyl isothiocyanates *I—XI*, a group of *XIV* which can be formally regarded aza analogues of carbamoyl or thiocarbamoyl isothiocyanates, have so far not been much investigated.



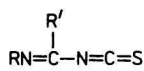
I—XI



XII



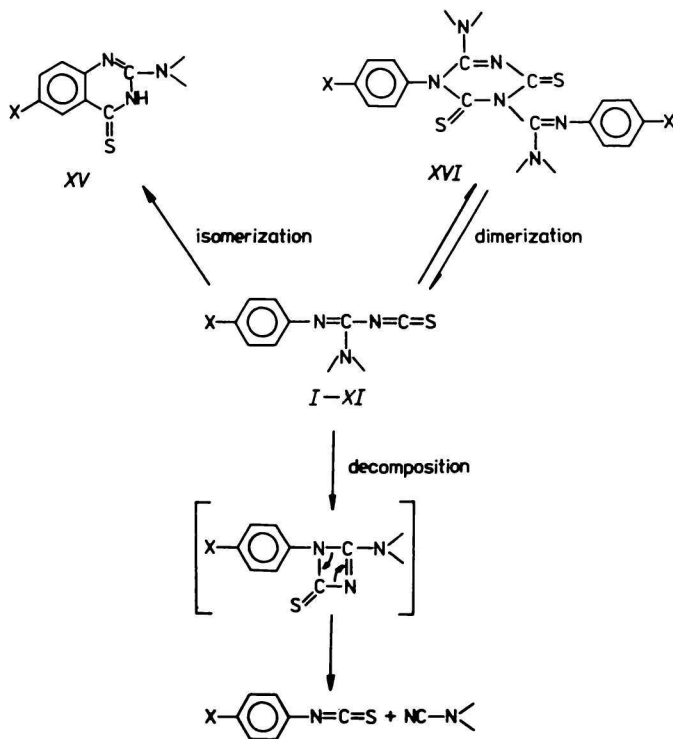
XIII



XIV

The preparation of only nine amidinoyl isothiocyanates ($\text{R} = 4\text{-X}-\text{C}_6\text{H}_4$, where $\text{X} = \text{NO}_2, \text{Br}, \text{Cl}$; $-\text{N} \leftarrow$ = diethylamine, pyrazoline, piperidine, morpholine) was reported [9, 10]. These isothiocyanates bear such substituents the deactivation effect of which increases their stability. A low stability of these compounds is manifested by isomerization or dimerization to afford derivatives of quinazoline-4(3*H*)-thione (*XV*) and 1-amidinoyl-*s*-triazine-2,6-dithione *XVI*, respectively (Scheme 1). Whereas isomeric products of all hitherto known amidinoyl isothiocyanates are described, only three dimers ($-\text{N} \leftarrow$ = pyrazoline) are known [10].

This paper deals with the preparation and spectral properties of amidinoyl isothiocyanates *I—XI*, containing no deactivation substituent and possessing an



Scheme 1

Concurrent reactions of amidinoyl isothiocyanates

amino group (dimethylamine, piperidine, morpholine), which increases their reactivity. Dimers obtained from them were characterized.

Experimental

Infrared absorption spectra were recorded with a UR-20 (Zeiss, Jena) spectrophotometer. Compounds soluble in CHCl_3 were measured in solution in a 0.05 cm NaCl cell. Sparingly soluble dimers were measured in KBr tablets; reading accuracy $\pm 4 \text{ cm}^{-1}$. Mass spectra of dimers were taken with an MS 902-S (AEI, Manchester) apparatus at an ionizing electron energy 70 eV, trap current 100 μA , ionization chamber temperature 180–220°C.

Isothiocyanates I—XI

To a stirred and cooled (-5 to -15°C) solution of dried KSCN (1.94 g; 20 mmol) in acetone (40 ml) chloroformamidine (20 mmol) dissolved in acetone (40 ml) was added during 20 min; stirring was continued at this temperature for additional $1\frac{1}{2}$ h. The colour of

this reaction mixture used to turn to yellow at the end, when the separated KCl was filtered off and acetone from the filtrate was distilled off at room temperature. Crystalline products separated during evaporation. Due to instability of these compounds no recrystallization was attempted; the substances were spectrally characterized and used in further syntheses. Yields and properties of monomers are listed in Table 1.

Table 1
Characterization of amidinoyl isothiocyanates

Compound	X	-N< ^a	Yield %	M.p. °C	$\nu(\text{NCS})$	$\nu(\text{C=N})$ cm^{-1}	$\nu(\text{C=N})^b$
I	NO ₂	Pi	65	69—73	2003	1625	1654
II	Br	Di	92	Oil	2002	1633	1665
III	Br	Mo	97	87—89 (91 [10])	1993	1629	1661
IV	Cl	Mo	95	83 (83 [10])	1992	1628	1665
V	Cl	Pi	77	55—56 (58 [10])	2004	1623	1654
VI	CH ₃	Mo	89	71—80	1992	1626	1656
VII	H	Mo	96	85—88	1992	1626	1650
VIII	H	Pi	91	Oil	1997	1631	1632
IX	H	Di	93	Oil	2000	1632	1662
X	H	DP	70	105—107	1995	1635	1670
XI	H	PPi	93	185—186	1992	1631	1660

a) Pi — piperidine, Di — dimethylamine, Mo — morpholine, DP — diphenylamine, PPi — 4-phenylpiperazine.

b) $\nu(\text{C=N})$ vibrations of the starting chloroformamidines.

Dimers of amidinoyl isothiocyanates

A solution of freshly prepared amidinoyl isothiocyanate (5 mmol) in acetone (25 ml) was left to stand in a closed flask at room temperature in the dark. Yellow crystalline substances separating within 24 h were filtered off after 48 h and crystallized either from benzene or ethanol. (Benzene solutions of these compounds fluoresce.) Characteristic data of these substances are given in Table 2.

Results and discussion

Amidinoyl isothiocyanates were synthesized from the respective chloroformamidines [11, 12] and KSCN by a modified *Abraham* and *Barnikow* procedure [10].

At a sufficiently low reaction temperature (–5 to –15°C) amidinoyl isothiocyanates I—XI can be isolated; their infrared spectra were measured immediately

Table 2
Characterization of dimers of amidinoyl isothiocyanates

X	-N< ^a	Formula	M ⁺	Yield %	M.p. °C	Calculated/found			ν(C=N) cm ⁻¹
						% C	% H	% N	
NO ₂	Pi	C ₂₆ H ₂₈ N ₈ O ₄ S ₂	580	35	222—224	53.76	4.86	19.30	1626 ^b
						53.62	4.73	19.20	
Br	Di	C ₂₀ H ₂₀ Br ₂ N ₆ S ₂	566 (568)	40	204—206	42.26	2.54	14.78	1607
						42.32	3.51	14.91	
Br	Mo	C ₂₄ H ₂₄ Br ₂ N ₆ O ₂ S ₂	650 (652)	45	203—205	44.18	3.71	12.88	1608
						44.07	3.61	12.90	
Cl	Mo	C ₂₄ H ₂₄ Cl ₂ N ₆ O ₂ S ₂	—	45	214—215	51.15	4.29	14.91	1620 ^b
						51.04	4.26	14.80	
Cl	Pi	C ₂₆ H ₂₈ Cl ₂ N ₆ S ₂	—	43	179—181	55.81	5.01	15.02	1619 ^b
						55.73	4.83	14.91	
CH ₃	Mo	C ₂₆ H ₃₀ N ₆ O ₂ S ₂	522	32	256—258	59.74	5.78	16.07	1605
						59.78	5.71	16.18	
H	Mo	C ₂₄ H ₂₆ N ₆ O ₂ S ₂	494	35	204—205	58.32	5.29	16.99	1617
						58.24	5.70	16.83	
H	Pi	C ₂₆ H ₃₀ N ₆ S ₂	490	42	219—220	63.86	6.16	17.13	1620 ^b
						63.53	5.98	17.26	
H	Di	C ₂₀ H ₂₂ N ₆ S ₂	—	37	207—209	58.51	5.40	20.47	1615
						58.16	5.41	20.89	

a) Cf. Table 1.

b) In KBr discs.

after preparation, since after a 30 min standing in a solvent or without it the absorption band at 2000 cm⁻¹ disappears mainly with unsubstituted derivatives VII—XI. These unstable derivatives could not be identified either with the known reaction of isothiocyanates with amines under formation of thioureas. It has been found that benzene solutions of these reactants afford the corresponding stable thiourea, nevertheless the yield was very low and the product was contaminated with a considerable amount of isomeric and dimeric products, the separation of which is, however, labourious.

Isothiocyanates I—XI reveal in their infrared spectra a characteristic ν(NCS) vibration at 2000 cm⁻¹. The effect of a substituent, or the nature of the *sec*-amino group on the shift of this band is not especially notable. This band lies in the region by 100 cm⁻¹ lower than that of aromatic isothiocyanates [13], which could possibly be formed by their decomposition [7]. Since there are no other groups absorbing in this region with the exception of the above-mentioned isothiocyanates I—XI, XII—XIV, this band is of diagnostic value.

Another intense and characteristic band of isothiocyanates under study lies at 1630 cm^{-1} ($\nu(\text{C}=\text{N})$). In contrast to the corresponding chloroformamidines, position of this band is approximately by 30 cm^{-1} lower (*cf.* Table 1). Little intense band of these isothiocyanates associated with $\nu(\text{C}-\text{H})$ of aliphatic $-\text{CH}_2-$ groups of substituents at the *sec*-amino group is located between 2800 and 2950 cm^{-1} and accords with that of the starting chloroformamidines.

Imidoyl isothiocyanates [7] likely amidinoyl isothiocyanates are unstable and undergo either decomposition to an aromatic isothiocyanate and cyanamide, or a reversible formation of a dimer which affords upon heating or a longer standing, an isomer (Scheme 1).

The acetone solution of isothiocyanates I—XI furnished upon standing yellow crystalline products, the benzene solutions of which fluoresced. Their infrared spectra displayed little intense absorption bands at 1620 — 1605 cm^{-1} ascribable to amidine $\nu(\text{C}=\text{N})$ vibrations. An intense complex band at 1590 — 1570 cm^{-1} might be due to an aromatic $\nu(\text{C}=\text{C})$ vibration overlapped by a $\nu(\text{C}=\text{N})$ one of a triazine skeleton. In the region of aliphatic $\nu(\text{C}-\text{H})$ vibrations (2900 — 2800 cm^{-1}) absorption bands corresponding to vibrations of $-\text{CH}_2-$ groups of *sec*-amines can be observed. The presented arguments indicate the dimeric character of isothiocyanates, *i.e.* 1-amidinotetrahydro-*s*-triazine-2,6-dithiones. Molecular weights determined mass spectrometrically also are in favour of dimers. Isomers are excluded on the basis of infrared evidence showing no characteristic $-\text{NH}-$ vibration bands.

Formation of dimers of amidinoyl isothiocyanates formally represents a Diels—Alder $4 + 2$ cycloaddition, where the $-\text{NCS}$ group is a dienophile and the $-\text{N}=\text{C}-\text{N}=\text{C}=\text{S}$ system is a conjugated diene. Mass spectrometric fragmentation of dimeric isothiocyanates is of typical retro-Diels—Alder pattern, *i.e.* a cleavage to starting compounds takes place.

Dimers of little reactive isothiocyanates X, XI could not be obtained by standing. Aiming to accelerate this reaction the acetone solution was refluxed; as a result only isomeric quinazolines could be isolated. The reaction mixture after recovery of crystals was chromatographed on Silufol (Kavalier, Votice) plates; it has been found that in addition to a concurrent product, *i.e.* a quinazoline which is better soluble than the corresponding dimer, also aromatic isothiocyanates were present. Formation of aromatic isothiocyanates from amidinoyl isothiocyanates, resulting from the loss of the corresponding cyanamide, was reliably proved [14]. Due to formation of these by-products yields of dimers are relatively low.

References

1. Goerdeler, J., *Quarterly Reports on Sulfur Chemistry* 5, 169 (1971).
2. Goerdeler, J. and Wobig, D., *Angew. Chem.* 79, 272 (1967).

3. Goerdeler, J. and Lüdke, H., *Chem. Ber.* 103, 3393 (1970).
4. Blatter, H. M. and Lukaszewski, H., *Tetrahedron Lett.* 1964, 855.
5. Goerdeler, J. and Weber, D., *Tetrahedron Lett.* 1964, 799.
6. Blatter, H. M. and Lukaszewski, H., *J. Org. Chem.* 31, 722 (1966).
7. Goerdeler, J. and Weber, D., *Chem. Ber.* 101, 3475 (1968).
8. Goerdeler, J., Panshiri, F. M., and Vollrath, W., *Chem. Ber.* 108, 3071 (1975).
9. Barnikow, G. and Abraham, W., *Z. Chem.* 10, 193 (1970).
10. Abraham, W. and Barnikow, G., *Tetrahedron* 29, 691, 699 (1973).
11. *Brit.* 888646 (1962); *Chem. Abstr.* 57, 136962 (1962).
12. Ried, W. and Merkel, W., *Chem. Ber.* 105, 1532 (1972).
13. Stankovský, Š. and Kováč, Š., *Chem. Zvesti* 28, 243 (1974).
14. Stankovský, Š. and Martvoň, A., *Collect. Czech. Chem. Commun.*, in press.

Translated by Z. Votický