γ-TRIMETHYLSILYL(TRIPHENYLSILYL)PYRIDINES IN SYNTHESES OF SILICON-CONTAINING PYRIDINIUM YLIDS AND INDOLIZINES

N. S. Prostakov, A. V. Varlamov,
N. Saksena, A. A. Savina,
G. Datta Rai, and L. V. Maslova

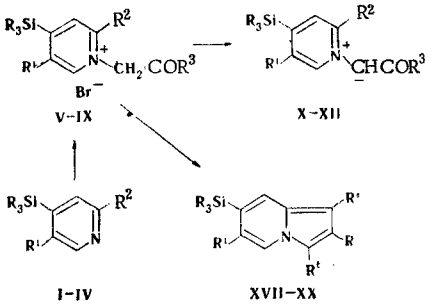
UDC 547.245'821'826'83'759.4

Three N-phenacyl-γ-trimethylsilyl(triphenylsilyl)pyridinium bromides were converted to stable silyl-substituted pyridinium ylids. Six previously unknown silicon-containing indolizines were obtained by two methods, viz., 1,3-dipolar cycloaddition of dimethyl acetylenedicarboxylate (DMAD) to the pyridinium ylids and the Chichibabin reaction. Spectral data that confirm the structures of the synthesized compounds are presented.

Continuing our research on the synthesis and study of silyl-substituted pyridine bases we turned to the preparation of previously unknown silyl-substituted pyridinium ylids and indolizines. Compounds of both of these groups are of interest for the study of their physiological activity [1].

Quaternary salts V-VIII, respectively, were obtained from 4-trimethylsilyl- (I) [2] and triphenylsilylpyridines (II) [3], as well as from 3-methyl- (III) [4] and 3,5-dimethyl-4-triphenylsilyl pyridines [5], and bromoacetophenone, while salt IX was obtained from pyridine III and ethyl bromoacetate. When salts V-VII were treated with a 40% solution of potassium carbonate, they were conveted to γ-silyl-substituted pyridinium benzoylmethylids X-XII, which are stable-colored compounds, the stability of which is evidently due to the participation of the d orbitals of the silicon atom in delocalization of the negative charge of the ylid grouping, As a consequence of the strong positive inductive effect of the trimethylsilyl group [6], ylid X is less stable (at 3-5°C it remains unchanged for 3 weeks) than ylids XI and XII (these compounds remained unchanged for 4 months under the same conditions), in which the triphenylsilyl group displays a negative inductive effect. The structures of ylids X-XII were proved by the analytical and spectral data, as well as by some chemical transformations.

The intensity of the broad signal of the ylid proton (6.2-6.65 ppm) in the PMR spectra of ylids X-XII increases markedly as the temperature is lowered (W = 28 Hz at 26°C for X, and W = 4 Hz at −55°C for X): This is associated with slowing down of the exchange processes. The presence of an ylid carbonion in ylids X-XII is confirmed by a comparison of their PMR spectra in CF_3COOH and CF_3COOD, in which sharp NCH_2



I, V, X, XVII R=CH_3; II—IV, VI—IX, XI, XII, XVIII—XX R=C_6H_5; I, II, V, VI, X, XI $R^1=R^2=H$; IV, VIII $R^1=R^2=CH_3$; III, VII, IX, XII, XIX, XX $R^1=CH_3$; XVII, XVIII $R^1=H$; III, VII, IX, XII $R^2=H$; V—VIII, X—XII $R^3=C_6H_5$; IX $R^3=OC_2H_5$; XVII—XIX $R^4=R^5=COOCH_3$; XVII—XVIII $R^6=COC_6H_5$; XIX $R^6=COOC_2H_5$; XX $R^4=R^6=H$, $R^5=C_6H_5$

P. Lumumba International-Friendship University, Moscow 117923. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 7, pp. 965-968, July, 1980. Original article submitted December 25, 1979.

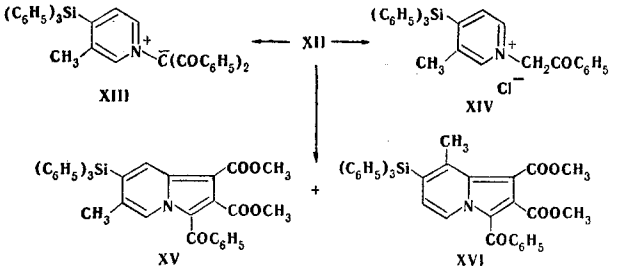
0009-3122/80/1607-0748$07.50

TABLE 1. Physicochemical and Spectral Characteristics of Quaternary Salts of Pyridine Bases (V-IX and XIV), Ylids (X-XIII), and Indolimines (XV-XX)

Compound	mp, °C	M^+	IR spectrum, cm^{-1}	PMR spectrum, ppm	Found, %			Empirical formula	Calc., %			Yield, %
					C	H	N		C	H	N	
V	182—183[a]	—	1740 (C=O), 1250, 870 [$Si(CH_3)_3$]	9,34, d 2H (2-H, 6-H); 7,15, s 2H (NCH_2)	55,2	6,0	3,4	$C_{18}H_{20}NOSiBr$	54,8	5,7	4,0	40
VI	250—252[a] (dec.)	—	1740 (C=O), 1420, 1150 ($SiPh_3$)	9,35, d 2H (2-H, 6-H)	69,4	5,0	2,3	$C_{31}H_{26}NOSiBr$	69,4	4,9	2,6	90
VII	218—219[b]	—	1695 (C=O), 1445, 1120 ($SiPh_3$)	9,16, s 1H (2-H); 9,05, d 1H (6-H); 2,22, s 3H (CH_3)	69,5	5,2	2,5	$C_{32}H_{28}NOSiBr$	69,5	5,1	2,5	93
VIII	222—224[b]	—	1700 (C=O), 1437, 1122 ($SiPh_3$)	9,39, s 1H (6-H); 2,60, s 3H (α-CH_3); 2,12, s 3H (β-CH_3)	69,8	5,2	2,5	$C_{33}H_{30}NOSiBr$	70,2	5,3	2,5	50
IX	166—167[c]	—	1780 (C=O), 1450, 1130 ($SiPh_3$)	9,5, s 1H (2-H); 9,35, d 1H (6-H); 6,5, s 2H (NCH_2); 4,3, g 2H (CH_2); 2,28, s 3H (CH_3); 1,33, t 3H (CH_3)	64,6	5,3	3,1	$C_{28}H_{28}NO_2SiBr$	64,3	5,2	2,8	70
X	115—117	—	—	9,52, d 2H (2-H, 6-H); 6,65, s 1H (N—CH)	—	—	4,9	$C_{16}H_{19}NOSi$	—	—	4,9	90
XI	168—170	—	—	9,34, d 2H (2-H, 6-H); 6,53, s 1H (N—CH)	—	—	2,6	$C_{31}H_{25}NOSi$	—	—	3,1	80
XII	175—177[d] (dec.)	469	1530 (C=O); 1425, 1110 ($SiPh_3$)	9,58, s 1H (2-H); 8,71, d 1H, (6-H); 6,22, s 1H, (N—CH); 1,95, s 3H (CH_3)	81,5	6,1	2,7	$C_{32}H_{27}NOSi$	81,8	5,8	3,0	71
XIII	199—202[e]	573	1543 (C=O); 1433, 1110 ($SiPh_3$)	8,42, s 1H (2-H); 8,32, d 1H (6-H); 2,12, s 3H (CH_3)	81,3	5,5	2,1	$C_{39}H_{31}NO_2Si$	81,6	5,4	2,4	14
XIV	209—210[b]	—	—		75,7	5,8	2,5	$C_{32}H_{28}NOSiCl$[f]	75,9	5,5	2,7	61
XV	215—216[a]	609	1742, 1713 ($COOCH_3$); 1623 (COPh); 1429, 1110 ($SiPh_3$)	9,35, s 1H, (5-H); 8,18, s 1H (8-H); 3,47, s 3H (OCH_3); 3,20, s 3H (OCH_3); 2,0, s 3H (CH_3)	74,9	5,3	2,0	$C_{38}H_{31}NO_5Si$	74,9	5,0	2,3	17
XVI	240—241[c]	609	—	9,05, d 1H (5-H); 6,82, d 1H (6-H); 3,72, s 3H (OCH_3); 3,12, s 3H (OCH_3); 2,3, s 3H (CH_3)	75,1	5,1	2,0	$C_{38}H_{31}NO_5Si$	74,9	5,0	2,3	17
XVII	126[a]	409	1770 ($COOCH_3$); 1745 ($COOCH_3$); 1660 (ArCOAr); 1250, 875 [$Si(CH_3)_3$]	9,5, d 1H (5-H); 8,74, s 1H (8-H); 7,06, s 1H (6-H); 3,83, s 3H (CH_3O); 3,20, s 3H (CH_3O)	64,8	5,2	3,4	$C_{22}H_{23}NO_5Si$	64,5	5,6	3,4	21
XVIII	166—168[g]	595	—	9,5, d 1H (5-H); 8,74, s 1H (8-H); 3,70, s 3H (OCH_3); 3,28, s 3H (OCH_3)	74,3	5,2	2,2	$C_{37}H_{29}NO_5Si$	74,6	4,9	2,4	59
XIX	150—152[a]	577	—	9,24, s 1H (5-H); 8,1, s 1H (8-H); 4,25, q 2H (CH_2); 3,76, s 3H (OCH_3); 3,48, s 3H (OCH_3); 2,02, s 3H (6-CH_3); 1,30, t 3H (CH_3)	70,1	5,1	2,3	$C_{34}H_{31}NO_6Si$	70,3	5,2	2,5	30
XX	187—188	465	1428, 1108 ($SiPh_3$)	6,5, s 1H (3-H); 1,8, s 3H (CH_3)	85,7	6,1	3,4	$C_{33}H_{27}NSi$	85,2	5,8	3,0	54

[a] From methanol. [b] From ethanol. [c] From ethyl acetate–ethanol. [d] From acetonitrile. [e] From acetonitrile–ether. [f] Found: Cl 7.3%. Calculated: Cl 7.9%. [g] From ethyl acetate.

and NCHD signals with intensities of two and one proton units, respectively, are observed at 6.19, 6.10, and 5.83 ppm.



Dibenzoylmethylid XIII was obtained by Schotten–Baumann benzoylation of ylid XII, while N-phenacyl-3-methyl-4-triphenylsilylpyridinium chloride was obtained by treatment with hydrogen chloride. As expected [7], in the reaction of ylid XII with dimethyl acetylenedicarboxylate (DMAD) cycloaddition occurs at both α positions of the pyridine ring, as a result of which two isomeric (with respect to the position of the methyl group) indolizines, viz., 6-methyl- (XV) and 8-methyl-7-triphenylsilyl-3-benzoyl-1,2-dicarbomethoxyindolizine (XVI), are formed. The position of the methyl groups in them was established from the character of the multiplicity of the 5-H, 6-H, and 8-H signals. The same mixture of indolizines XV and XVI is formed in the reaction of salt VII with DMAD in the presence of triethylamine.

7-Trimethylsilyl- (XVII) and triphenylsilyl-3-benzoyl-1,2-dicarbomethoxyindolizines (XVIII) were obtained without isolation of the corresponding pyridinium ylids from quaternary salts V and VI by reaction with DMAD in the presence of triethylamine (2,3-dipolar cycloaddition of DMAD to the pyridinium ylid formed in the reaction), while 6-methyl-7-triphenylsilyl-3-carbethoxy-1,2-dicarbomethoxyindolizine (XIX) was obtained from salt IX. 6-Methyl-2-phenyl-7-triphenylsilylindolizine (XX) was obtained from quaternary salt VIII via the Chichibabin reaction. The structures of all of the synthesized compounds were confirmed by the spectral data (Table 1).

EXPERIMENTAL

The PMR spectra of solutions of the compounds in $CDCl_3$, CF_3COOH, and CF_3COOD were recorded with a BS-487 spectrometer with hexamethyldisiloxane as the internal standard. The IR spectra of KBr pellets of the compounds were recorded with a UR-20 spectrometer. The mass spectra of the compounds were obtained with a Varian MAT CH-8 spectrometer. Activity II aluminum oxide was used for thin-layer chromatography (TLC) [elution with ethyl acetate–hexane (1:4)]. The characteristics of the synthesized compounds are presented in Table 1.

N-Phenacyl-4-trimethylsilylpyridinium Bromide (V). A solution of 1.8 g (0.012 mole) of pyridine base I and 2.3 g (0.012 mole) of bromoacetophenone in 10 ml of benzene was refluxed for 5.5 h, after which the benzene was removed by distillation, and the residue was triturated in absolute ether and crystallized to give 1.7 g of quaternary salt V. Quaternary salts VI-IX were similarly obtained from silyl-substituted pyridine bases II-IV.

4-Trimethylsilylpyridinium Benzoylmethylid (X). A 3-ml sample of a 40% solution of potassium carbonate was added to a solution of 1 g (3 mmole) of quaternary salt V in 10 ml of chloroform, and the mixture was stirred for 1.5 h. The chloroform was removed by distillation in vacuo without heating, and the residue was triturated in absolute ether to give 0.7 g of pale-green crystals of pyridinium ylid IX. Pyridinium ylids XI (orange powder) and XII (orange-brown powder) were similarly obtained from quaternary salts VI and VII.

Pyridine base III was formed in the reaction of quaternary salt VII with pyridine.

3-Methyl-4-triphenylsilylpyridinium Benzoylmethylid. (XIII). A solution of 1 g (2 mmole) of pyridinium ylid XII and 0.42 g (0.03 mole) of benzoyl chloride in 15 ml of chloroform was stirred for 15 min, after which 2 ml of a 40% solution of potassium carbonate was added, and the mixture was stirred for another 30 min. The chloroform solution was separated, and the dark-brown residue remaining after removal of the chloroform by distillation was dissolved in 5 ml of acetonitrile. The solution was filtered, absolute ether was added to the filtrate until it became turbid, and the mixture was maintained at 0°C for 12 h. Workup gave 0.17 g of yellow crystals of XIII.

N-Phenacyl-3-methyl-4-triphenylsilylpyridinium Chloride (XIV). Hydrogen chloride was bubbled into a

solution of 1 g (2 mmole) of pyridinium ylid XII in 10 ml of chloroform until the solution became colorless, after which the chloroform was removed by distillation, and the residue was crystallized from ethanol to give 0.65 g of white crystals of XIV.

6-Methyl- (XV) and 8-Methyl-7-triphenylsilyl-3-benzoyl-1,2-dicarbomethoxyindolizine (XVI). A mixture of 1.1 g (2.4 mmole) of ylid XII, 0.7 g (5 mmole) of DMAD, and 25 ml of acetonitrile was refluxed for 6 h, and the resulting precipitate (0.53 g) was crystallized from a mixture of ethanol and ethyl acetate (1:1) to give 0.23 g of yellow crystals of indolizine XVI with R_f 0.27. The acetonitrile was removed from the filtrate remaining after separation of 0.53 g of precipitate by distillation, and the residue (1.5 g) was crystallized from methanol to give 0.25 g of indolizine XV with R_f 0.2.

7-Trimethylsilyl-3-benzoyl-1,2-dicarbomethoxyindolizine (XVII). A mixture of 0.9 g (2.6 mmole) of quaternary salt V, 10 ml of methylene chloride, 0.75 g (5.3 mmole) of DMAD, and 1.05 g (0.1 mole) of triethylamine was refluxed with stirring for 5 h, after which it was shaken in a separatory funnel with 40 ml of water. The solution of the reaction products in methylene chloride was dried with magnesium sulfate, the solvent was removed by distillation, and the residue was crystallized to give 0.22 g of colorless crystals of indolizine XVII. Light-orange crystals of indolizine XVIII were similarly obtained from quaternary salt VI.

6-Methyl-7-triphenylsilyl-1,2-dicarbomethoxy-3-carbethoxyindolizine (XIX). A mixture of 0.9 g (1.8 mmole) of N-ethoxycarbonylmethyl-3-methyl-4-triphenylsilylpyridinium bromide (mp 166-167°C), 0.5 g (3.5 mmole) of DMAD, 0.7 g (7.2 mmole) of triethylamine, and 15 ml of chloroform was refluxed with stirring for 5 h, after which it was shaken in a separatory funnel with 30 ml of water. The chloroform solution was dried with magnesium sulfate, the chloroform was removed by distillation, and the residue was crystallized from methanol to give 0.3 g of colorless crystals of XIX.

6-Methyl-2-phenyl-7-triphenylsilylindolizine (XX). A 4-ml sample of a solution of potassium carbonate was added to 0.5 g (0.8 mmole) of quaternary salt VIII in 8 ml of chloroform, and the mixture was refluxed for 1.5 h. The chloroform solution of the reaction products was dried with magnesium sulfate, the chloroform was removed by distillation, and the residue was chromatographed (H = 40 cm, d = 2 cm, elution with ether) to give 0.22 g of yellow crystals of substituted indolizine XX with R_f 0.82.

LITERATURE CITED

1. M. G. Voronkov and É. Ya. Lukevits, Usp. Khim., 38, 2173 (1969).
2. R. A. Sulzbach, J. Organomet. Chem., 24, 307 (1970).
3. D. Wittenberg and H. Gilman, Chem. Ind., 390 (1958).
4. N. S. Prostakov, A. V. Varlamov, and V. P. Zvolinskii, Khim. Geterotsikl. Soedin., No. 7, 957 (1972).
5. N. S. Prostakov and A. V. Varlamov, Khim. Geterotsikl. Soedin., No. 12, 637 (1970).
6. D. G. Anderson, J. R. Chipperfield, and D. E. Webster, J. Organomet. Chem., 12, 323 (1968).
7. T. Sasaki, K. Kanematsu, R. Yukimoto, and S. Achiai, J. Org. Chem., 36, 813 (1971).