of anhydrous pyridine, and the mixture was heated to 100°C and allowed to stand for 1 h. It was then diluted with 100 ml of water, and the precipitate was removed by filtration, dried, and dissolved in 20 ml of chloroform and chromatographed on silica gel (100-250 μm) by elution with chloroform. The first (green) fraction was collected, and the eluent was evaporated to give 0.3 g (64%) of dark acicular crystals. The characteristics of VI are presented in Table 1.

## LITERATURE CITED


1. E. V. Tsoi, G. B. Afanas'eva, and O. N. Chupakhin, Khim. Geterotsikl. Soedin., No. 3, 330 (1984).
2. B. Boduszek and J. L. Kice, J. Org. Chem., 47, 2055 (1982).
3. P. Muller, T. Venakis, and C. H. Eugster, Helv. Chem. Acta, 62, 2350 (1979).
4. G. B. Afanas'eva, V. I. Vysokov, T. K. Pashkevich, and O. N. Chupakhin, Khim. Geterotsikl. Soedin., No. 2, 214 (1983).
5. W. A. Spitzer, T. Goodson, S. R. Lammert, and S. Kukolja, J. Org. Chem., 46, 3570 (1981).
6. Y. Ueno, Ann., No. 7, 1403 (1982).
7. A. Blackhall and R. H. Thomsom, J. Chem. Soc., 1138 (1953).
8. Y. Ueno, Y. Takeuchi, J. Koshitani, and T. Yoshida, J. Heterocycl. Chem., 18, 645 (1981).
9. T. K. Pashkevich, G. B. Afanas'eva, I. Ya. Postovskii, and K. I. Pashkevich, Khim. Geterotsikl. Soedin., No. 3, 353 (1975).
10. T. K. Pashkevich, G. B. Afanas'eva, I. Ya. Postovskii, and L. P. Anan'ina, Khim. Geterotsikl. Soedin., No. 10, 1430 (1975).
11. K. I. Pashkevich, G. B. Afanas'eva, and I. Ya. Postovskii, Khim. Geterotsokl. Soedin., No. 6, 746 (1971).


# 1-ACYLOXYAZIRIDINE-2,2-DICARBOXYLIC ACID ESTERS


A. I. Mishchenko, A. V. Prosyanik, P. N. Belov, V. A. Romanchenko, E. G. Belova, and V. I. Markov



UDC 547.717'791.6'26.07:542.924.5:543.422



The reaction of diazomethane and O-acylisonitrosomalonates gave $\Delta^2$-1,2,3-triazoline-5,5-dicarboxylic acid esters, the rates of formation and thermal stabilities of which are determined by the character of ths substituent attached to the oxygen atom. Thermolysis of the triazolines leads to mixtures of 1-acyloxyaziridine-2,2-dicarboxylic acid esters and isomeric dialkyl O-acylisonitrososuccinates; acidolysis with $BF_3 \cdot Et_2O$ makes it possible to obtain exclusively aziridines. The acidic decompositions of dimethyl 4-methyl-$\Delta^2$-1,2,3-triazoline-5,5-dicarboxylate, which was obtained from the reaction of diazoethane and dimethyl O-tosylisonitrosomalonate, leads to dimethyl α-tosyloxyamino-α-vinylmalonate. A dependence of the spin-spin coupling constants (SSCC) of the protons of the aziridine ring on the electronegativities of the substituents attached to the oxygen atom was observed.


Owing to the high pyramidal stability of the nitrogen atom, derivatives of 1-hydroxyaziridine-2,2-dicarboxylic acid esters are ideal subjects for the investigation of the stereochemistry of nitrogen [1]. Enantiomerically pure compounds that have a chiral center only at the nitrogen atom were obtained for the first time in this series [2], and the maximally high barrier to inversion of the nitrogen atom was determined experimentally (31.3 kcal/mole [3]). The principal method for the synthesis of compounds of this class is the reaction of diazomethane with O-substituted derivatives of isonitrosomalonic ester [4].

1-Acyloxyaziridine-2,2-dicarboxylic acid esters are of particular interest. Up until now, only one representative of this series, viz., 1-tosyloxyaziridine, which was obtained by thermolysis or acidolysis (with trifluoroacetic acid) of 1-tosyloxy-$\Delta^2$-1,2,3-triazoline-5,5-dicarboxylic acid ester, was known [4]. However, decomposition of the triazoline in


F. É. Dzerzhinskii Dnepropetrovsk Institute of Chemical Technology, Dnepropetrovsk 320640.


Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 3, pp. 338-342, March, 1984. Original article submitted November 17, 1982; revision submitted April 19, 1983.




0009-3122/84/2003-0270$08.50

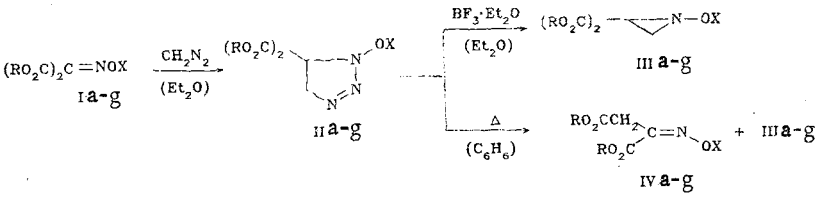
TABLE 1. Characteristics of the Synthesized Compounds

| Compound | mp, °C | $n_D^{20}$ | Found, % | | | Empirical formula | Calculated, % | | | Yield, % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | H | N | | C | H | N | |
| Ia | 49—50 | — | 30,0 | 3,9 | 5,6 | $C_6H_9NO_7S$ | 30,1 | 3,8 | 5,9 | 68 |
| Ib | 65 | — | 38,5 | 4,1 | 6,5 | $C_7H_9NO_7$ | 38,8 | 4,1 | 6,4 | 46 |
| Ic | —[a] | 1,4624 | 41,0 | 5,1 | 11,8 | $C_8H_{12}N_2O_6$ | 41,4 | 5,2 | 12,1 | 78 |
| Id | 73—74 | — | 36,0 | 3,6 | 4,9 | $C_8H_{13}NO_7S$ | 36,0 | 3,9 | 5,2 | 71 |
| Ie | 62—63[b] | — | — | — | — | $C_{14}H_{17}NO_7S$ | — | — | — | 75 |
| If | 191—192 (1,5)[c] | 1,4480 | 58,9 | 5,6 | 4,8 | $C_{14}H_{15}NO_6$ | 58,6 | 5,6 | 4,6 | 69 |
| Ig | 125—126 (2)[c] | 1,4440 | 46,4 | 5,3 | 5,8 | $C_9H_{13}NO_6$ | 46,8 | 5,7 | 6,1 | 89 |
| Ih | 94—95[d] | — | — | — | — | $C_{12}H_{13}NO_7S$ | — | — | — | 70 |
| IIa | 65 (dec.) | — | 29,7 | 3,7 | 15,1 | $C_7H_{11}N_3O_7S$ | 29,9 | 3,9 | 14,9 | 96 |
| IIb | 83 (dec.) | — | 36,5 | 4,3 | 15,9 | $C_8H_{11}N_3O_7$ | 36,8 | 4,2 | 16,1 | 73 |
| IIc | 82 (dec.) | — | — | — | — | $C_9H_{14}N_4O_6$ | — | — | — | 57 |
| IId | 68 (dec.) | — | — | — | — | $C_9H_{15}N_3O_7S$ | — | — | — | 93 |
| IIe | 47 (dec.) | — | — | — | — | $C_{15}H_{19}N_3O_7S$ | — | — | — | 96 |
| IIf | 50 (dec.) | — | — | — | — | $C_{15}H_{17}N_3O_6$ | — | — | — | 89 |
| IIg | 54 (dec.) | — | — | — | — | $C_{10}H_{15}N_3O_6$ | — | — | — | 69 |
| IIh | 59 (dec.) | — | — | — | — | $C_{14}H_{17}N_3O_7S$ | — | — | — | 79 |
| IIIa | 82 | — | 33,0 | 4,2 | 5,5 | $C_7H_{11}NO_7S$ | 33,2 | 4,4 | 5,5 | 67 |
| IIIb | 125—126 (0,5)[c] | 1,4541 | 41,1 | 4,5 | 6,2 | $C_8H_{11}NO_7$ | 41,2 | 4,8 | 6,0 | 71 |
| IIIc | — | 1,4684 | 43,6 | 5,9 | 11,4 | $C_9H_{14}N_2O_6$ | 43,9 | 5,7 | 11,4 | 69 |
| IIId | 52—53 | — | 38,3 | 5,2 | 5,5 | $C_9H_{15}NO_7S$ | 38,4 | 5,0 | 5,4 | 84 |
| IIIe | 52 | — | 50,6 | 5,1 | 4,1 | $C_{15}H_{19}NO_7S$ | 50,4 | 5,4 | 3,9 | 69 |
| IIIf | — | 1,4994 | 58,9 | 5,5 | 4,5 | $C_{15}H_{17}NO_6$ | 58,6 | 5,6 | 4,6 | 77 |
| IIIg | 125—126 (0,5)[c] | 1,4508 | 48,9 | 6,0 | 5,8 | $C_{10}H_{15}NO_6$ | 49,0 | 6,2 | 5,7 | 86 |
| IVe | 69—70 | — | 50,6 | 5,4 | 4,0 | $C_{15}H_{19}NO_7S$ | 50,4 | 5,4 | 3,9 | 46 |
| VIII | 75 | — | 49,0 | 4,9 | 4,3 | $C_{14}H_{17}NO_7S$ | 48,8 | 5,2 | 4,1 | 56 |

[a]Isolated by column chromatography [silica gel (100/160 μm), $CHCl_3$]. [b]This compound has mp 63.5°C in [5]. [c]Boiling point (mm). [d]This compound has mp 94-95°C in [4].

both cases leads to mixtures of compounds that are difficult to separate. The goal of the present research was the specific synthesis of 1-sulfonyl- and the previously unknown 1-acyloxyaziridine-2,2-dicarboxylic acid esters.

We found that the reaction of diazomethane with O-acylisonitrosomalonates Ia-g in ether at 0-5°C (monitoring by means of the PMR spectra) leads to $\Delta^2$-1,2,3-triazolines IIa-g (Table 1):



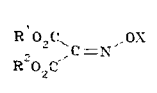
III, IV a R=Me, X=Ms; b R=Me, X=MeOCO; c R=Me, X=$Me_2NCO$; d R=Et, X=Ms; e R=Et, X=Ts; f R=Et, X=PhCO; g R=Et, X=MeCO

The reaction time increases (0.25 h for Ia,d, 1 h for Ie, 2 h for Ib, 20 h for Ic, 72 h for Ig, and 120 h for If) as the electron-acceptor properties of substitutents X decrease in the order Ms > Ts > MeOCO > PhCO > $Me_2NCO$ > MeCO, which was determined on the basis of the $\sigma_m$ substituent constants [6]. The anomalously long reaction time in the case of O-benzoyloxime If is evidently explained by shielding of the C=N bond by the bulky phenyl group.

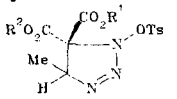
The individual triazolines and their solutions are relatively stable. For example, O-acetyltriazoline IIg remains unchanged for 3 months at 0-5°C, whereas O-methylsulfonyl analog IId decomposes appreciably in 3 weeks (monitoring by means of the PMR spectra). When the temperature of the solutions is raised to 20°C, these differences level out, and the decomposition of the triazolines goes to completion overnight. Consequently, intermediate triazolines could not be isolated or detected in the analogous synthesis of 1-alkoxylaziridine-2,2-dicarboxylic acid esters [4], since the reaction of $CH_2N_2$ with O-alkyl esters of isonitrosomalonates proceeds at 20°C for 2 weeks.

Thermolysis of solutions of triazolines IIa-g in benzene at 20°C for 24 h leads to mixtures of the corresponding aziridines IIa-g and the isomeric isonitrososuccinates IVa-g

TABLE 2. Parameters of the IR (ν, $cm^{-1}$) and PMR (5% solutions in $CHCl_3$, δ, ppm) Spectra of O-Acyloximes and Thiazolines



Ia-h

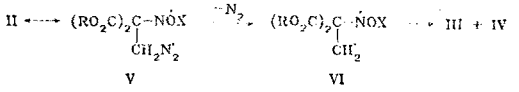


IIh

| Compound | IR spectrum[a] | | PMR spectrum | | | | |
|---|---|---|---|---|---|---|---|
| | C=O | C=N (N=N) | X | $R^1$ | | $R^2$ | |
| | | | Me | Me | $CH_2$ | Me | $CH_2$ |
| Ia | 1715, 1738 | 1638 | 3,11[b] | 3,90 | — | 3,91 | — |
| Ib | 1754, 1807 | 1628 | 3,27[c] | 3,15 | — | 3,17 | — |
| Ic | 1755, 1768 | 1621 | 2,93[b] | 3,88 | — | 3,90 | — |
| Id | 1718, 1750 | 1635 | 3,25 | 1,34 | 4,55 | 1,34 | 4,58 |
| Ie | 1719, 1748 | 1625 | 2,38[b,d] | 1,25 | 4,21 | 1,28 | 4,33 |
| If | 1728, 1745 | 1624 | —[b,e] | 1,34 | 4,29 | 1,34 | 4,34 |
| Ig | 1725, 1745 | 1625 | 2,11[b] | 1,30 | 4,36 | 1,33 | 4,36 |
| Ih | 1732, 1752 | 1629 | 2,37[b] | 3,74 | — | 3,80 | — |
| IIa | 1710, 1729 | (1529) | 3,31 | 3,78 | — | — | 4,88[f] |
| IIb | 1718, 1765 | (1534) | 3,80 | 3,95 | — | — | 4,87[f] |
| IIc | 1758, 1771 | (1551) | 3,00 | 3,83 | — | — | 4,98[f] |
| IId | 1709, 1730 | (1529) | 3,31 | 1,25 | 4,23 | — | 4,85[f] |
| IIe | 1720, 1735 | (1557) | 2,35 | 1,21 | 4,21 | — | 4,66[f] |
| IIf | 1743, 1764, 1782 | (1550) | — | 1,23 | 4,30 | — | 5,05[f] |
| IIg | 1740, 1803 | (1549) | 2,26 | 1,30 | 4,33 | — | 4,91[f] |
| IIh | 1719, 1731 | (1532) | 1,75 | 3,09 | 1,10[g] | 3,53 | 4,70[f] |

[a]Obtained from KBr pellets of solid samples and thin layers of liquid samples. [b]In $CCl_4$. [c]In $C_6H_6$. [d]δH(aryl) = 7.60 ppm, Δν = 0.51 ppm, $J_{HH}$ = 8.8 Hz. [e]Ph, multiplet at 7.18-7.90 ppm. [f]Ring $CH_2$. [g]5-Me.

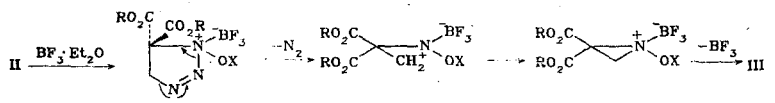
(Tables 1-3). In the case of O-tosyl derivative IIe methyl tosylate is formed in addition to III and IV. The ratios of the isomers were determined from the PMR spectra of the reaction mixtures: a, d 17/83; c 31/69; e 24/44; f 22/78; g 30/70. An increase in the electron-acceptor properties of the O-substituents leads to a decrease in the thermal stabilities of the triazolines in the order IIf, g > IIb > IIc > IIa, d; this is evidently due to an increase in the stabilities of intermediate diradicals V and VI [4].



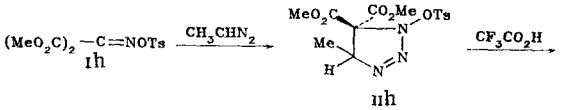
V VI

It should be noted that O-dimethylcarbamoyl derivatives Ic and IIIc decompose with $CO_2$ evolution during storage. The relatively low stability of triazoline IIc is evidently also due to radical decomposition of the $Me_2NCOON$ group, which initiates decomposition of the triazoline.

In contrast to thermolysis and the previously used decomposition with an equimolar amount of $CF_3CO_2H$ [4], the decomposition of triazolines IIa-g with a catalytic amount of $BF_3 \cdot Et_2O$ leads exclusively to aziridines IIIa-g (Table 1):

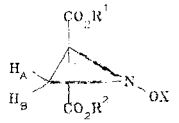


The acidic decomposition of triazoline IIh, obtained by the reaction of O-tosyloxime Ih with diazomethane, evidently also proceeds similarly. However, in this case stabilization with splitting out of a proton is preferable for the intermediately formed cation as a consequence of the steric and thermodynamic factors:

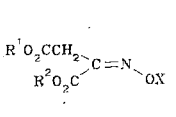


IIh

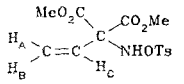
TABLE 3. Parameters of the IR (ν, $cm^{-1}$) and PMR (5% solutions in $CCl_4$, δ, ppm) Spectra of O-Acylaziridines and Their Isomers



IIIa-g



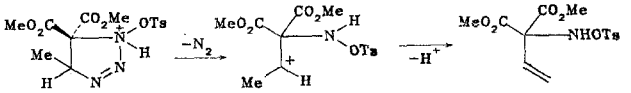
IVa-g



VIII

| Compound | IR spectrum[a] | | PMR spectrum | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C=O | $CH_2$ | X | $R^1$ | | $R^2$ | | $H_A$ | $H_B$ | $J_{AB}$[b] |
| | | | Me | Me | $CH_2$ | Me | $CH_2$ | | | |
| IIIa | 1735, 1740 | 3115 | 3,16[c] | 3,75 | — | 3,81 | — | 2,77 | 3,20 | −4,20 |
| IIIb | 1732, 1765 | 3108 | 3,74 | 3,73 | — | 3,73 | — | 2,67 | 2,88 | −3,75 |
| IIIc | 1735, 1753 | 3112 | 2,78 | 3,79 | — | 3,84 | — | 2,74 | 2,93 | −3,60 |
| IIId | 1732, 1752 | 3106 | 3,14 | 1,28 | 4,23 | 1,29 | 4,31 | 2,73 | 3,11 | −4,20 |
| IIIe | 1729 | 3108 | 2,38[d] | 1,17 | 4,11 | 1,22 | 4,21 | 2,55 | 3,06 | −3,80 |
| IIIf | 1755 | 3106 | —[e] | 1,18 | 4,25 | 1,30 | 4,30 | 2,88 | 3,11 | −3,75 |
| IIIg | 1745, 1752 1776 | 3120 | 1,95 | 1,28 | 4,28 | 1,28 | 4,31 | 2,70 | 2,88 | −3,15 |
| IVb | — | — | 3,79 | 3,71 | — | 3,70 | — | 3,80 | | — |
| IVc | — | — | 2,78 | 3,79 | — | 3,83 | — | 3,76 | | — |
| IVd | — | — | 3,11 | 1,28 | 4,21 | 1,28 | 4,36 | 3,75 | | — |
| IVe | 1715, 1723 | 1629[f] | 2,36[e] | 1,17 | 4,11 | 1,22 | 4,21 | 3,75 | | — |
| IVf | — | — | — | 1,20 | 4,26 | 1,31 | 4,32 | 3,78 | | — |
| IVg | — | — | 2,05 | 1,26 | 4,25 | 1,26 | 4,28 | 3,82 | | — |
| VIII | 1725 | 3240[g] | 2,62[h] | 3,67 | — | — | 5,19[i] | 5,09 | 5,12 | 0,5 |

[a]Obtained from KBr pellets of solid samples and thin layers of liquid samples. [b]The sign of J was taken as in [4]. [c]In $CDCl_3$. [d]$\delta_{H(aryl)}$ = 7.54 ppm, Δν = 0.55 ppm, $J_{HH_h}$ = 8.0 Hz. [e]Ph, multiplet at 7.75-8.13 ppm. [f]νC=N. [g]νNH. [h]$\delta_{H(aryl)}$ = 7.53 ppm, Δν = 0.5 ppm, $J_{HH}$ = 8.0 Hz. [i]$H_C$, $J_{AC}$ = 9.13, $J_{BC}$ = 5.63 Hz.



VII VIII

The structure of VIII was proved by the IR spectrum, which displays a narrow absorption band of an NH group at 3240 $cm^{-1}$ [7] [which excludes the alternative $H_2C{=}CHN(OTs)CH(CO_2Me)_2$ structure], and by the PMR spectrum, in which the characteristic subspectrum of a vinyl group is observed; the assignment of the signals of the protons was realized on the basis of the known relationship of the spin-spin coupling constants (SSCC) for vinyl systems: $|J_{trans}| > |J_{cis}| > |J_{gem}|$ [8].

The structures of the remaining synthesized compounds were also confirmed by the PMR and IR spectra (Tables 1-3). Except for IVe, O-acylisonitrososuccinates IV were not isolated in the individual state but were characterized from the PMR spectra, which display a singlet of a $CH_2$ group at 3.7-3.8 ppm [4] (Table 3). The IR spectra of triazolines IIa-g contain an absorption band of an N=N bond at 1529-1551 $cm^{-1}$ [7] (Table 2), and the PMR spectra contain a singlet of a $CH_2$ group of a triazoline ring at 4.4-5.1 ppm [9] (Table 2). The formation of O-acylisonitrososuccinates IVa-g from triazolines IIa-g proves their $\Delta^2$-1,2,3-triazoline structure. The assignment of the signals of the protons of ester groups and of the ring protons in the PMR spectra of O-acyloximes Ia-h (Table 2) and aziridines IIIa-g (Table 3) was made on the basis of the shielding effect of the unshared pair of electrons of the nitrogen atom as compared with the XON group [4]. The decrease in absolute value of the geminal SSCC of the protons of the aziridine ring from 4.20 to 3.15 Hz in the order IIIa, d > IIIe > IIIb, f > IIIc > IIIg is due to the decrease in the electronegativities of the O-acyl substituents; this is confirmed by the decrease in the $|^2J_{AB}|$ values to 2.8-2.3 Hz in 1-alkoxyaziridine-2,2-dicarboxylic acid esters [4].

## EXPERIMENTAL

The PMR spectra of 5% solutions of the compounds were recorded with Tesla BS-487C (80 MHz) and RYa-2305 (60 MHz) spectrometers with hexamethyldisiloxane as the internal standard. The IR spectra were obtained with a UR-20 spectrometer.

Dimethyl Mesoxalate O-Methylsulfonyloxime (Ia). This compound was obtained in 68% yield by mesylation of dimethyl mesoxalate oxime by the method in [5] (Table 1). O-Acylisonitrosomalonates Ic-h were similarly obtained (Table 1).

Dimethyl Mesoxalate O-Methoxycarbonyloxime (Ib). A solution of 13 g (0.13 mole) of triethylamine in 100 ml of absolute ether was added with cooling (0°C) and stirring to a solution of 16.1 g (0.1 mole) of dimethyl mesoxalate oxime and 12.3 g (0.13 mole) of MeOCOCl in 100 ml of absolute ether, after which stirring was continued at 20°C for 4 h, and the mixture was allowed to stand overnight. The precipitate was removed by filtration, the solvent was removed, and the residue was distilled in vacuo to give 10.1 g (46%) of Ib (Table 1).

1-Methoxysulfonyl-5,5-bis(carbomethoxy)-$\Delta^2$-1,2,3-triazoline (IIa). An ether solution (200 ml) of diazomethane [4.2 g (0.1 mole)] was added dropwise with stirring and cooling from −15 to −10°C to a solution of 11.2 g (0.05 mole) of Ia in 100 ml of $CH_2Cl_2$, after which stirring was continued at 0 to −5°C for 1 h. The solvent was removed in vacuo to give 12.7 g of triazoline IIa, which was recrystallized from $CH_2Cl_2$–$Et_2O$–$C_5H_{12}$ (1:4:1) (Table 1). Triazolines IIb-g were similarly obtained, except that the reactions were carried out in ether solutions (Table 1).

Dimethyl 1-(Methylsulfonyloxy)aziridine-2,2-dicarboxylate (IIIa). Three to five drops of $BF_3 \cdot Et_2O$ were added with cooling at 0°C to a solution of 10.6 g (0.04 mole) of IIa in 50 ml of $CH_2Cl_2$, and the mixture was allowed to stand overnight at 0°C. The solvent was removed in vacuo, and the residue was crystallized from isopropyl alcohol to give 6.3 g (6.7%) of ester IIIa (Table 1). Aziridines IIb-g were similarly obtained, except that the reactions were carried out in ether solutions (Table 1).

Diethyl Z-O-Tosylisonitrososuccinate (IVe). A 19.27-g (0.05 mole) sample of triazoline IIe was maintained at room temperature for 3 days, after which the solid reaction mixture, which, judging from the PMR spectrum, contained 20.5% aziridine IIIe and 79.5% ester IVd, was crystallized twice from the minimum amount of $CCl_4$ to give 8.2 g (46%) of isonitrososuccinate IVe (Table 1).

1-Tosyloxy-4-methyl-5,5-bis(carbomethoxy)-$\Delta^2$-1,2,3-triazoline (IIh). This compound was obtained in 70% yield (Table 1) by the reaction of Ih with diazoethane in solution in $C_6H_6$–$Et_2O$ (1:5) by a procedure similar to that used to prepare triazoline IIa.

Dimethyl α-Tosyloxyamino-α-vinylmalonate (VIII). A solution of 3.4 g of trifluoroacetic acid in 5 ml of absolute methanol was added slowly to 0 to −10°C to a solution of 5.0 g (0.013 mole) of triazoline IIh in 20 ml of $CH_2Cl_2$, and the mixture was allowed to stand overnight at 0°C. The precipitated crystals of p-toluenesulfonic acid were removed by filtration, and the residue remaining after removal of the solvent was crystallized from MeOH–$Et_2O$–$C_6H_{14}$ (1:10:10) at −78°C to give 2.5 g (56%) of ester VIII (Table 1).

## LITERATURE CITED


1. R. G. Kostyanovskii, V. F. Rudchenko, A. V. Prosyanik, M. D. Isobaev, I. I. Chervin, and V. I. Markov, Izv. Akad. Nauk SSSR, Ser. Khim., No. 3, 628 (1977).
2. R. G. Kostyanovskii and V. F. Rudchenko, Dokl. Akad. Nauk SSSR, 231, 878 (1976).
3. G. V. Shustov, N. B. Tavakalyan, N. L. Zaichenko, and R. G. Kostyanovskii, Izv. Akad. Nauk SSSR, Ser. Khim., No. 9, 2183 (1980).
4. R. G. Kostyanovskii, A. V. Prosyanik, A. I. Mishchenko, G. V. Shustov, I. I. Chervin, N. L. Zaichenko, A. P. Pleshkova, P. N. Belov, and V. I. Markov, Izv. Akad. Nauk SSSR, Ser. Khim., No. 8, 1780 (1979).
5. J.-M. Biehler, J. Perchais, and J.-P. Fleury, Bull. Soc. Chim. Fr., No. 19, 2711 (1971).
6. A. Gordon and R. Ford, The Chemist's Companion, Wiley (1973).
7. A. A. Kazitsina and N. B. Kuplet-skaya, Application of UV, IR, and NMR Spectroscopy in Organic Chemistry [in Russian], Vysshaya Shkola, Moscow (1971), p. 35.
8. J. W. Emsley, J. Feeney, and L. H. Sutcliffe, High-Resolution NMR Spectroscopy, Pergamon, Oxford (1965).
9. R. G. Kostyanovskii, G. I. Kadorkina, G. V. Shustov, and K. S. Zakharov, Dokl. Akad. Nauk SSSR, 221, 370 (1975).