(*E*)- and (*Z*)-α-Hydroxy and α-Methoxyimino-4-nitro-1*H*-imidazole-1-acetic Acids and Esters. Spectral Properties, Conformations and Photoisomerization of the new Compounds

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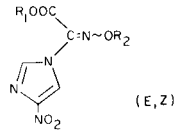
Received June 5, 1979

Detailed experimental procedures are given for the preparation of the stereoisomeric (*E*)- and (*Z*)-methyl-α-hydroxy and α-methoxyimino-4-nitro-1*H*-imidazole-1-acetates and of the related acids. (*Z*)-Isomers have been prepared by synthesis. (*E*)-Isomers have been obtained only by photoisomerization. Decarboxylation of the acids left the corresponding aldehydes which are ideal compounds for structural studies and configurational assignments.

J. Heterocyclic Chem., **16**, 1545 (1979).

The purpose of the present work was to investigate the possibility of synthesizing the two stereoisomeric α-methoxyimino-4-nitro-1*H*-imidazole-1-acetic acids. Since no α-hydroxy or α-methoxyiminoacetic acid bonded to an heterocycle at the ring nitrogen atom has ever been reported in the literature, we became interested both in the preparation and in the structural assignment of these double-bond stereoisomeric acids and esters (*E* and *Z*):



(E,Z)

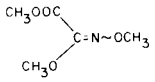
1a,b $R_1 = CH_3$; $R_2 = H$ 3a,b $R_1 = CH_3$; $R_2 = CH_3$

2a,b $R_1 = H$; $R_2 = H$ 4a,b $R_1 = H$; $R_2 = CH_3$

The reaction of methyl 4-nitro-1*H*-imidazole-1-acetate (1) with *n*-amyl nitrite in methanol and sodium methoxide afforded, after acidification, an α-hydroxyimino ester **1a**. A careful isolation (by column chromatography) of all the spots that were seen on tlc led to the recovery of the starting material and of two by-products, with no trace of the other stereoisomer. The by-products were identified as 4(5)-nitro-1*H*-imidazole and *n*-amyl 4-nitro-1*H*-imidazole-1-acetate. The formation of 4(5)-nitro-1*H*-imidazole was probably due to a cleavage; its yield increased when the reaction with *n*-amyl nitrite was carried out with an ultraviolet light source immersed in the reaction vessel.

Compound **1a** was a white solid. Thin layer chromatographic controls revealed only one spot with several eluents (detection by visualization under uv light and by spraying with an alcoholic solution of copper acetate: light green spots). The infrared spectrum in the solid state shows a strongly hydrogen-bonded OH absorption between 2800 and 2500 cm^{-1}, the ester carbonyl at 1735 cm^{-1}, a C = N band of medium intensity at 1630 cm^{-1}. The uv absorption spectrum in ethanol shows λ max 282 nm (ε = 8,565). The nmr spectrum of **1a** in DMSO-d_6 shows a three-protons singlet at 3.83 ppm due to the methyl ester, two doublets at 8.02 and 8.47 ppm of the ring protons, and a broad OH signal at 13.67 ppm. From these data it was impossible to deduce a configuration for **1a**, and it was therefore desirable to try to prepare the other geometrical isomer. E. Poziomek (2a) reported a simple and convenient method of synthesizing the *anti*-isonicotinaldehyde oxime by photochemically induced isomerization of the *syn* derivative.

In our case, an attempt to obtain the other isomer by irradiating a methanolic solution of **1a** failed completely. Guillot-Edelheit (2b) reported the easy photoisomerization of the (E)-acetophenone oxime *O*-trimethylsilyl ether. A similar experiment, in our case, led to a photostationary state whose composition was nearly 75% **1a** and 25% of its isomer **1b** (3a). Since the physical data by comparison (see Table I) do not throw light on the configuration of these two isomers, we undertook the *O*-methylation of **1a**. When compound **1a** was allowed to react with methyl iodide in methanol in the presence of silver oxide, a product with high Rf was obtained and was characterized as methyl α-methoxy-α-methoxyimino acetate **5** (analyses and spectral data are detailed in the experimental section):



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When compound **1a** was allowed to react with methyl iodide in methanol (or in benzene-dimethylformamide) in the presence of sodium methoxide, the *O*-methyl derivative **3a** was obtained. When a solution of **3a** was irradiated with ultraviolet light, a photochemically induced isomerization about the C=N double bond has been observed. The isomerization was readily followed by nmr measurement (3b) and when it reached an equilibrium the irradiation was stopped and the new compound isolated. Analyses and

0022-152X/79/081545-06$02.25

Table I

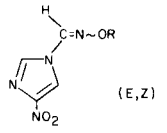
Compound	Nmr Spectra				UV Absorption Spectra (Ethanol)		Infrared Spectra (KBr)		Melting Points °C
	δ	Assignment (No. of protons)		Solvent	λ max (nm)	ε	cm^{-1}	Assignment	
0 (a)	3.75 s	(3)	OCH_3	DMSO-d_6	286	7,494	1755	C = O	138 - 140 (b)
	5.13 s	(2)	CH_2						
	7.87 d	(1)	H-im						
	8.38 d	(1)	H-im						
1a	3.83 s	(3)	OCH_3	DMSO-d_6	282	8,565	2800-2500	OH bonded	
	8.02 d	(1)	H-im				1735	C = O	
	8.47 d	(1)	H-im				1630 medium	C = N	
	13.67 broad		OH						
1b	3.90 s	(3)	OCH_3	DMSO-d_6	282	9,148	2850 strong		
	8.20 d	(1)	H-im				1742	C = O	
	8.63 d	(1)	H-im				1755	C = O	
	12.97 broad		OH				1650	C = N	
2a	8.07 d	(1)	H-im	DMSO-d_6			3600	OH	
	8.53 d	(1)	H-im				3500	OH	
							2800-2500	OH bonded	
	8.00 d	(1)	H-im	CD_3COCD_3			1720	C = O	
	8.37 d	(1)	H-im				1620 weak	C = N	
3a	3.87 s	(3)	OCH_3	DMSO-d_6	280-281	7,694	1720	C = O	142-143
	4.13 s	(3)	$NOCH_3$				1608 strong	C = N	
	8.15 d	(1)	H-im						
	8.58 d	(1)	H-im						
	4.00 s	(3)	OCH_3	$CDCl_3$					
	4.23 s	(3)	$NOCH_3$						
	7.90 d	(1)	H-im						
	8.17 d	(1)	H-im						
3b	3.95 s	(3)	OCH_3	DMSO-d_6	281	9,145	1725	C = O	99-100
	4.08 s	(3)	$NOCH_3$				1585 weak	C = N	
	8.28 d	(1)	H-im						
	8.72 d	(1)	H-im						
	4.05 s	(3)	OCH_3	$CDCl_3$					
	4.12 s	(3)	$NOCH_3$						
	7.85 d	(1)	H-im						
	8.13 d	(1)	H-im						
4a	4.12 s	(3)	$NOCH_3$	DMSO-d_6	281-283	7,294	3580	(c)	110-112 dec.
	8.12 d	(1)	H-im				3400-3300		
	8.60 d	(1)	H-im				1950		
							1710	C = O	
							1615 strong	C = N	
4b	4.05	(3)	$NOCH_3$	DMSO-d_6	286-288	8,388	2500		98-100 dec.
	8.18 d	(1)	H-im				1900		
	8.53 d	(1)	H-im				1715	C = O	
							1590 weak	C = N	

Table I (Continued)

Compound	Nmr Spectra δ	Assignment (No. of protons)		Solvent	UV Absorbtion Spectra (Ethanol) λ max (nm)	ε	Infrared Spectra (KBr) cm^{-1}	Assignment	Melting Points °C
6a	7.90 s	(1)	= CH	DMSO-d_6			1665 medium	C = N	
	8.45 d	(1)	H-im						
	8.75 d	(1)	H-im						
	12.27 s	(1)	OH						
7a	4.05 s	(3)	$NOCH_3$	DMSO-d_6	281-282	10,870	1650 medium	C = N	128-130
	8.00 s	(1)	= CH						
	8.38 d	(1)	H-im						
	8.68 d	(1)	H-im						
	4.10 s	(3)	$NOCH_3$	$CDCl_3$					
	7.40 s	(1)	= CH						
	8.02 d	(1)	H-im						
	8.38 d	(1)	H-im						
7b	3.92 s	(3)	$NOCH_3$	DMSO-d_6	286	(d)	1635 weak	C = N	
	8.12 d	(1)	H-im						
	8.43 d	(1)	H-im						
	8.85 s	(1)	= CH						
	3.97 s	(3)	$NOCH_3$	$CDCl_3$					
	7.75 d	(1)	H-im						
	8.08 d	(1)	H-im						
	8.37 s	(1)	= CH						

(a) Methyl 4-nitro-1H-imidazole-1-acetate. (b) Reported (1) 142. (c) Water of crystallization. (d) $E^{1\%}_{1cm}$ = 518.13 .

spectral data (see Table I) confirmed that new compound **3b** and **3a** are geometrical isomers, but did not throw light on their configuration. The study was therefore carried on, and the parent acids have been prepared with the aim of finding a compound to which a definite configuration could be assigned. Acid **2a** has been prepared by careful hydrolysis of the ester **1a**. Attempts to purify the acid resulted in spontaneous decarboxylation and finally in the formation of 4-nitro-1*H*-imidazole, identified by comparison with an authentic sample (Aldrich). The crude and unstable decarboxylated compound has been examined spectroscopically, and interpretation of the data led to the conclusion that it was the oxime **6a** of 4-nitro-1*H*-imidazole-1-carboxaldehyde:



6a R = H 7a,b R = CH_3

Acid **2b** has not been prepared.

The acids **4** have been prepared from the corresponding esters **3**, and both gave an *O*-methyl oxime by thermal decarboxylation. The isomer **7a** has been obtained as nearly sole and pure compound, whereas **7b** was always in mixture with its isomer in a ratio of about 9:1. The rate of decarboxylation was nearly the same for both acids **4**. An attempt to induce a photoisomerization about the carbon-nitrogen double bond of the acid **4a** afforded a mixture of **7a** and **7b** in a ratio of 7:3. These *O*-methyl oximes appeared the ideal compounds for configurational assignments.

Melting points and spectral data of all new compounds are recorded in Table I.

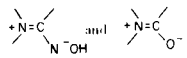
Configurational Assignment to Compounds Listed in Table I.

The configuration of the two acids **4** was inferred from that of the corresponding *O*-methyl oximes **7**. The nmr spectrum (deuteriochloroform and DMSO-d_6) of **7a**,

associated with the acid **4a** and the related ester **3a**, shows a higher field for the aldehyde proton and a lower field for the methoxy and ring protons relative to **7b**. These data are consistent with the imidazole ring and the methoxyimino group in a *cis* or *syn* position and are in accord with the data reported in the literature (4) for pairs of stereoisomeric oxime ethers. The fact that *O*-methyl oxime **7a** has a (*Z*)-configuration is strong evidence for a (*Z*)-configuration of all compounds related to it, and for an (*E*)-configuration of all compounds obtained by photoisomerization. This assignment received further support from the nmr spectra (deuteriochloroform) of the two isomeric esters **3** with the $=N\text{-}OCH_3$ signal at 4.23 ppm for (*Z*)-**3** and at 4.12 ppm for (*E*)-**3**. The same difference in chemical shift ($\Delta\delta$ = 0.11 ppm) has been observed for other pairs of stereoisomeric (*E*)- and (*Z*)-ethyl α-methoxyimino heteroarylacetate (5 and 6).

To complete this work, since the moiety *imidazole nitrogen-hydroxyimino group* can be regarded as an amidoxime system, we also investigated the possibility of revealing the two labile configurational isomers of a selected compound ((*Z*)-**3**) which can result from hindered rotation about the carbon-nitrogen single bond.

Such studies have already been carried out on amidoximes (7) and on *N*-acylimidazoles (8); the latter can be considered as analogues of amides with the nitrogen atom forming part of an aromatic ring. In both systems the barrier to internal rotation can arise from a partial double bond character of the N-C bond, and hence from the contribution of polar forms such as



The rotational barrier about the N-C bond in (*Z*)-**3** was investigated by nmr spectroscopy, and more particularly by recording ambient - and low - temperature spectra of (*Z*)-**3** obtained in chloroform-methylene chloride solvent. Unfortunately the examined sample failed to exhibit splitting of the resonance of H-2 and H-5 ring protons even at the lowest temperature at which it was examined (−125°). It is possible either that the energy barrier in the N-C bond is lower than that found for the examined series of *N*-acylimidazoles (8b) or that the imidazole ring and the oxime group do not lie in the same plane. A decreased torsional barrier may be due to the presence of the nitro group on the imidazole ring and to the related delocalization of the nitrogen lone pair.

EXPERIMENTAL

Melting points were taken in capillary tubes on a Büchi apparatus and are uncorrected. Infrared spectra were recorded on a Perkin-Elmer 577 spectrophotometer. Ultraviolet spectra were recorded on a Beckman DB-T spectrophotometer and maxima are reported in nanometers. Nmr spectra were determined with a Varian 60 MHz instrument with TMS as internal standard. These data are summarized in Table I. No effort was made to improve the yields.

(*Z*)-Methyl α-Hydroxyimino-4-nitro-1*H*-imidazole-1-acetate (**1a**).

To a stirred suspension of methyl 4-nitro-1*H*-imidazole-1-acetate (7.5 g., 40.5 mmoles) in methanol (100 ml.) were added first 48.6 ml. of *N* sodium methoxide and then, dropwise, 14.2 g. of freshly prepared *n*-amyl nitrite (120 mmoles = 3 moles/mole). No rise in temperature was noted. The mixture was stirred at room temperature and after 4 hours a complete dissolution occurred. After a total of 24 hours all of the starting material had reacted. The brown solution was evaporated to 25 ml., water (25 ml.) was added and the *p*H was adjusted to 3 with 6 *N* hydrochloric acid. The bulky material that precipitated was removed after 12 hours in the ice-box. The crude solid was washed well with methanol and dried to give 5.3 g. of **1a**. The aqueous mother liquors were extracted 3 times with ethyl acetate, the organic layer was combined with the methanolic washings and evaporated to dryness *in vacuo*. The residue showed five spots on tlc (ethyl acetate) and was chromatographed on a silica gel column using ethyl acetate as the eluent. Four products were eluted and identified except the residue at the origin. The first (Rf = 0.6 with ethyl acetate) was amyl 4-nitro-1*H*-imidazole-1-acetate, the second (Rf = 0.36) corresponded to **1a**, the third (Rf = 0.29) to methyl 4-nitro-1*H*-imidazole-1-acetate, the fourth (Rf = 0.2) to 4(5)-nitro-1*H*-imidazole. A sample of **1a** was crystallized for analyses. The melting point was not well defined and is not given.

Anal. Calcd. for $C_6H_6N_4O_5$ (214.14): C, 33.65; H, 2.82; N, 26.17. Found: C, 33.51; H, 2.85; N, 26.03.

B.

A similar experiment was carried out by irradiating the reaction solution. No formation of the other isomer was observed and only the formation of 4(5)-nitro-1*H*-imidazole increased.

(*E*)-Methyl α-Hydroxyimino-4-nitro-1*H*-imidazole-1-acetate (**1b**).

In a flask protected from moisture, 9.5 ml. (43.78 mmoles) of hexamethyldisilazane was added to a suspension of **1a** (8.0 g., 37.33 mmoles) in benzene (500 ml.) at room temperature under magnetic stirring. The mixture was heated at reflux until complete solution was attained (2 hours). The clear solution was irradiated (9) at 50° for several hours. The isomerization was followed by nmr measurements (3a) and when it seemed to stop (after seven hours) the solvent was removed *in vacuo*. Addition of water (50 ml.) to the residue allowed the recovery of 5.41 g. of **1a**. The mother liquor was extracted with ethyl acetate. Evaporation of the solvent left a solid (2.45 g.) which consisted of a mixture of **1b** and **1a** in a molar ratio of 4:1, as determined by nmr analysis (3a). This solid was dissolved in ethyl acetate and chromatographed on a silica gel column eluting with ethyl acetate-petroleum ether 2:3. Removal of the solvent from the portion of the eluate containing the faster moving isomer (Rf = 0.47 with ethyl acetate) gave pure **1b** (1.3 g.). The melting point was not well defined and is not given.

Anal. Calcd. for $C_6H_6N_4O_5$ (214.14): C, 33.65; H, 2.82; N, 26.17. Found: C, 33.48; H, 2.84; N, 26.06.

(*Z*)-α-Hydroxyimino-4-nitro-1*H*-imidazole-1-acetic Acid (**2a**).

To a stirred suspension of **1a** (640 mg., 3 mmoles) in methanol (6 ml.) was added 6 ml. of *N* sodium hydroxide. After 20 minutes, when the tlc (silica gel; ethyl acetate) revealed a complete hydrolysis of the starting ester, the solution was cooled to 10°, treated with 12 ml. of 0.5 *N* hydrochloric acid and concentrated *in vacuo* to give 300 mg. of **2a** as colourless crystals. This compound was not sufficiently stable to be correctly analyzed but it was sufficiently pure to meet the nmr analyses (*cf.* Table I). When a sample of **2a** was dissolved in acetone, a nearly colourless precipitate formed while standing at room temperature for several hours; ir and nmr analysis revealed it to be the somewhat impure aldehyde **6a**. When a sample of **2a** was dissolved in anhydrous ethanol, a nearly colourless precipitate separated after 48 hours at room temperature. Analyses, m.p. and mixed m.p. revealed that the isolated compound was identical with authentic sample (Aldrich) of 4-nitro-1*H*-imidazole.

(*Z*)-Methyl α-Methoxyimino-4-nitro-1*H*-imidazole-1-acetate (**3a**).

A.

Methyl iodide (10.57 g., 75 mmoles) was added to a solution of **1a** (10.7 g., 50 mmoles) in 150 ml. of methanol containing sodium methoxide (50 mmoles). After heating at reflux for 24 hours water was added and the *p*H adjusted to 6.50 with 2 *N* sodium hydroxide. The mixture was warmed to complete solution and evaporated to 200 ml. After cooling, the cream-coloured precipitate was filtered and washed with ice-water and dried. Since tlc revealed the presence of a trace of **1a**, the product (6.5 g.) was chromatographed on a silica gel column, eluting with ethyl acetate. A sample of the recovered **3a** (5.0 g.) was crystallized from methanol for analyses; Rf = 0.48 (ethyl acetate).

Anal. Calcd. for $C_7H_8N_4O_5$ (228.17): C, 36.85; H, 3.53; N, 24.56; CH_3O, 27.18. Found: C, 36.55; H, 3.55; N, 24.44; CH_3O, 26.90.

B.

A solution of **1a** (15 g., 70 mmoles) in 70 ml. *N* sodium methoxide was evaporated to dryness and the residue was dissolved in 150 ml. of benzene-dimethylformamide 2:1. To this solution were added, dropwise, 8.7 ml. of methyl iodide. After stirring 2 hours at room temperature, the solution was diluted with ethyl acetate (300 ml.), washed with sodium bicarbonate aqueous solution and with saturated sodium chloride solution, and then evaporated to yield 10.82 g. of nearly pure **3a** which was crystallized from methanol (7.0 g.).

Methyl α-Methoxy-α-methoxyiminoacetate (**5**).

To a mixture of **1a** (5.5 g.) in methanol (150 ml.) and methyl iodide (30 ml.) was added 11 g. of silver oxide. The slurry was stirred at room temperature and was monitored by tlc (ethyl acetate). After a total of 24 hours a trace amount of **1a** was still present, but no **3a** was detectable by tlc; the principal component was a spot with high Rf (0.75). The mixture was filtered and evaporated. The residue (5.1 g.) was chromatographed on a silica gel column eluting with chloroform. Fractions containing the compound with the higher Rf were collected, combined and concentrated to an oil. A yield of 2.3 g. of methyl α-methoxy-α-methoxyiminoacetate **5** was obtained; ir (liquid film): 1745 cm^{-1} strong (C = O), 1615 cm^{-1} strong (C = N); nmr (deuteriochloroform): δ 3.83 (s, 3H), 3.92 (s, 3H), 4.00 (s, 3H).

Anal. Calcd. for $C_5H_9NO_4$ (147.13): C, 40.81; H, 6.17; N, 9.52; CH_3O, 63.23. Found: C, 41.13; H, 6.20; N, 9.44; CH_3O, 63.86.

(*E*)-Methyl α-Methoxyimino-4-nitro-1*H*-imidazole-1-acetate (**3b**).

A.

Two g. of **3a** in 1000 ml. of methanol were irradiated at room temperature for several hours. A sample of the solution was taken up regularly and monitored by tlc (ethyl acetate). When a new spot began to appear, quantitative measurements were made by nmr in deuteriochloroform (3b). After six hours, when the integration showed a 23% transformation and the isomerization seemed to stop, the solution was concentrated to dryness and the residue chromatographed on silica gel column. Elution with ethyl acetate-petroleum ether 1:2 furnished 400 mg. of pure **3b** with Rf = 0.54 (ethyl acetate).

Anal. Calcd. for $C_7H_8N_4O_5$ (228.17): C, 36.85; H, 3.53; N, 24.56; CH_3O, 27.18. Found: C, 36.50; H, 3.50; N, 24.46; CH_3O, 26.87.

B.

Seventeen g. of **3a** in 1000 ml. of benzene were irradiated at 50° for 5 hours. The solution was evaporated to 200 ml. and 11 g. of pure **3a** were recovered. The filtrate was concentrated to dryness and the residue (6 g. of a 50% mixture **3a** and **3b**) chromatographed. Elution with ethyl acetate-petroleum ether 1:2 gave pure **3b** as a white solid (2.5 g.).

(*Z*)-α-Methoxyimino-4-nitro-1*H*-imidazole-1-acetic Acid (**4a**).

To a stirred suspension of 2.280 g. (10 mmoles) of **3a** in 40 ml. of methanol and 100 ml. of water was added at 0-5°, under stirring, 10 ml. of *N* sodium hydroxide. The solution obtained was monitored by tlc (acetone-acetic acid 95:5) and after 20 minutes, when no more ester was detectable, 10 ml. of *N* hydrochloric acid was added. The precipitated solid was filtered, washed with ice-water, and dried *in vacuo* over phosphorus pentoxide to give 1.90 g. of **4a** with Rf = 0.24 (ethyl acetate-acetic acid 7:3). Crystallization from methanol gave white crystals with 0.8 moles water of crystallization (6.4%).

Anal. Calcd. for $C_6H_6N_4O_5 \cdot 0.8H_2O$: C, 31.50; H, 3.35; N, 24.49. Found: C, 31.43; H, 3.38; N, 24.41.

(*E*)-α-Methoxyimino-4-nitro-1*H*-imidazole-1-acetic Acid (**4b**).

A suspension of **3b** (3.7 g., 16.2 mmoles) in 35 ml. of water and 16 ml. of *N* sodium hydroxide was stirred at room temperature as long as solution occurred (30 minutes). The solution was treated with 16 ml. of *N* hydrochloric acid and then exhaustively extracted with ethyl acetate. The organic extract was dried and stripped to a solid which was triturated with benzene and filtered. The resulting colourless product weighed 2.78 g. (Rf = 0.36 with ethyl acetate-acetic acid 7:3).

Anal. Calcd. for $C_6H_6N_4O_5$ (214.14): C, 33.65; H, 2.82; N, 26.17. Found: C, 33.38; H, 2.87; N, 25.99.

(*Z*) 4-Nitro-1*H*-imidazole-1-carboxaldehyde *O*-Methyloxime (**7a**).

A solution of the acid **4a** (300 mg.) in 16 ml. of acetone and 24 ml. of benzene was heated under reflux for 90 minutes in order to have a complete decarboxylation. Evaporation of the solvent *in vacuo* left a white solid (Rf = 0.52 in ethyl acetate) which was identified by analyses and ir and nmr spectra as pure **7a**.

Anal. Calcd. for $C_5H_6N_4O_3$ (170.13): C, 35.30; H, 3.55; N, 32.93. Found: C, 35.12; H, 3.58; N, 32.69.

(*E*) 4-Nitro-1*H*-imidazole-1-carboxaldehyde *O*-Methyloxime (**7b**).

The procedure was the same as for **7a** except that 300 mg. of acid **4b** were dissolved in 32 ml. of acetone and 24 ml. of benzene. Evaporation of the solvent left a light yellow solid (Rf = 0.52 in ethyl acetate) which consisted of a mixture of **7b** and **7a** in a molar ratio of 9:1, as determined by nmr analysis in DMSO-d_6 (comparative integrations of peaks at δ 8.00 (=CH of **7a**) and at δ 8.85 (=CH of **7b**).

Irradiation of a Solution of **4a**.

When a solution of **4a** (885 mg.) in 400 ml. of acetone and 600 ml. of benzene was irradiated (9) at 50° until tlc indicated the disappearance of **4a** (5 hours), evaporation of the solvent left a solid which was a mixture of **7a** and **7b** in a molar ratio of 7:3.

REFERENCES AND NOTES

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(2a) E. J. Poziomek, *J. Pharm. Sci.*, **54**, 333 (1965); (b) G. Guillot-Edelheit and R. Beugelmans, *Bull. Soc. Chim. France*, 368 (1977).

(3a) For quantitative measurements the spectra were run in DMSO-d_6 at a 50-Hz sweep rate, and the region of ring protons was integrated carefully; (b) for quantitative measurements the spectra were run in deuteriochloroform at 25-Hz sweep width in the 0-25 Hz region. The region was integrated carefully. The two sharp three-proton singlets associated with the OCH_3 and the $NOCH_3$ group in **3a** (Δ = 13.8 Hz) decreased gradually in intensity, and in the meantime two new singlets appeared with Δ = 3.6 Hz. These new peaks are located between the other two.

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(5) The comparison is with the pairs of (*E*)-ethyl α-methoxyimino-2-furanacetate and (*Z*)-ethyl α-methoxyimino-2-thiophenacetate (4.07 ppm), and of (*Z*)-ethyl α-methoxyimino-2-furanacetate and (*E*)-ethyl α-methoxyimino-2-thiophenacetate (3.95 ppm) with the same configurations at the double bond (unpublished data from this laboratory).

(6) R. Bucourt, R. Heymes, A. Lutz, L. Pénasse and J. Perronnet, *Tetrahedron*, **34**, 2233 (1978).

(7) See for example: (a) A. Dondoni, L. Lunazzi, P. Giorgianni, D. Macciantelli, *J. Org. Chem.*, **40**, 2979 (1975); (b) H. Gozlan, R. Michelot and R. Rips, *Tetrahedron Letters*, 859 (1975); (c) H. Gozlan, R. Michelot, C. Riche and R. Rips, *Tetrahedron*, **33**, 2535 (1977); (d) A. Dondoni, G. Gilli and M. Sacerdoti, *J. Chem. Soc., Perkin Trans. II*, 1036 (1976).

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(9) Photochemical isomerizations were performed with an immersed high-pressure mercury lamp (Hanau TQ 150) having a water-cooled jacket.