Russian Journal of Organic Chemistry, Vol. 39, No. 4, 2003, pp. 585–588. Translated from Zhurnal Organicheskoi Khimii, Vol. 39, No. 4, 2003, pp. 621–624.

Dedicated to Full Member of the Russian Academy of Sciences I. P. Beletskaya on occasion of her jubilee

Functional Acetal Methacrylates: IV.* Electrophophilic Addition of Triazoles to Vinyloxyalkyl Methacrylates

O. V. Vysotskaya[1], L. A. Oparina[1], L. N. Parshina[1], B. V. Timokhin[2], N. K. Gusarova[1], and B. A. Trofimov[1]

[1]*Faworsky Institute of Chemistry, Siberian Division, Russian Academy of Sciences, Irkutsk, 664033 Russia*
[2]*Irkutsk State University, Irkutsk, Russia*

Received October 25, 2002

Abstract—Reactions of vinyloxyalkyl methacrylates with triazoles (1,2,4-triazole, 1,2,3-benzotriazole, 5-methyl-1,2,3-benzotriazole) under electrophilic conditions (50°C, 1–2 h, 1 wt% CF_3COOH) occur chemoselectively and afford in quantitative yield polyfunctional methacrylates with triazole and benzotriazole yields.

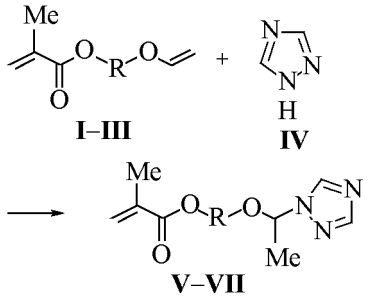
Vinyloxyalkyl methacrylates are highly active bifunctional monomers, building blocks and semiproducts for new polymer materials, for medicine and agriculture. Two unsaturated bonds of quite dissimilar reactivity combined in a single molecule provide almost unlimited possibility for application of these compounds to polymer chemistry and fine organic synthesis [2, 3].

This study was aimed at synthezing from vinyloxy methacrylates new representatives of polyfunctional methacrylates containing triazole and benzotriazole substituents as promising monomers, comonomers, and synthons. For instance, it is known that a benzotriazole moiety can be successfully used as a key function in organic synthesis playing the role of activating or leaving group [4–6].

Among triazoles efficient stimulators of heart function [7 9], inhibitors of histidine biosynthesis [10], and fungicides of the second generation [11, 12] were revealed.

In the present study we first carried out and investigated the reaction of triazoles with vinyloxyalkyl methacrylates. Their highly reactive ("anchor") vinyloxy group is able to selectively take up various protogenic reagents by electrophilic mechanism [1, 13] opening a route to new classes of substituted methacrylates. A selective triazoles addition to vinyl ethers in keeping with Markownikoff rule was reported in [14].

Actually, 1,2,4-triazole (**IV**) under mild conditions (50°C, 1–2 h, 1 wt% of trifluoroacetic acid, solvent dimethoxyethane) undergoes regio- and chemoselective addition to the electron-rich vinyloxy group of vinyloxyalkyl methacrylates (**I–III**) affording in high yield the expected [1-(1*H*-1,2,4-triazol-1-yl)ethoxy]alkylmethacrylates (**V–VII**) (Table 1).



I–III **IV** **V–VII** (1)

R = $(CH_2)_2$ (**I, V**), $(CH_2)_2O(CH_2)_2$ (**II, VI**), $CHMe(CH_2)_2$ (**III, VII**).

The reaction progress was monitored qualitatively by IR spectra of the reaction mixtures where gradual changes were observed in the characteristic absorption bands of vinyloxy group. In the course of the reaction the low-frequency component of the stretching vibrations of ν C=C–O (1620 cm^{-1}) disappears and the intensity of bands [15] coinciding with the stretching (1637 cm^{-1}) and bending (1320, 960, and

* For communication III see [1].

1070-4280/03/3904-0585$25.00 © 2003 MAIK "Nauka/Interperiodica"

Table 1. Yields and characteristics of methacrylates **V**–**VII, X**–**XII**

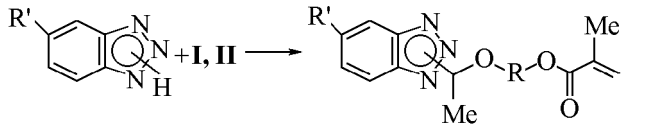
Compd. no.	Yiield, %	bp., °C, *p*, mm Hg	n_{D20}	Found, %			Formula	Calculated, %		
				C	H	N		C	H	N
V	90	135 (2)	1.4786	53.12	6.67	19.13	C10H15N3O3	53.32	6.71	18.66
VI	92	145 (1)	1.4720	53.24	7.34	15.19	C12H19N3O4	53.52	7.11	15.60
VII	93	90 (1)	1.4672	56.04	7.67	16.55	C12H19N3O3	56.90	7.56	16.59
Xa, b	90		1.5218	60.95	6.26	14.81	C14H17N3O3	61.08	6.22	15.26
XIa, b	92		1.5092	59.86	6.81	13.43	C16H21N3O4	60.14	6.63	13.16
XIIa, b	90		1.5272	62.67	7.87	13.92	C15H19N3O3	62.27	7.62	14.52

[a] Mixtures of 1H- and 2H-isomers in 4 : 1 ratio (^{1}H NMR). [b] The product was isolated by column chromatography.

815 cm^{-1}) vibrations of $CH_2=C$ in the methacryl group decreases.

The structure of methacrylates obtained was confirmed by ^{1}H NMR spectra (Table 2). The doublet signal from a methyl gtoup at 1.7 ppm and a quartet from a methane proton at 5.6 ppm reveal the presence of a CH–Me moiety in keeping with the expected addition of 1,2,4-triazole (**IV**) to the vinyloxy group of esters **I**–**III** according to Markownikoff rule. The appearance of two signals from triazole ring protons in the region 7.9–8.3 ppm evidencing the nonequivalence of $H^{3,5}$ atoms in the ring indicates that the triazole adds to vinyloxyalkyl methacrylates **I**–**III** at N^1 atom. The ratio of integral intensity of proton signals belonging to methacrylate (5.5–6.1 and 1.9 ppm) and aminal N–CH(Me)–O (5.6 and 1.7 ppm) moieties equals to 5 : 4 testifying to the regiospecificity of the reaction.

Under conditions of reaction (1) 1,2,3-benzotriazole (**VIII**) and 5-methyl-1,2,3-benzotriazole (**IX**) almost quantitatively react with vinyl esters **I, II** affording the corresponding 1-(benzotriazol-1(or 2)-yl)ethoxy alkyl methacrylates (**X**–**XII**) (Table 1).



VIII, IX **X**–**XII** (2)

R = $(CH_2)_2$, R = H (**X**); R = $(CH_2)_2O(CH_2)_2$, R = H (**XI**); R = $(CH_2)_2$, R = Me (**XII**).

Methacrylates **X**–**XII** are obtained as isomer mixtures of compounds with benzotriazol-1-yl and benzotriazol-2-yl substituents as show the double signal in the ^{1}H NMR spectrum of the methine proton N–CH–O in the region 6.1–6.3 ppm, and also a double set of proton signals from the aromatic ring (7.2–8.3 ppm). The isomers ratio is almost independent of the structure of the initial vinyloxyalkyl methacrylate **I, II** and attains 4(1) : 1(2) in agreement with the tautomers ratio in solutions of the initial benzotriazoles [16]. Compounds obtained **V**–**VII**, **X**–**XII** are stable at long storage at room temperature even in the presence of an acid catalyst due to the stabilizing effect of the triazole substituent. The symmetrization characteristic of unsymmetrical acetals [15] was not observed with these compounds.

EXPERIMENTAL

IR spectra were recorded on spectrometer Bruker JFS-25 from thin films. ^{1}H NMR spectra were registered on spectrometer Bruker DPX-400 (400 MHz) in $CDCl_3$, internal reference HMDS. Initial triazoles were commercial products which were dried before synthesis by known procedures; their physical constants were in agreement with the published data. Vinyloxyalkyl methacrylates were prepared and purified as in [17, 18].

2-[1-(1*H*-1,2,4-triazol-1-yl)ethoxy]ethyl-2-methylacrylate (V). To a solution of 0.69 g (0.01 mol) of 1,2,4-triazole in 2 ml of 1,2-dimethoxyethane was added 1.56 g (0.01 mol) of vinyl ether **I** and 0.02 g (~1 wt% on the weight of reagents) of trifluoroacetic acid. The mixture was stirred for 1 h at 50°C till in the IR spectrum of the reaction mixture the absorption bands of the vinyloxy group completely disappeared. On removing the solvent the residue was distilled in a vacuum in the presence of 1 wt% of hydroquinone. Similarly were prepared methacrylates **VI, VII** (Table 1).

2-[1-(1*H*-1,2,3-benzotriazol-1-yl)ethoxy]ethyl-2-methylacrylate and 2-[1-(1*H*-1,2,3-benzotriazol-2-yl)ethoxy]ethyl-2-methylacrylate (isomer mixture **X**).

Table 2. Spectral characteristics of methacrylates **V**–**VII, X**–**XII**

Compd. no.	IR spectrum, cm^{-1}
V	521, 606, 661, 680, 714, 753, 815, 865, 878, 944, 955, 1002, 1045, 1081, 1126, 1172, 1196, 1246, 1276, 1298, 1320, 1384, 1405, 1438, 1453, 1637, 1719, 2882, 2930, 2957, 2994, 3121
VI	521, 598, 661, 680, 714, 756, 816, 859, 878, 949, 1002, 1043, 1075, 1127, 1171, 1196, 1248, 1276, 1298, 1320, 1383, 1404, 1441, 1453, 1637, 1718, 2882, 2929, 2991, 3121
VII	521, 592, 661, 680, 714, 760, 793, 816, 834, 892, 941, 955, 974, 988, 1006, 1066, 1087, 1124, 1176, 1194, 1245, 1276, 1297, 1322, 1356, 1381, 1402, 1438, 1451, 1637, 1715, 2875, 2931, 2980, 3121
X[a]	519, 634, 653, 669, 715, 749, 750, 768, 785, 815, 831, 864, 946, 963, 1016, 1044, 1089, 1120, 1169, 1242, 1277, 1297, 1320, 1382, 1402, 1453, 1493, 1637, 1719, 2889, 2930, 2956, 2991, 3107
XI[a]	521, 663, 680, 714, 757, 816, 894, 955, 988, 1005, 1066, 1124, 1174, 1196, 1245, 1275, 1297, 1321, 1356, 1381, 1435, 1451, 1637, 1717, 2882, 2930, 2984, 3119
XII[a]	520, 604, 656, 669, 698, 762, 785, 809, 848, 864, 945, 963, 1016, 1042, 1139, 1167, 1239, 1279, 1297, 1320, 1381, 1405, 1454, 1499, 1637, 1719, 2882, 2926, 2957, 3039, 3107

Compd. no.	^{1}H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz)					
	NCHO q (^3J)	Me, d (^3J)	$=CH_2$, s	Me–C=, s	R	Protons of triazole or benzotriazole rings
V	5.65 (6.0)	1.73 (6.0)	5.57 (*trans*), 6.07 (*cis*)	1.92	3.63 m, 3.75 m (each 1H, OCH_2), 4.18 m, 4.23 m (each 1H, OCH_2)	7.93 s (1H), 8.28 s (1H)
VI	5.68 (6.0)	1.74 (6.0)	5.58 (*trans*), 6.11 (*cis*)	1.93	3.60 m, 3.75 m (each 1H, OCH_2 4.29 t (2H, OCH_2, ^3J 4.7)	7.95 s (1H), 8.34 s (1H)
VII	5.57 (6.1)	1.70 (6.1)	5.51 (*trans*), 6.03 (*cis*)	1.89	1.22 s (3H, Me) , 3.34 m, 3.52 m (each 2H, $2CH_2$), 5.02 m (1H, CH)	7.94 s (1H), 8.33 s (1H)
X (1)[b]	6.32 (6.1)	1.87 (6.1)	5.50 (*trans*), 5.97 (*cis*)	1.90	3.42 m, 3.86 m (each 1H, OCH_2), 4.12 m, 4.28 m (each 1H, OCH_2)	7.38 t (1H, ^3J 7.4), 7.48 t (1H, ^3J 7.0), 7.78 d (1H, ^3J 7.7), 8.07 d (1H, ^3J 7.5)
X (2)[c]	6.29 (6.0)	1.89 (6.1)	5.68 (*trans*), 5.95 (*cis*)	1.90	3.58 m, 3.91 m (each 1H, OCH_2), 4.12 m, 4.28 m (each 1H, OCH_2)	7.46 t (2H, ^3J 7.4), 7.88 d (2H, ^3J 7.0)
XI (1)[b]	6.31 (6.0)	1.87 (6.0)	5.55 (*trans*), 6.09 (*cis*)	1.92	3.56 m, 3.67 m (each 3H, $3CH_2$), 4.22 t (2H, OCH_2, ^3J 4.7)	7.36 t (1H, ^3J 8.5), 7.46 t (1H, ^3J 7.1), 7.80 d (1H, ^3J 8.5), 8.05 d (1H, ^3J 8.2)
XI (2)[c]	6.13 (6.0)	1.89 (6.0)	5.55 (*trans*), 6.09 (*cis*)	1.92	3.55 m, 3.62 m (each 3H, $3CH_2$), 4.28 t (2H, OCH_2, ^3J 4.7)	7.36 t (2H, ^3J 7.1), 7.88 d (2H, ^3J 8.5)
XII(1)[b]	6.25 (6.1)	1.85 (6.1)	5.49 (*trans*), 5.95 (*cis*)	1.84	3.43 m, 3.71 m (each 1H, OCH_2), 4.15 m, 4.25 m (each 1H, OCH_2)	2.49 s (3H, Me), 7.19 d (1H, ^3J 8.8), 7.52 s (1H, ^3J 8.4), 7.91 d (1H, ^3J 8.6)
XII (2)[c]	6.08 (6.0)	1.90 (6.1)	5.50 (*trans*), 6.02 (*cis*)	1.92	3.56 m, 3.80 m (each 1H, OCH_2), 4.25 m (2H, OCH_2)	2.47 s (3H, Me), 7.28 d (1H, ^3J 8.6), 7.60 s (1H, ^3J 8.5), 7.64 d (1H, ^3J 8.4)

[a] Mixtures of 1H- and 2H-isomers in 4 : 1 ratio (^{1}H NMR). [b] Benzotriazol-1-yl isomer. [c] Benzotriazol-2-yl isomer.

To a solution of 1.19 g (0.01 mol) of 1,2,3-benzotriazole **VIII** in 2 ml 1,2-dimethoxyethane was added 1.56 g (0.01 mol) of vinyl ether **I** and 0.02 g (~1 wt% on the weight of reagents) of trifluoroacetic acid. The mixture was stirred for 2 h at 50°C till complete consumption of ether **I** (IR monitoring). On removing the solvent the product was isolated by column chromatography on alumina (eluent chloroform benzene ethanol, 8 : 4 : 1). We obtained 2.47 g (90%) of methacrylates **X** as colorless viscous fluid. Similarly were prepared methacrylates **XI**, **XII** (Table 1).

REFERENCES

1. Vysotskaya, O.V., Oparina, L.A., Parshina, L.N., Gusarova, N.K., and Trofimov, B.A., *Zh. Org. Khim.*, 2002, vol. 38, p. 1133.
2. Itoh, H., Kameyama, A., and Nishikubo, T., *J. Polym. Sci., Polym. Chem.*, 1997, vol. 35, p. 3217.
3. Stohr, A. and Strohriegl, P., *Macromol. Chem. Phys.*, 1998, vol. 199, p. 751.
4. Katritzky, A.R., *J. Heterocyclic Chem.*, 1999, vol. 36, p. 1501.
5. Katritzky, A.R., Zhang, L., Yao, J., and Denisko, O., *J. Org. Chem.*, 2000, vol. 65, p. 8074.
6. Katritzky, A.R., Rogovoy, B.V., Vvedensky, V.Y., Kovalenko, K., Steel, P.J., Markov, V.I., and Forood, B., *Synthesis*, 2001, p. 897.
7. Mashevskaya, I.V., Aniskina, L.V., Vikharev, Yu.B., Safin, V.A., Kol'tsova, S.V., and Maslivets, A.N., *Khim.-Farm. Zh.*, 2001, p. 11.
8. Butters, M., Ebbs, J., Green, S., Morland, J., Matthew, C., Murtiashaw, C., and Pettman, A., *Org. Proc. Res. Dev.*, 2001, vol. 5, p. 28.
9. Geslin, M., Gully, D., Maffrand, J.P., and Roger, P., French Patent 2802530, 1999; *Ref. Zh. Khim.*, 2002, 1O133P.
10. Ventura, L., PerezGonzales, J., and Ramon, D., *Microbiology Lett.*, 1997, no. 149, p. 207.
11. Tomoyuki, K., Takashi, I., Akihiro, T., Hiroshi, H., Yoshihiro, M., Ryogo, H., Kenji, O., and Katsumi, I., *Chem. Pharm. Bull.*, 2000, vol. 48, p. 1935.
12. Stetter, J. and Lied, F., *Angew. Chem., Int. Ed.*, 2000, vol. 39, p. 1725.
13. Gorelova, O.V., Oparina, L.A., Parshina, L.N., Gusarova, N.K., and Trofimov, B.A., *Zh. Org. Khim.*, 2001, vol. 37, p. 1763.
14. Belousov, A.M., Gareev, G.A., Kirillova, L.P., and Vereshchagin, L.I., *Zh. Org. Khim.*, 1980, vol. 16, p. 2622.
15. Trofimov, B.A., *Geteroatomnye proizvodnye atsetilena. Novye monomery, reagenty i poluprodukty* (Heteroatomic Derivatives of Acetylene. New Monomers, Reagents, and Intermediates), Moscow: Nauka, 1981, 320 p.
16. Volovodenko, A.P., Trifonov, R.E., and Ostrovskii, V.A., *Zh. Org. Khim.*, 2000, vol. 36, p. 1396.
17. Trofimov, B.A., Lavrov, V.I., Alekankin, V.N., Stankevich, V.K., Maksimov, S.M., Grigorenko, V.I., Petrov, G.N., Rappoport, L.Ya., and Parshina, L.N., *USSR Inventor*'s Certificate, 1978; SSSR Byull. Izobr., 1980, no. 38.
18. Trofimov, B.A., Lavrov, V.I., Parshina, L.N., Alekankin, V.N., Stankevich, V.K., and Grigorenko, V.I., *Zh. Org. Khim.*, 1982, vol. 18, p. 528.