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LETTERS TO THE EDITOR

One-Pot Synthesis of Polycarboxylic Acids of Adamantane Type

E. A. Ivleva, D. I. Gnusarev, V. A. Osyanin, and Yu. N. Klimochkin

Samara State Technical University, ul. Molodogvardeyskaya 244, Samara, 443100 Russia
e-mail: elena.a.ivleva@yandex.com

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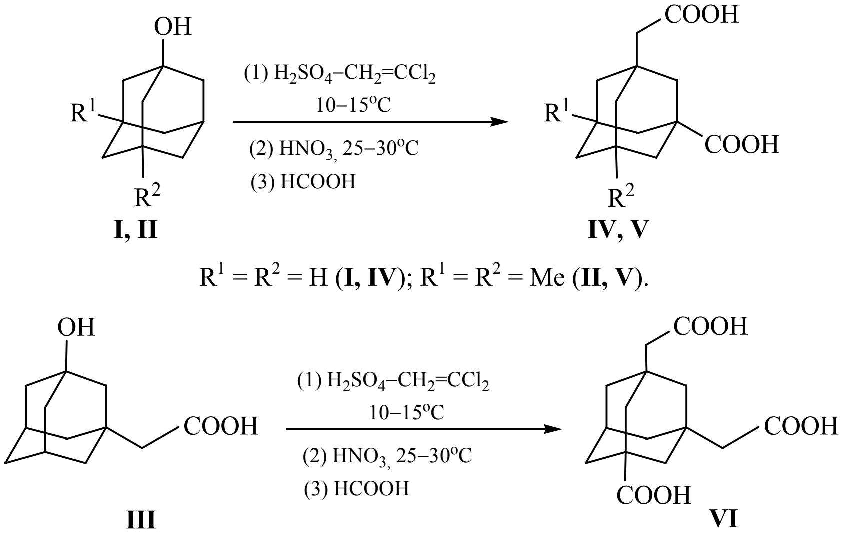
Due to the presence of the scaffold fragment, new materials derived from polycarboxylic acids of adamantane type possess unique combination of properties and are widely used in various fields of technology [1–4]. Polycarboxylic acids combining both carboxyl and carboxymethyl groups in the structure are of particular interest.

The known methods to prepare 3-carboxymethyl-1-adamantylcarboxylic acid include nucleophilic substitution of corresponding nitroxy- [5], hydroxyl- [6] and halogen-substituted [7] monocarboxylic acids in the presence of sulfuric acid. Synthesis of 3-carboxymethyl-1-adamantylcarboxylic acid from 1-adamantylacetic acid has been reported in [8].

In this work, we have proposed a new one-pot method to prepare substituted 3-carboxymethyl-1-adamantylcarboxylic acids **IV**–**VI** via the Bott and the Koch–Haaf reactions starting from 1-hydroxyl derivatives of adamantane **I**–**III** [9]. The method afforded compounds **IV**–**VI** in yields of 53–81% (Scheme 1).

According to gas chromatography–mass spectrometry data, the corresponding 3-chloro-1-adamantylacetic acids were detected in the reaction mixture along with compounds **IV**–**VI**. Formation of 3-chloro-1-adamantylacetic acids may be assigned to the competing substitution of hydroxyl group of the adamantane moiety with chlorine. It was found that the amount of 1,1-dichloroethylene affected the yields of **IV**–**VI**. For example, when using a 2-fold molar excess of 1,1-dichloroethylene, the yield of **VI** was reduced by 17% due to formation of 3-chloro-1-adamantylacetic acid.

Scheme 1.



I, II **IV, V**

$R^1 = R^2 = H$ (**I, IV**); $R^1 = R^2 = Me$ (**II, V**).

III **VI**

The presence conformationally rigid adamantane moiety and several carboxyl groups in the molecule of the prepared compounds allows their application as building blocks for further synthesis of new useful materials.

General procedure for synthesis of compounds VI–IV. Freshly distilled 1,1-dichloroethylene, 0.045 mol, was added dropwise to a solution of 0.03 mol of the corresponding 1-hydroxyladamantane **I**–**III** in 50 mL of 96% sulfuric acid upon vigorous stirring at 10–15°C. After 1.5 h stirring, 0.09 mol of fuming nitric acid was added dropwise to the reaction mixture at 25–30°C. Then, the resulting mixture was incubated at room temperature during 1 h. After addition of 0.09 mol of 100% formic acid, the reaction mixture was stirred during 12 h and poured into 300 g of crushed ice. The formed precipitate was filtered off and twice recrystallized from glacial acetic acid.

3-Carboxymethyl-1-adamantycarboxylic acid. Yield 61%, mp 229–231°C (mp 236°C [7]).

5,7-Dimethyl-3-carboxymethyl-1-adamantylcarboxylic acid. Yield 81%, mp 199–201°C. IR spectrum, ν, cm^{-1}: 2947, 2924, 2897 (CH_{Ad}), 1699 (C=O). ^{1}H NMR spectrum, δ, ppm: 0.82 s (6H, CH_3), 1.04–1.50 m (12H, CH_{2Ad}), 2.03 s (2H, CH_2), 12.00 s (2H, COOH). ^{13}C NMR spectrum, δ_C, ppm: 30.44 (CH_3), 31.62 ($\underline{C}CH_3$), 34.27 ($\underline{C}CH_2COOH$), 42.27 (CH_2), 42.66 ($\underline{C}COOH$), 44.62 (CH_2), 47.64 (CH_2), 47.72 (CH_2), 50.06 ($\underline{CH_2}COOH$), 172.92 ($CH_2\underline{COOH}$), 178.53 (COOH). Found, %: C 67.69; H 8.35. $C_{15}H_{22}O_4$. Calculated, %: C 67.65; H 8.33. *M* 266.34. Mass spectrum, *m*/*z* (I_{rel}, %): 294 (10) $[M]^+$, 235 (100), 221 (70), 203 (18), 161 (50), 119 (48).

3,5-Bis(carboxymethyl)-1-adamantylcarboxylic acid. Yield 53%, mp 267–269°C. IR spectrum, ν, cm^{-1}: 2937, 2912, 2856 (CH_{Ad}), 1730, 1691 (C=O). ^{1}H NMR spectrum, δ, ppm: 1.37–1.60 m (12H, CH_2Ad), 1.99 s (2H, $\underline{CH_2}COOH$), 2.04 s (1H, CHAd), 11.50 br.s (3H, COOH). ^{13}C NMR spectrum, δ_C, ppm: 28.63 (CH), 33.33 ($\underline{C}CH_2COOH$), 37.74 (CH_2), 40.64 (CH_2), 41.60 ($\underline{C}COOH$), 42.88 (CH_2), 45.95 (CH_2), 47.92 ($\underline{CH_2}COOH$), 172.85 ($CH_2\underline{COOH}$), 178.50 (COOH). Found, %: C 60.83; H 6.84. $C_{15}H_{20}O_6$. Calculated, %: C 60.80; H 6.80. *M* 296.32. Mass spectrum, *m*/*z* (I_{rel}, %): 338 (17) $[M]^+$, 299 (55), 298 (30), 283 (62).

^{1}H and ^{13}C NMR spectra of the solutions in DMSO-d_6 were recorded with a Jeol JNM ECX-400 spectrometer (400 MHz). IR spectra were registered with a Shimadzu IR Affinity-1 spectrometer (KBr pellets). Mass spectra were obtained with a ThermoFinnigan DSQ gas chromatography–mass spectrometer with EI at 70 eV, using a BPX-5 (30 × 0.32) capillary column for separation. Elemental analysis was performed with a EuroVector 3000 EA analyzer using L-cysteine as a reference.

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REFERENCES

1. Blazek, V., Mlinaric-Majerski, K., Qin, W., and Basaric, N., *J. Photochem. Photobiol. (A)*, 2012, vol. 229, p. 1. DOI: 10.1016/j.jphotochem.2011.12.005.
2. Bagrii, E.I. and Maravin, G.B., *Petroleum Chem.*, 2013, vol. 53, no. 6, p. 418. DOI: 10.1134/S0965544113060029.
3. Mu, Y.J., Ma, X.L., Han, B., Qin, G.F., Niu, Y.Y., and Lu, H.X., *Polyhedron*, 2014, vol. 67, p. 44. DOI: 10.1016/j.poly.2013.08.054.
4. Wanka, L., Cabrele, C., Vanejews, M., and Schreiner, P., *Eur. J. Org. Chem.*, 2007, vol. 9, p. 1474. DOI: 10.1002/ejoc.200600975.
5. Moiseev, I.K., Stulin, N.V., Yudashkin, A.V., and Klimochkin, Yu.N., *Russ. J. Gen. Chem.*, 1985, vol. 55, no. 7, p. 1655.
6. Šilhar, P., Silvaggi, N.R., Pellett, S., Capkova, K., Johnson, E.A., Allen, K.N., and Janda, K.D., *Bioorg. Med. Chem.*, 2013, vol. 21, p. 1344. DOI: 10.1016/j.bmc.2012.12.001.
7. Butenko, L.N., Khardin, A.P., and Shraibert, A.I., Inventor's Sertificate 483393, 1976; *Ref. Zh. Khim.*, 1977, 6 H 129.
8. Butenko, L.N., Protopopov, P.A., Derbisher, V.E., and Khardin, A.P., *Synth. Commun.*, 1984, vol. 14, no. 2, p. 113. DOI: 10.1080/ 00397918408062813.
9. Ivleva, E.A., Gnusarev, D.I., and Klimochkin, Yu.N., Russian Patent 2489417, 2012; *Bull. Izobret.*, 2013, no. 22.