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LETTERS TO THE EDITOR

Preparation and Membrane Transport Properties of Phosphorylated Derivatives of Sarcosine

A. R. Garifzyanov, N. V. Davletshina, M. S. Valeeva, S. A. Koshkin, and R. A. Cherkasov

Kazan Federal University, ul. Kremlevskaya 18, Kazan, Ttarstan, 420008 Russia
e-mail: rafael.cherkasov@kpfu.ru

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Phosphorylated derivatives of amino acids are of significant interest due to their pronounced biological activity and complexing properties; however, their preparation has faced certain experimental difficulties [1]. Recently, we have suggested a new procedure to prepare lipophilic α-aminomethylphosphinoxides containing structural fragments of glycine and β-alanine; these derivatives have exhibited properties of efficient membrane transport carriers towards natural carboxylic acids [2].

In this work, we report on preparation of previously unknown phosphorylated derivatives of sarcosine (methylaminoacetic acid) used for extraction of ions of groups I–III metals and of selected natural oligocarboxylic acids (oxalic, tartaric, and citric ones). The aminophosphoryl compounds $R_2P(O)CH_2N(CH_3)\cdot CH_2C(O)OH$ [R = C_8H_{17} (**I**), $C_{10}H_{21}$ (**II**), O-*i*-C_5H_{11} (**III**), and O-*i*-C_8H_{17} (**IV**)] were prepared via the Kabachnik-Fields method, by heating of the three-component mixture of the corresponding hydrophosphoryl compound, paraformaldehyde, and sarcosine in acetonitrile medium with the Dean-Stark trap attached during 2–2.5 h, followed by treatment of the reaction mixture as described in [2]. In order to achieve the hydrophilic-lipophilic balance desired for extraction application of the products, long-chain fragments were introduced at their phosphorus atom. The reaction proceeded smoothly, without formation of any side products. Crystalline compounds **I** and **II** could be easily purified by recrystallization from acetone. Compounds **III** and **IV** (light viscous liquids) were individual compounds according to NMR and mass spectrometry results, and therefore required no further purification.

Membrane transport of the groups I–III metal ions was studied as described elsewhere [3]; the results demonstrated that the singly charged ions transportation was slow. In the case of lithium ions, initially fast carrying over stopped after 15 min, probably, due to the formation of a complex poorly soluble in the membrane solvent, and thus accumulated in the membrane pores without participation in the ion transport. Of the doubly charged ions, Mg(II) transport was the least efficient, the flow of Ba(II) and Ca(II) ions was also low and quite similar. The higher flows were observed in the cases of triply charged metal

Table 1. Transmembrane transport flow ($\times 10^6$ mol m^{-2} min^{-1}) of metal nitrates [the carrier concentration in the membrane phase 0.1 mol/L, Nd(III) and Sm(III) concentration 0.05 mol/L, other substrates concentration of 0.2 mol/L]

Carrier	$NaNO_3$	$Ba(NO_3)_2$	$Mg(NO_3)_2$	$Ca(NO_3)_2$	$Nd(NO_3)_3$	$Sm(NO_3)_3$
I	2.05	12.90	5.90	16.9	126.00	128.00
II	0.1	27.80	7.10	44.7	201.50	951.00
IV	3.05	36.50	3.10	12.3	166.50	202.00

Table 2. Transmembrane transport flow ($\times 10^6$ mol m^{-2} min^{-1}) of carboxylic acids (the carrier concentration in the membrane phase of 0.1 mol/L, the substrates concentration of 0.1 mol/L)

Carrier	Oxalic acid	Tartaric acid	Citric acid
I	38.30	3.60	2.99
II	81.00	4.30	0.75
IV	24.10	4.80	0.19

ions. The described trend is typical of the amino-phosphorylated carriers [3] (Table 1).

The carrier **II**, containing decyl substituents at phosphorus atoms, the most lipophilic ones within the studied series, was efficient in transportation of the metal ions as well as the organic acids. The highest transportation rate was observed in the case of the dicarboxylic substrate, oxalic acid, whereas tartaric and citric acids (containing additional proton-donor groups) were carried over the membrane slower. The effect was likely to be connected with better retention of the substrates in the aqueous phase due to hydrogen bonding with water molecules (Table 2).

***N*-(Dioctylphosphorylmethyl)sarcosine (I).** White powder. ^{1}H NMR spectrum ($CDCl_3$, 400 MHz), δ, ppm: 3.03 d (2H, PCH_2N, $^2J_{PH}$ 5.2 Hz), 3.41 s [2H, $NCH_2C(O)OH$], 10.73 s [1H, C(O)OH)], 2.54 s ($\underline{CH_3}NCH_2$), 0.86 t (3H, CH_3, $^3J_{HH}$ 6.8 Hz), 1.15–1.90 m [14H, $(CH_2)_7$]. ^{31}P NMR spectrum (CH_3CN): δ_P 51.60 ppm.

***N*-(Didecylphosphorylmethyl)sarcosine (II).** White powder, R_f 0.22 (acetone–chloroform–methanol 5 : 8 : 1). ^{1}H NMR spectrum ($CDCl_3$, 400 MHz), δ, ppm: 3.07 d (2H, $P\underline{CH_2}N$, $^2J_{PH}$ 4.08 Hz), 3.49 s [2H, $N\underline{CH_2}C(O)OH$], 0.89 t (3H, CH_3, $^3J_{HH}$ 6.8 Hz), 7.27 s [1H, C(O)OH], 2.59 s (3H, $\underline{CH_3}NCH_2$), 1.25–1.90 m [18H, $(CH_2)_9$]. ^{31}P NMR spectrum (ethanol): δ_P 51.95 ppm. Found, %: C 67.37; H 11.91; N 3.28. $C_{24}H_{50}NO_3P$. Calculated, %: C 66.78; H 11.68; N 3.25. Mass spectrum: *m*/*z* 432.36 (*M* 431.35).

***N*-[*O,O*-Bis(3-methylbutyl)phosphorylmethyl]-sarcosine (III).** Viscous liquid, R_f 0.25 (acetone–chloroform–methanol 5 : 8 : 1). ^{1}H NMR spectrum ($CDCl_3$, 400 MHz), δ, ppm: 3.12 d (2H, PCH_2N, $^2J_{PH}$ 10.8 Hz), 3.47 s [2H, $N\underline{CH_2}C(O)OH$], 7.28 s [1H, C(O)OH], 2.60 s (3H, $\underline{CH_3}NCH_2$), 3.80–4.20 m [3H, CH (C$\underline{H}$H'O), CH], 0.80–1.80 m (3H, CH_2, CH). ^{31}P NMR spectrum (CH_3CN): δ_P 23.36 ppm. Found, %: C 51.55; H 9.28; N 4.48. $C_{14}H_{30}NO_5P$. Calculated, %: C 52.00; H 9.35; N 4.33. Mass spectrum: *m*/*z* 324.19 (*M* 323.19).

***N*-[*O,O*-Bis-(2-ethylhexyl)phosphorylmethyl]-sarcosine (IV).** Viscous liquid, R_f 0.44 (acetone–chloroform–methanol 5 : 8 : 1). ^{1}H NMR spectrum ($CDCl_3$, 400 MHz), δ, ppm: 3.12 d (2H, PCH_2N, $^2J_{PH}$ 10.4 Hz), 3.44 s [2H, $N\underline{CH_2}C(O)OH$], 0.87 t (3H, CH_3, $^3J_{HH}$ 7.4 Hz), 1.20–1.60 m (3H, CH_2, CH), 8.85 s [1H, C(O)OH], 2.57 s (3H, $\underline{CH_3}NCH_2$), 3.97 m [2H, CH(CHH'O)]. ^{31}P NMR spectrum (ethanol): δ_P 24.61 ppm. Found, %: C 58.46; H 11.11; N 3.24. $C_{20}H_{42}NO_5P$. Calculated, %: C 58.94; H 10.39; N 3.44. Mass spectrum: *m*/*z* 408.29 (*M* 407.19).

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