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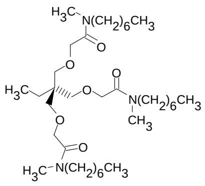
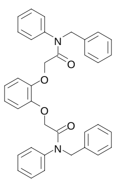
Sodium



Sodium Ionophore I

(ETH 227; *N,N′,N″*-Triheptyl-N,N',N''-trimethyl-4,4',4''-propylidynetris(3-oxabutyramide))
$C_{36}H_{71}N_3O_6$ M_r = 641.97 [61183-76-4]

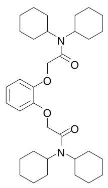
71732	**Selectophore®, function tested**	50 mg



Sodium Ionophore II

(ETH 157; *N,N′*-Dibenzyl-*N,N′*-diphenyl-1,2-phenylenedioxydiacetamide)
$C_{36}H_{32}N_2O_4$ M_r = 556.66 [61595-77-5]

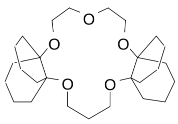
71733	**Selectophore®, function tested**	25 mg



Sodium Ionophore III

(ETH 2120; *N,N,N′,N′*-Tetracyclohexyl-1,2-phenylenedioxydiacetamide)
$C_{34}H_{52}N_2O_4$ M_r = 552.80 [81686-22-8]

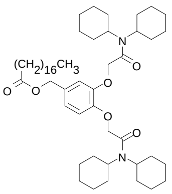
71734	**Selectophore®, function tested**	50 mg, 250 mg



Sodium Ionophore IV

(DD-16-C-5, 2,3:11,12-Didecalino-16-crown-5)
$C_{27}H_{46}O_5$ M_r = 450.65 [172883-29-3]

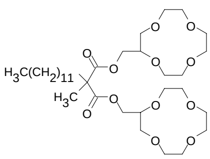
71745	**Selectophore®**	50 mg



Sodium Ionophore V

(ETH 4120; 4-Octadecanoyloxymethyl-*N,N,N′,N′*-tetracyclohexyl-1,2-phenylenedioxydiacetamide)
$C_{53}H_{88}N_2O_6$ M_r = 849.29 [129880-73-5]

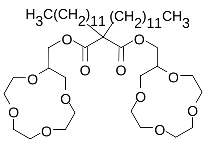
71738	**Selectophore®, function tested**	50 mg



Sodium Ionophore VI

(Bis[(12-crown-4)methyl] dodecylmethylmalonate)
$C_{34}H_{62}O_{12}$ M_r = 662.87 [80403-59-4]

71739	**Selectophore®, function tested**	50 mg, 500 mg



Sodium Ionophore VIII

(Bis[(12-crown-4)methyl] 2,2-didodecylmalonate)
$C_{45}H_{84}O_{12}$ M_r = 817.14 [174752-42-2]

73929	**Selectophore®, function tested**	50 mg, 500 mg

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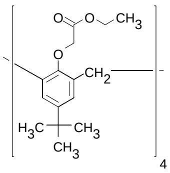
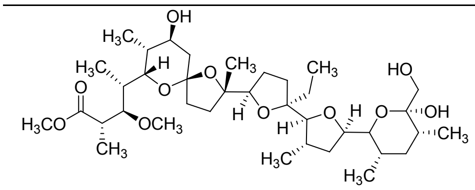


Sodium Ionophore X

(4-*tert*-Butylcalix[4]arene-tetraacetic acid tetraethylester)
$C_{60}H_{80}O_{12}$ M_r = 993.29 [97600-39-0]

71747 **Selectophore®, function tested** 50 mg



Monensin methyl ester

(Methyl monensin)
$C_{37}H_{64}O_{11}$ M_r = 684.90

30552 **Selectophore®** 100 mg

Sodium Ionophore I - Cocktail A

Sodium-selective membrane solution for microelectrodes

71176 **Selectophore®** package with 0.1 mL

Sodium Ionophore II - Cocktail A

Sodium-selective membrane solution for microelectrodes

71178 **Selectophore®** package with 0.1 mL

Electrochemical Transduction

- Ion-Selective Electrodes
- Microelectrodes
- Ion-selective Field Effect Transistors
- Coated Wire Electrodes
- Other Electrochemical Sensor Types

Optical Transduction

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Electrochemical Transduction

Ion-Selective Electrodes

Application 1 and Sensor Type [1,2,3,4]

Assay of Na^+ activity in whole blood, plasma, serum, undiluted urine and aqueous solutions with solvent polymeric membrane electrodes based on Sodium Ionophore I.

Recommended Cell Assembly

Reference | | sample solution | | liquid membrane | 0.1 M NaCl | AgCl,Ag

Recommended Membrane Composition

1.00	wt%	Sodium Ionophore I (71732)
66.00	wt%	Bis(1-butylpentyl) decane-1,10-diyl diglutarate (ETH 469) (30585)*
33.00	wt%	Poly(vinyl chloride) high molecular weight (81392)

** The use of bis(1-butylpentyl) adipate (BBPA) or bis(2-ethylhexyl)sebacate (DOS) leads to membrane electrodes of similar performance.*

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$

	Required[1)] for blood	urine	found
$\log K^{Pot}_{Na,H}$	< 4.4	< 1.4	0.1
$\log K^{Pot}_{Na,K}$	< -0.6	< -2.1	-1.5
$\log K^{Pot}_{Na,Mg}$	< -1.2	< -0.6	-3.2
$\log K^{Pot}_{Na,Ca}$	< -1.3	< 0.6	-1.8

Stability:	Drift [mV h^{-1}]:			0.03
	Standard deviation [mV]	< 0.12		0.12
	Reproducibility [mV]			0.23
Lifetime:	log P_{TLC}[2)] ionophore	> 8.4	> 2.3	7.8
	log P_{TLC}[2)] plasticizer	> 12.8	> 4.1	10.8

[1)] 1% interference, worst case [5,6]
[2)] lipophilicity, determined by thin layer chromatography [7]

[1] D. Ammann, P. Anker, E. Metzger, U. Oesch, W. Simon, in: Ion Measurements in Physiology and Medicine, Eds. M. Kessler, D.K. Harrison, J. Höper, Springer-Verlag, Berlin, Heidelberg 120 (1985)
[2] H.-B. Jenny, D. Ammann, R. Dörig, B. Magyar, R. Asper, W. Simon, Neutral carrier based ion-selective electrode for the determination of Na^+ in urine. **Mikrochim. Acta *74***, 125 (1980)
[3] P. Anker, H.-B. Jenny, U. Wuthier, R. Asper, D. Ammann, W. Simon, Potentiometry of Na in undiluted serum and urine with use of an improved neutral carrier-based solvent polymeric membrane-electrode. **Clin. Chem**. ***29***, 1508 (1983)
[4] D. Ammann, H.-B. Jenny, P. Anker, U. Oesch, W. Simon, in: Progress in Enzyme and Ion-Selective Electrodes, Eds. D.W. Lübbers, H. Acker, R.P. Buck, G. Eisenman, M. Kessler, W. Simon, Springer-Verlag, Berlin, Heidelberg, New York 21 (1981)
[5] A. Lewenstam, Ion selective electrodes in clinical chemistry, **Anal. Proc. *28***, 106 (1991)
[6] U. Oesch, P. Anker, D. Ammann, W. Simon, in: Ion-Selective Electrodes, ed. E. Pungor, I. Buzás, Akadémiai Kiadó, Budapest (1985)
[7] O. Dinten, U.E. Spichiger, N. Chaniotakis, P. Gehrig, B. Rusterholz, W.E. Morf, W. Simon, Lifetime of neutral-carrier-based liquid membranes in aqueous samples and blood and the lipophilicity of membrane components, **Anal. Chem. *63***, *596* (1991)

Application 2 and Sensor Type [8,9,10]
Determination of Na^+ in drinking water and environmental samples with solvent polymeric membrane electrodes based on Sodium Ionophore II.

Recommended Cell Assembly
Reference | | sample solution | | liquid membrane | 0.1 M NaCl | AgCl,Ag

Recommended Membrane Composition

1.0	wt%	Sodium Ionophore II (71733)
0.1	wt%	Potassium tetrakis(*p*-chlorophenyl)borate (KT*p*ClPB) (60591)
65.9	wt%	Bis(2-ethylhexal) sebacate (DOS) (84818)
33.0	wt%	Poly(vinyl chloride) high molecular weight (81392)

Electrode Characteristics and Function [9]

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method.

$\log K^{Pot}_{Na,H}$	-1.4	$\log K^{Pot}_{Na,Mg}$	-4.0
$\log K^{Pot}_{Na,K}$	-0.4	$\log K^{Pot}_{Na,Ca}$	-2.6

Slope:	57.9 mV/dec
Resistance:	2.2 MΩ
Response time: 90% response time:	< 2 min
Lifetime: log P_{TLC} [1)] ionophore	4.5

[1)] lipophilicity, determined by thin layer chromatography [7]

Application 3 and Sensor Type [11]
Assay of Na^+ activity in whole blood, plasma, serum and aqueous solutions with solvent polymeric membrane electrodes based on Sodium Ionophore III.

Recommended Membrane Composition

1.00	wt%	Sodium Ionophore III (71734)
66.00	wt	Bis(1-butylpentyl) adipate (02150)
33.00	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended Cell Assembly
Reference | | sample solution | | liquid membrane | 0.01 M NaCl | AgCl,Ag

[8] Ion and Enzyme Electrodes in Biology and Medicine, ed. M. Kessler, L.C. Clark, Jr., D.W. Lübbers, I.A. Silver, W. Simon, Urban & Schwarzenberg, München, Berlin, Wien 22 (1976)
[9] M. Huser, P.M. Gehrig, W.E. Morf. W. Simon, E. Lindner, J. Jeney, K. Tóth, E. Pungor, Membrane Technology and Dynamic Response of Ion-Selective Liquid-Membrane Electrodes, **Anal. Chem. *63***, 1380 (1991).
[10] J.R. Farrell, P.J. Iles, T. Dimitrakopoulos, Photocured polymers in ion-selective electrode membranes. Part 5 : Photopolymerised sodium sensitive ion-selective electrodes for flow injection potentiometry, **Anal. Chim. Acta**. ***334***, 133 (1996)
[11] T. Maruizumi, D. Wegmann, G. Suter, D. Ammann, W. Simon, Na^+-Selective Electrode for Application in Blood Serum. **Mikrochim. Acta *88***, 331 (1986)

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Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method.

	Required[1] for blood	found
$\log K^{Pot}_{Na,H}$	< 4.4	-0.6
$\log K^{Pot}_{Na,Li}$	< -0.1[3]	-1.2
$\log K^{Pot}_{Na,K}$	< -0.6	-1.5
$\log K^{Pot}_{Na,Mg}$	< -1.2	-4.4
$\log K^{Pot}_{Na,Ca}$	< -1.3	-2.9

Lifetime:	$\log P_{TLC}$[2] ionophore > 8.4	8.3
	$\log P_{TLC}$[2] plasticizer > 12.8	9.3

[1] 1% interference, worst case [5,6]
[2] lipophilicity, determined by thin layer chromatography [7]
[3] therapeutical Li^+ concentrations

Application 4 and Sensor Type [12]
Assay of Na^+ activity human intracellular fluid with solvent polymeric membrane electrodes based on Sodium Ionophore IV. This ionophore shows an extremely high selectivity for Na^+ over K^+.

Recommended Membrane Composition

3.0	wt%	Sodium Ionophore IV (71745)
0.3	wt%	Potassium tetrakis(4-chlorophenyl)borate (60591)
65.6	wt%	Bis(1-butylpentyl) adipate (02150)
2.0	wt%	Tris(2-ethylhexyl) phosphate (93299)
29.1	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended Cell Assembly
Ag,AgCl | 3 M KCl || 0.3 M NH_4NO_3 || sample solution || liquid membrane | 0.1 M NaCl | AgCl,Ag

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method (0.1 M solutions of the chlorides).

$\log K^{Pot}_{Na,K}$	-3.0	$\log K^{Pot}_{Na,Cs}$	-4.0
$\log K^{Pot}_{Na,Li}$	-3.1	$\log K^{Pot}_{Na,Ca}$	-4.0
$\log K^{Pot}_{Na,NH_4}$	-3.3	$\log K^{Pot}_{Na,Mg}$	-4.2
$\log K^{Pot}_{Na,Rb}$	-3.7	$\log K^{Pot}_{Na,Ba}$	-4.3
$\log K^{Pot}_{Na,Sr}$	-3.9		

Lifetime: $\log P_{TLC}$[1] ionophore 11.8
[1] lipophilicity, determined by thin layer chromatography [7]

Detection limit: $3 \cdot 10^{-4}$ M Na^+ in human intracellular fluid
$8 \cdot 10^{-6}$ M Na^+ without interfering ions

[12] K. Suzuki et al., Design and Synthesis of Sodium Ion-Selective Ionophores Based on 16-Crown-5 Derivatives for an Ion-Selective Electrode, **Anal. Chem. *68***, 208 (1996)

Application 5 and Sensor Type [13]
Assay of Na^+ activity with solvent polymeric membrane electrodes based on the highly lipophilic Sodium Ionophore V.

Recommended Membrane Composition

1.00	wt%	Sodium Ionophore V (71738)
0.06	wt%	Potassium tetrakis(4-chlorophenyl)borate (60591)
65.96	wt%	Bis(1-butylpentyl) adipate (02150)
32.98	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended Cell Assembly
Reference| |sample solution| |liquid membrane|0.01 M NaCl|AgCl,Ag

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method (0.1 M solutions of the chlorides).

$\log K^{Pot}_{Na,H}$	-0.6	$\log K^{Pot}_{Na,Mg}$	-3.8
$\log K^{Pot}_{Na,Li}$	-1.0	$\log K^{Pot}_{Na,Ca}$	-1.5
$\log K^{Pot}_{Na,K}$	-1.4		

Slope of linear regression: 58.2 ± 1.1 mV/dec (10^{-3} to 10^{-1} M NaCl)
Detection limit: $2.5 \cdot 10^{-5}$ M Na^+
Lifetime: $\log P_{TLC}$ [1)] ionophore 17.2 ± 2.6

[1)] lipophilicity, determined by thin layer chromatography [7]

Application 6 and Sensor Type [14,15]
Assay of Na^+ activity with solvent polymeric membrane electrodes based on Sodium Ionophore VI.

Recommended Membrane Composition

6.50	wt%	Sodium Ionophore VI (71739)
66.70	wt%	2-Nitrophenyl octyl ether (73732)
26.80	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended Cell Assembly
Reference| |sample solution| |liquid membrane|0.01 M NaCl|AgCl,Ag

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the mixed solution method.

$\log K^{Pot}_{Na,Li}$	-3.0	$\log K^{Pot}_{Na,Mg}$	-3.7
$\log K^{Pot}_{Na,K}$	-2.0	$\log K^{Pot}_{Na,Ca}$	-3.7
$\log K^{Pot}_{Na,NH_4}$	-3.0		

Slope of linear regression: 53 mV/dec
Response time: 90% response time: < 5 min

[13] P. Gehrig, B. Rusterholz, W. Simon, Very lipophilic sodium-selective ionophore for chemical sensors of high lifetime, **Anal. Chim. Acta *233***, 295 (1990)
[14] T. Shono, M. Okahara, I. Ikeda, K. Kimura, H. Tamura, Sodium-selective PVC Membrane Electrodes Based on Bis(12-crown-4)s, **J. Electroanal. Chem. *132***, 99 (1982)
[15] H. Tamura, K. Kumami, K. Kimura, T. Shono, Simultaneous Determination of Sodium and Potassium in Human Urine or Serum Using Coated-wire Ion-selective Electrodes Based on Bis(crown ether)s, **Mikrochim. Acta 2**, 287(1983)

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Application 7 and Sensor Type [16]
Assay of Na^+ activity with solvent polymeric membrane electrodes based on Sodium Ionophore VIII.

Recommended Membrane Composition

2.8	wt%	Sodium Ionophore VIII (73929)
0.6	wt%	Sodium tetrakis[3,5-bis(trifluoromethyl)phenyl]borate (NaTFPB) (72017)
69.0	wt%	2-Nitrophenyl octyl ether (73732)
27.6	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended Membrane Composition
Reference| |sample solution| |liquid membrane|0.01 M NaCl|AgCl,Ag

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the mixed solution method.

$\log K^{Pot}_{Na,Li}$	-3.3	$\log K^{Pot}_{Na,Mg}$	-4.7
$\log K^{Pot}_{Na,K}$	-1.95	$\log K^{Pot}_{Na,Ca}$	-3.9
$\log K^{Pot}_{Na,NH_4}$	-3.4	$\log K^{Pot}_{Na,H}$	-4.1

Slope of linear regression: 60 mV/dec ($6 \cdot 10^{-2}$ - $1 \cdot 10^{-5}$ Na^+)
Detection limit: $9 \cdot 10^{-6}$ M Na^+

Application 8 and Sensor Type [17]
Assay of Na^+ activity with solvent polymeric membrane electrodes based on Sodium Ionophore X.

Recommended Membrane Composition

0.70	wt%	Sodium Ionophore X (71747)
0.20	wt%	Potassium tetrakis((4-chlorophenyl)borate (60591)
66.10	wt%	2-Nitrophenyl octyl ether (73732)
33.00	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended Cell Assembly
Reference| |sample solution| |liquid membrane|0.1 M NaCl|AgCl,Ag

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method (0.1 M solutions of the chlorides).

$\log K^{Pot}_{Na,Li}$	-2.5	$\log K^{Pot}_{Na,Ca}$	-2.5
$\log K^{Pot}_{Na,K}$	-1.9	$\log K^{Pot}_{Na,Mg}$	< -6
$\log K^{Pot}_{Na,Cs}$	-1.6		

Slope of linear regression: 60 mV (10^{-4} to 10^{-1} M Na^+).
Detection limit: $3.5 \cdot 10^{-6}$ M Na^+.
Response time: $t_\infty \leq 20$ s.

[16] K. Kimura et al., Effects of -Substituents on Ion Selectivity of Bis(12-crown-4-methyl) Malonates as Neutral Carriers for Sodium Ion-Selective Electrodes, **Anal. Sci.** ***12***, 67 (1996)
[17] A.M. Cadogan, D. Diamond, M.R. Smyth, M. Deasy, M.A. McKervey, S.J. Harris, Sodium-selective polymeric membrane electrodes based on calix[4]arene ionophores, **Analyst** ***114***, 1551 (1989)

Microelectrodes

Application 1 and Sensor Type [general 18, application 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36]
Assay of Na^+ activity in intracellular (single cell) liquids with Na^+ microelectrodes based on Sodium Ionophore I.

Sodium Ionophore I - Cocktail A (71176)
Cocktail Composition:

10.0	wt%	Sodium Ionophore I (71732)
89.5	wt%	2-Nitrophenyl octyl ether (o-NPOE) (73732)
0.5	wt%	Sodium tetraphenylborate (72018)

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method (0.1M solutions of the chlorides) [18]:

$\log K^{Pot}_{Na,Li}$	- 0.4	$\log K^{Pot}_{Na,Ca}$	- 0.2
$\log K^{Pot}_{Na,K}$	- 0.2 (-2.3)[18]	$\log K^{Pot}_{Na,Acetylcholine}$	- 1.8
$\log K^{Pot}_{Na,Mg}$	- 2.4		

Slope of linear regression: 53.0±2.5 mV (20°C, 10^{-1} to 10^{-3} M NaCl)
Detection limit (NaCl, intracellular ion background of 200 mM K^+, 2.0 mM Mg^{2+}, 0.01 mM Ca^{2+}): $\log a_{Na}$ ~-2.5

Electrical Resistance	Tip diameter ~2 μm: ~1010 Ω
Response Time	90% response time: ≤ 5 s

[18] R. A. Steiner, M. Oehme, D. Ammann, W. Simon, Neutral carrier sodium ion-selective microelectrode for intracellular studies, **Anal. Chem. *51***, 351 (1979)
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[20] A. Ullrich, R. Steinberg, P. Baierl, G. ten Bruggencate, Changes in extracellular potassium and calcium in rat cerebellar cortex related to local inhibition of the sodium pump, **Pflügers Arch. *395***, 108 (1982)
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[23] H.G. Glitsch, H. Pusch, On the temperature dependence of the Na pump in sheep Purkinje fibres, **Pflügers Arch. *402***, 109 (1984)
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[25] J.W. Deitmer, W.R. Schlue, Intracellular Na^+ and Ca^{2+} in leech Retzius neurones during inhibition of the Na^+-K^+ pump, **Pflügers Arch. *397***, 195 (1983)
[26] H. Oberleithner, F. Lang, W. Wang, G. Messner, P. Deetjen, Evidence for an amiloride sensitive Na^+ pathway in the amphibian diluting segment induced by K+ adaptation, **Pflügers Arch. *399***, 166 (1983)
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[29] S.A. Lewis, N.K. Wills, Resistive artifacts in liquid-ion exchanger microelectrode estimates of Na^+ activity in epithelial cells, **Biophys. J. *31***, 127 (1980)
[30] T. Zeuthen, Relations between intracellular ion activities and extracellular osmolarity in Necturus gallbladder epithelium, **J. Membr. Biol. *66***, 109 (1982)
[31] F. Giraldez, Active sodium transport and fluid secretion in the gall-bladder epithelium of Necturus, **J. Physiol. *348***, 431 (1984)
[32] J.A. Coles, R.K. Orkand, Sodium Activity in drone photoreceptors, **J. Physiol. *332***, 16P (1982)
[33] J.A. Coles, R.K. Orkand, Changes in sodium activity during light stimulation in photoreceptors, glia and extracellular space in drone retina, **J. Physiol. *362***, 415 (1985)
[34] W.-B. Im, C.O. Lee, Quantitative relation of twitch and tonic tensions to intracellular Na+ activity in cardiac Purkinje fibers, **Am. J. Physiol. *247***, C478 (1984)
[35] B.J. Harvey, B. Lahlou, Ion-selective micro-electrode studies of the electrochemical potentials in trout urinary bladder, **J. Physiol. *370***, 467 (1986)
[36] D. Ammann, P. Caroni, Preparation and use of micro- and macroelectrodes for measurement of transmembrane potentials and ion activities, **Methods in Enzymol. *172***, 136 (1989)

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Application 2 and Sensor Type general[37], application[38,39,40,41]
Assay of Na^+ activity in extracellular liquids with Na^+ microelectrodes based on Sodium Ionophore II.

Sodium Ionophore II - Cocktail A (71178)
Cocktail Composition

10.0	wt%	Sodium Ionophore II (71733)
89.5	wt%	2-Nitrophenyl octyl ether (o-NPOE) (73732)
0.5	wt%	Sodium tetraphenylborate (72018)

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ as obtained by the separate solution method (0.1M solutions of the chlorides) [9]:

$\log K^{Pot}_{Na,Li}$	- 1.7
$\log K^{Pot}_{Na,K}$	- 0.4
$\log K^{Pot}_{Na,Mg}$	- 3.4
$\log K^{Pot}_{Na,Ca}$	- 1.3
$\log K^{Pot}_{Na,Acetylcholine}$	- 1.6

Nernstian electrode response
Detection limit (NaCl, extracellular ion background of 4 mM K^+, 0.6 mM Mg^{2+}, 1.1 mM Ca^{2+}): log a_{Na} ~-2.7

Electrical Resistance	Tip diameter ~0.7 µm: ~3 · 1010 Ω
Response Time	90% response time: ≤ 3 s

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Ion-selective Field Effect Transistors

Application 1 and Sensor Type [42,43,44,45]

Cocktail Composition

5.00	wt%	Sodium Ionophore I (71732)
44.77	wt%	Bis(2-ethylhexyl) phthalate (80030)
0.23	wt%	Potassium tetrakis((4-chlorophenyl)borate (60591)
50.00	wt%	Urushi (polymer from lacquer tree)

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$

$\log K^{Pot}_{Na,K}$	-1.5	$\log K^{Pot}_{Na,Ca}$	0.0
$\log K^{Pot}_{Na,NH_4}$	-1.6	$\log K^{Pot}_{Na,Mg}$	-2.4

Slope of linear regression: 53 mV (10^{-1} to $3 \cdot 10^{-4}$ M Na^+).

Application 2 and Sensor Type [42,43,46,47]
Determination of sodium activity with ISFET based on Sodium Ionophore III incorporated in the gate membrane.

Cocktail Composition

2.00	wt%	Sodium Ionophore III (71734)
65.00	wt%	Bis(2-ethylhexyl) sebacate (84818)
33.00	wt%	Poly(vinyl chloride) high molecular weight (81392)

The ISFET used contains a polyHEMA interlayer. The membrane solution (a total 100 mg of components in 1 ml THF) is cast on the polyHEMA layer.

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ (Fixed Interference Method with 0.1 M solutions of chlorides)

$\log K^{Pot}_{Na,K}$	-1.6	$\log K^{Pot}_{Na,Rb}$	-2.2
$\log K^{Pot}_{Na,Cs}$	-2.6	$\log K^{Pot}_{Na,Ca}$	-3.2
$\log K^{Pot}_{Na,Li}$	-1.4	$\log K^{Pot}_{Na,Mg}$	-3.6

Slope of linear regression: 58.4 - 61.6 mV (background of 0.1 M interfering ion)

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Coated Wire Electrodes

Application 1 and Sensor Type [48,49]
Determination of sodium activity with Coated Wire Electrode based on Sodium Ionophore VI.

Cocktail Composition

3.20	wt%	Sodium Ionophore VI (71739)
64.30	wt%	2-Nitrophenyl octyl ether (73732)
32.50	wt%	Poly(vinyl chloride) high molecular weight (81392)

The components are dissolved in 3 ml THF to prepare the coating solution.

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ determined by the mixed solution method.

$\log K^{Pot}_{Na,K}$	-2.0	$\log K^{Pot}_{Na,Ca}$	-4.0
$\log K^{Pot}_{Na,Rb}$	-2.0	$\log K^{Pot}_{Na,Mg}$	-4.0
$\log K^{Pot}_{Na,Cs}$	-1.5	$\log K^{Pot}_{Na,Sr}$	-4.0
$\log K^{Pot}_{Na,NH_4}$	-2.2	$\log K^{Pot}_{Na,Ba}$	-3.7
$\log K^{Pot}_{Na,Li}$	-3.0		

Slope of linear regression: 53 mV (10^{-1} to 10^{-4} M Na^+)

Other Electrochemical Sensor Types

Application 1 and Sensor Type [50]
Determination of sodium activity with disposable sodium sensor in double matrix membrane technology based on Sodium Ionophore II.

Cocktail Composition

1.00	wt%	Sodium Ionophore II (71733)
66.00	wt%	Bis(1-butylpentyl) adipate (02150)
33.00	wt%	Poly(vinyl chloride) high molecular weight (81392)

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ (Fixed Interference Method with 0.01 M solutions for Ca, Li, Mg and 0.005 M solution for NH_4, K)

$\log K^{Pot}_{Na,K}$	-1.0	$\log K^{Pot}_{Na,Ca}$	-2.9
$\log K^{Pot}_{Na,NH_4}$	-0.8	$\log K^{Pot}_{Na,Mg}$	-2.6
$\log K^{Pot}_{Na,Li}$	-1.7		

Slope of linear regression: 55.4 mV (10^{-1} to $3 \cdot 10^{-4}$ M Na^+)
Detection limit: 10^{-4} M NaCl

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Tel. +41 / 81 755 25 11 · Fax +41 / 81 756 54 49 · Flukatec@sial.com

Application 2 and Sensor Type [51]
Determination of sodium activity with an All-Solid-State Electrode based on Sodium Ionophore X.

Cocktail Composition

0.70	wt%	Sodium Ionophore X (71747)
0.20	wt%	Potassium tetrakis((4-chlorophenyl)borate (60591)
66.10	wt%	2-Nitrophenyl octyl ether (73732)
33.00	wt%	Poly(vinyl chloride) high molecular weight (81392)

The sensor is a Pt/polypyrrole electrode coated with the PVC-Film.

Electrode Characteristics and Function

Selectivity Coefficients $\log K^{Pot}_{Na,M}$ determined by the separate solution method.

$\log K^{Pot}_{Na,K}$	-2.7
$\log K^{Pot}_{Na,Cs}$	-3.4
$\log K^{Pot}_{Na,Li}$	-3.4

Slope of linear regression: 58.7 mV (10^{-1} to 10^{-4} M Na^+)
Detection limit: 10^{-5} M Na^+
Response time: < 20 s

[51] A. Cadogan, Z. Gao, A. Lewnstam, A. Ivaska, D. Diamond, All-solid-state sodium-selective electrode based on a calixarene ionophore in a poly(vinyl chloride) membrane with a polypyrrole solid contact, **Anal. Chem.** ***64***, 2496 (1992)

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Optical Transduction

Application 1 and Sensor Type [52,53,54]
Assay of Na^+ activity in aqueous solutions and diluted blood plasma with solvent polymeric optode membranes based on Chromoionophore II (ETH 2439) and Sodium Ionophore V (ETH 4120).

Recommended Membrane Composition

0.56	wt%	Chromoionophore II (27087)
12.04	wt%	Sodium Ionophore V (71738)
0.72	wt%	Sodium tetrakis[3,5-bis(trifluoromethyl)phenyl]borate (72017)
57.78	wt%	Bis(1-butylpentyl) adipate (02150)
28.89	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended pH Buffer
0.05 M Magnesium acetate, adjusted to pH 4.9 with acetic acid for recording the calibration curve and for diluting blood plasma samples.

Absorbance Maxima of Chromoionophore II in Polymeric Optode Membranes[52]

$\lambda_{deprot.}^{max}$: 512 nm $\lambda_{prot.}^{max}$: 656 nm

Optode Characteristics and Function

Selectivity Coefficients $\log K_{Na,M}^{Opt}$ as obtained by the fixed interference method (0.01 M solution of the acetates, buffered to pH 5.5).

$\log K_{Na,K}^{Opt}$	-1.2	$\log K_{Na,Ca}^{Opt}$	-1.2
$\log K_{Na,Li}^{Opt}$	-1.1	$\log K_{Na,Mg}^{Opt}$	-2.5

Detection range: 10^{-1} to 10^{-4} M NaCl (pH 4.9).

Application 2 and Sensor Type '
Assay of Na^+ activity in aqueous solutions with solvent polymeric optode membranes based on Chromoionophore III (ETH 5350) and Sodium Ionophore V (ETH 4120).

Recommended Membrane Composition

0.40	wt%	Chromoionophore III (27088)
12.06	wt%	Sodium Ionophore V (71738)
0.72	wt%	Sodium tetrakis[3,5-bis(trifluoromethyl)phenyl]borate (72017)
57.87	wt%	Bis(1-butylpentyl) adipate (02150)
28.94	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended pH Buffer
0.1 M Tris(hydroxymethyl)aminomethane adjusted to pH 7.6 with HCl. Available as ready-to-use solution (82626).

Absorbance Maxima of Chromoionophore II in Polymeric Optode Membranes[52]

$\lambda_{deprot.}^{max}$: 498 nm $\lambda_{prot.}^{max}$: 645 nm

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Fluka 58165: K. Seiler, Ionenselektive Optodenmembranen, dt. Monographie, herausgegeben von Fluka Chemie GmbH, Buchs, Switzerland (1993)
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Optode Characteristics and Function

Selectivity Coefficients $\log K_{Na,M}^{Opt}$ as obtained by the fixed interference method (0.01 M solution of the acetates, buffered to pH 5.5).

$\log K_{Na,K}^{Opt}$	-1.2	$\log K_{Na,Ca}^{Opt}$	-1.4
$\log K_{Na,Li}^{Opt}$	-1.1	$\log K_{Na,Mg}^{Opt}$	-3.0

Detection range: 10^{-4} to 10^{-7} M NaCl (pH 7.6 (TRIS-buffer)).

Application 3 and Sensor Type [55]

Assay of Na^+ activity in aqueous solutions with solvent polymeric optode membranes based on Chromoionophore I (ETH 5294) and Sodium Ionophore X.

Recommended Membrane Composition

0.47	wt%	Chromoionophore I 27086)
4.20	wt%	Sodium Ionophore X (71747)
1.45	wt%	Sodium tetraphenylborate (72018)
62.60	wt%	Bis(2-ethylhexyl) phthalate (80030)
31.30	wt%	Poly(vinyl chloride) high molecular weight (81392)

Recommended pH Buffer

0.1 M TRIS-HCl buffer

Absorbance Maxima of Chromoionophore I in Polymeric Optode Membranes

$\lambda_{deprot.}^{max}$: 545 nm $\lambda_{prot.}^{max}$: 660 nm, 614 nm

Optode Characteristics and Function

Selectivity Coefficients $\log K_{Na,M}^{Opt}$ as obtained by the separate solution method (TRIS-HCl buffer pH 8.0).

$\log K_{Na,K}^{Opt}$	-2.1	$\log K_{Na,Ca}^{Opt}$	-2.3
$\log K_{Na,Li}^{Opt}$	-3.1	$\log K_{Na,Mg}^{Opt}$	-2.9

Detection range: $3 \cdot 10^{-2}$ to $3 \cdot 10^{-5}$ M NaCl (pH 9.0 (TRIS-buffer)).

[55] W.H. Chan, A.W.M. Lee, C.M. Lee, K.W. Yau, K. Wang, Design and characterization of sodium-selective optode membranes based on the lipophilic tetraester of calix[4]arene, **Analyst *120***, 1963 (1995)