J. Iran. Chem. Soc., Vol. 4, No. 1, March 2007, pp. 1-29.

JOURNAL OF THE
**Iranian
Chemical Society**

One Decade of Research on Ion-Selective Electrodes in Iran (1996-2006)

M.R. Ganjali*, P. Norouzi, F. Faridbod, M. Rezapour and M.R. Pourjavid
Center of Excellence in Electrochemistry, Faculty of Chemistry, Tehran University, Tehran, Iran

(Received 1 December 2006, Accepted 27 December 2006)

This review presents a general overview about the development of ion-selective electrodes in Iran during the past decade (1996-2006). All of the reported ion-selective sensors (for cations, anions and organic species) are cited in this review. Sensors for 39 cations, 12 anions, and 23 organic compounds and drugs have been reported in this reivew. Some of the main group cations (*e.g.* beryllium) as well as most of the lanthanide ion (i.e., presidium, erbium, lutetium, cerium, neodymium, europium, gadolinium, terbium, dysprosium, holmium, ytterbium, and thulium) sensors have been reported for the first time. It is noticable that the best reported sensors for HPO_4^{2-}, SO_4^{2-}, Cl^-, ClO_4^-, Br^-, and I_3^- have been designed and constructed by the Iranian researchers.

Keywords: Sensors, Liquid membrane, Potentiometry, Ion-selective

INTRODUCTION

Liquid Membrane Sensor ISE

In general, a liquid membrane sensor is a device, comprising a non-polar solvent supported by a highly porous polymeric layer. The liquid membrane allows only the selective permeation of certain ionic species through itself, due to of the incorporation of special ingredients, called "ionophore" or in other words "ion carrier". A consequence of this selective permeation is a potential difference formation at the two membrane surfaces, measured by the two reference electrodes at both sides of the membrane.

Despite the fact that other ingredients such as ionic additives, membrane solvent, and polymeric support can affect the membrane behavior. Knowing that the ion carrier is the most determining species in a liquid membrane ion selective electrode, the history of these devices and their design are going to be studied, with respect to the type of ionophores used for their construction. The appearance order of the species in this article will be similar to the periodic table pattern.

ION SELECTIVE ELECTRODES IN IRAN

In this review, we present the historical trend and status of

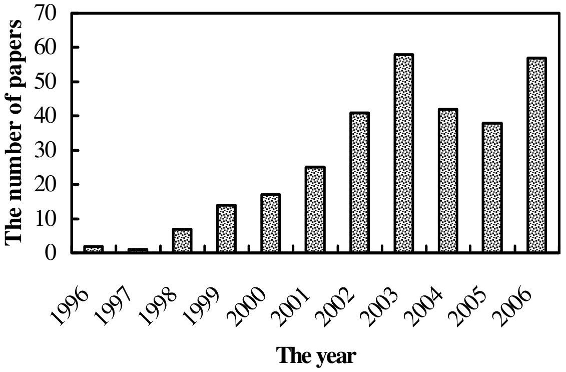

Fig. 1. Number of published papers *vs*. the year of publication.

---

*Corresponding author. E-mail: Ganjali@khayam.ut.ac.ir the studies performed on ion selective electrodes and their development during the last decade in Iran. Figure 1 depicts a statistical history of development of ion sensors in Iran over the past decade. The first sensors were developed in 1996 and 1997. At that time, the number of ion sensors reported by the Iranian researcher did not exceed the number of fingers in hands. Experiments on this field, however, caught on in the following years, increasing the average number of published reports to around 50 per year in recent years.

CATION SELECTIVE SENSORS

Table 1 shows a summary of the cation-selective potentiometric sensors designed and constructed by the Iranian reaserchers over the past decade. This table contains the name of the ionophore, slope, linear range (LR), detection limits (DL), $\log K_{sel}$ (selectivity coefficient), and type of the sensor (TS). Overally, there have been more than 190 reports on cation selective electrodes out of which about 60 of the sensors were selective for the main group metal ions.

In the field of alkali metal ions, the ionophores that have been used are mostly crown ethers and calixarens [1,2,4,5,7,8]. The ionophores were mostly used to construct PMEs (polymeric memberane electrodes) and CGEs (coated graphite electrodes), although a zeolite membrane electrode (ZME) was also reported as a Cs^+ selective electrode [9]. The most common interfereing ions in the case of first group metal were found to be Pb^{2+} and NH_4^+, in addition to the ions from the same group. The detection limits of these senspors were in the range of 10^{-7}-10^{-5} and almost all of the sensors revealed Nerstian or at least Very close-to-Nerstian calibration curve slopes [1-10]. The most sensitive alkaline metal sensors were two K^+ polymeric membrane sensors based on 1,10-bis(2'-benzoic acid)-1,4,7,10-tetradecane and 1,7-bis(2'-benzoic acid)-1,4,7-trioxaheptane [3], which exhibited potential slopes of 61.8 and 62.6 mV dec^{-1} of concentration, respectively.

As seen in Table 1, most of the alkaline earth metal ions were based on crown ether derivatives [11,13-18,24]. However other compounds like 3,4-di[2-(2-tetrahydro-2H-pyranoxy)] ethoxy styrene-styrene copolymer [12], 2,3,5,6,8,9-hexahydro-1,4,7,10-benzotetraoxacyclododecane-12-carbaldehyde-12-(2,4-dinitro-phenyl)hy [17], 1,13-diaza-3,4;12,13-dibenzo-5,8,11- trioxabicyclo[13,2,2]heptadecane-2,14-dione [23], a synthesized benzo-9-crown-3 derivative [19], 1,4-diaza-2,3;8,9-dibenzo-7,10-dioxacyclododecane-5,12-dione [20], 2-[(2-hydroxyphenyl)imino]-1,2-diphenylethanone [21], dimethyl-1-(4-nitrobenzoyl)-8-oxo-2,8-dihydro-1H-pyrazolo[5,1-a] iso-indole-2,3-dicarboxylate [22], 1,13-diaza-2,3;11,12-dibenzo-4,7,10-trioxacyclopenta-decane-14,15-dione [23] have also been reported to show selectivities to these ions. The sensors are mostly PMEs, GCEs, and even carbon paste electrodes with near to ideal slopes [11-25]. The most sensitive alkaline earth sensor has been reported to be a Sr^{2+} sensor having a potential slope of 30 mV dec^{-1} of concentration, which was based on 1,13-diaza-2,3,11,12-dibenzo-4,7,10-trioxacyclopentadecane-14,15-dione [23] as the selective ion carrier, while the loest detection limit belongs to a Be^{2+} selective 2,6-diphenyl-4-benzo-9-crown-3-pyridine sensor that was about 4.0×10^{-8} M [16].

Reports for the third and forth main groups are limited to Al^{3+} [26-29], Tl^+ [30,31], Sn^{2+} sensors [32], while there have been a relatively large number of Pb^{2+} sensors [33-59]. Almost all of the mentioned sensors were PMEs; however, some reports on CGEs [48,50,51], and one report on a CWE (coated wire electrode) has also been developed [49].

The minimum detection limit is observed for a lead-selective CGE with a membrane composition of PVC:banzyl acetate: DMCDA18C6 (ionophore):oleic acid percent ratio of 30:49:6:15 [48]. Meanwhile, detection limits in the range of 10^{-7} and 10^{-6} M for lead sensors are very common.

It can be seen in Table 1 that transition and heavy metal ion sensors reported include a PMME (polymeric memberane microelectrodes) for Y^{3+} [60], three PMEs [61,63,64] and one CGE [62] for Vanadyl ion, eight PMEs for Cr^{3+} [65-72], one of which could also be used in the CGE mode [70], and two Fe^{3+} PMEs based on 5,10,15,20-tetrakis(pentafluorophenyl)-21H,23H-porphyrin [73] and 2-[(2-hydroxy-1-propenyl-buta-1,3-dienylimino)-methyl]-4-p-tolylazo-phenol [74].

The other sensors include Ni^{2+} PMEs (and one CWE) based on dibenzodiaza-15-crown-4 [75], 2,5-thiophenyl bis(5-tert-butyl-1,3-benzoxazole) [76], 2-methyl-4-(4-methoxy-phenyl)-2,6-diphenyl-2H-thiopyran [77], 1,10-dibenzyl-1,10-diaza-18-crown-6 [78], 1,5-diphenyl-thiocarbazone [79], benzylbis(thiosemicarbazone) [80], 1,3,7,9,13,15,19,21-octaazapentacyclooctacosane (pentacyclooctaaza) [81], N,N'-bis (4-dimethylamino-benzylidene)- benzene-1,2-

Table 1. Cationic Sensors Published by the Iranian Researchers in the Past Decade

Cation	Ionophore	Slope (mV dec^{-1})	LR (M)	DL (M)	Cations with $logK_{Sel} > -2$	Type	Ref.
Na^+	Dibenzopyridino-18-crown-6	58.5	10^{-4}-10^{-1}	9.0×10^{-5}	K^+, Cs^+, NH_4^+, Pb^{2+}	PME	[1]
K^+-1	Styrene/4'-vinyl-benzo-24-crown-8 copolymer	57.0	4.0×10^{-6}-1.0×10^{-2}	1.0×10^{-6}	Li^+, Na^+, Cs^+	PME	[2]
K^+-2	1,10-Bis(2'-benzoic acid)-1,4,7,10-tetradecane and 1,7-Bis(2'-benzoic acid)-1,4,7-trioxaheptane	61.8 62.6	3.1×10^{-5}-2.7×10^{-2} 2.0×10^{-5}-7.3×10^{-2}	1.0×10^{-5} 4.0×10^{-6}	Na^+, Ba^{2+}	PME	[3]
K^+-3	2,3,9,10-Dibenzo-6-hydroxy-1,4,8,11,14-pentaoxacyclo-hexadecane	57.0	10^{-7}-10^{-1}	1.0×10^{-7}	Ba^{2+}	PME	[4]
Rb^+	Dibenzo-21-crown-7	57.8 55.3	5.0×10^{-5}-1.0×10^{-1} 1.0×10^{-5}-5.0×10^{-2}	1.5×10^{-5} 7.1×10^{-6}	K^+, Cs^+, NH_4^+	PME CGE	[5]
Cs^+-1	Derivative of gamma-pyrone	57.7	10^{-5}-10^{-3}	3.0×10^{-5}	Rb^+	PME	[6]
Cs^+-2	1,5-Diaza-2,3,4-naphthyl-8,11,14-trioxacyclohexadecane-6,16-dione	59.5	6.9×10^{-6}-5.0×10^{-1}	4.7×10^{-6}	Rb^+	PME	[7]
Cs^+-3	[25-(3-Bromo-proploxy)-5,11,-17,23-tetrakis(tert-butyl)-26,27,28-tris(1-propyloxy) calix-4[arene]	57.5	10^{-6}-10^{-1}	2.1×10^{-7}	K^+, Rb^+	PME	[8]
Cs^+-4	Poly (tetrafluoroethylene-co-ethylene-co-vinylacetate)	58.0	10^{-4}-10^{-1}	8.0×10^{-5}	$Na^{+,}$ NH_4^+, K^+	ZM E	[9]
Cs^+-5	7,11,15,28-Tetraiodo-1,21,23,25-tetramethyl-2,20:3,19-dimethano-1H,21H,23H,25H-bis[1,3]dioxocino[5,4-i:5',4'I'] benzo[1,2-d:5,4-d']-bis[1,3] benzodioxocin stereoisomer	59.1	10^{-5}-10^{-1}	5.0×10^{-6}	Na^+, Tl^+	PME	[10]
Be^{2+}-1	Benzo-9-crown-3	29.0	2.5×10^{-6}-4×10^{-3}	1.0×10^{-6}	Mg^{2+}, Li^+, K^+	PME	[11]
Be^{2+}-2	3,4-Di[2-(2-tetrahydro-2H-pyranoxy)]ethoxy styrene-styrene copolyme	29.0	10^{-6}-10^{-3}	8.0×10^{-7}	Ca^{2+}, Mg^{2+}, K^+	PME	[12]
Be^{2+}-3	2,4-Dinitrophenylhydrazine-benzo-9-crown-3	29.8	10^{-6}-10^{-1}	5.0×10^{-7}	-	PME	[13]
Be^{2+}-4	Naphto-9-crown-3	29.5	8.0×10^{-6}-10^{-1}	2.0×10^{-7}	-	PME	[14]
Be^{2+}-5	2,4-Dinitrophenylhydrazine benzo-9-crown-3	29.5	4.0×10^{-7}-10^{-1}	6.0×10^{-6}	-	PME	[15]
Be^{2+}-6	2,6-Diphenyl-4-benzo-9-crown-3-pyridine	29.6	10^{-7}-10^{-1}	4.0×10^{-8}	Sr^{2+}, Ba^{2+}, Cd^{2+}	CGE	[16]

Table 1. Continued

Be^{2+}-7	2,3,5,6,8,9-Hexahydro-1,4,7,10-benzotetraoxacyclo dodecine -12-carbaldehyde-12-(2,4-dinitrophenyl)hy	29.9	10^{-7}-10^{-1}	7.0×10^{-8}	-	PME	[17]
Be^{2+}-8	1,15-Diaza-3,4;12,13-dibenzo-5, 8,11-trioxabicyclo[13,2,2] heptadecane-2,14-dione	29.4 29.4	3.0×10^{-6}-3.0×10^{-2} 5.0×10^{-7}-2.0×10^{-2}	2.0×10^{-6} 4.0×10^{-7}	Ag^+, Hg^{2+}	PME CGE	[18]
Be^{2+}-9	A benzo-9-crown-3 derivative	29.5	10-7-10^{-1}	8.0×10^{-8}	-	CGE	[19]
Ca^{2+}-1	1,4-Diaza-2,3;8,9-dibenzo-7,10-dioxacyclododecane-5,12-dione	32.0	1.3×10^{-6}-3.2×10^{-3}	7.9×10^{-7}	Cd^{2+}, Co2$^+$	CPE	[20]
Ca^{2+}-2	2-[(2-Hydroxyphenyl)imino]-1,2-diphenylethanone	28.5	10^{-6}-10^{-1}	8.0×10^{-7}	Li^+	PME	[21]
Ca^{2+}-3	Dimethyl-1-(4-nitrobenzoyl)-8-oxo-2,8-dihydro-1H-pyrazolo [5,1-a]isoindole-2,3-dicarboxylate	29.5	8.0×10^{-7}-10^{-3}	5.0×10^{-7}	-	PME	[22]
Sr^{2+}-1	1,13-Ddiaza-2,3,11,12-dibenzo-4,7,10-trioxacyclopentadecane-14,15-dione	30.0	3.2×10^{-5}-10^{-1}	8.0×10^{-6}	K^+, Ca^{2+}, Pb^{2+}	PME	[23]
Sr^{2+}-2	Dibenzo-30-crown-10	29.2	10^{-5}-10^{-3}	5.0×10^{-6}	K^+	PME	[24]
Ba^{2+}	Dimethyl -1-acetyl-8-oxo-2,8-dihydro-1H-pyrazolo[5,1-a] isoindole-2,3-dicarboxylate	29.7	10^{-6}-10^{-1}	7.6×10^{-7}	-	PME	[25]
Al^{3+}-1	Ethandione, di-(2-furyl) (Furil)	18.5	10^{-6}-10^{-2}	1.3×10^{-7}	Cu^{2+}, Cd^{2+}, Hg^{2+}, Ba^{2+}	PME	[26]
Al^{3+}-2	Bis(5-phenylazosalicylaldehyde) -2,3-naphthalene diamine	19.8	5.0×10^{-6}-10^{-2}	2.5×10^{-6}	Fe^{3+}, Mg^{2+}, NH_4^+, Ag^+	PME	[27]
Al^{3+}-3	1-Hydroxy-3-methyl-thiocanthone	19.7	2.0×10^{-6}-2.0×10^{-2}	1.0×10^{-6}	Fe^{3+}, Hg^{2+}, Cu^{2+}	PME	[28]
Al^{3+}-4	1-Hydroxy-3-methyl-9H-xanthen-9-one	20.0	10^{-6}-1.6×10^{-1}	6.0×10^{-7}	NH_4^+, Ag^+, K^+, Na^+	PME	[29]
Tl^+-1	1,21,23,25-Tetramethyl-2,20: 3,19-dimetheno-[H,2] H,23H, 25H-bis-[1,3] dioxocino[5,4-i:5',4'-i] benzo [1,2d:5,4-d'] bis [1,3] benzodioxocin(II)	59.8	10-5-10^{-1}	5.0×10^{-6}	Ag^+, Na^+, K^+	PME	[30]
Tl^+-2	Dibenzyldiaza-18-crown-6	56.9	10^{-5}-10^{-1}	5.0×10^{-6}	K^+, Ag^+, NH^{4+}, Zn^{2+}, Co^{2+}	PME	[31]
Sn^{2+}	Dibenzo-18-crown-6	27.5	10^{-6}-10^{-2}	8.0×10^{-7}	Fe^{2+}, Mg^{2+}, Hg^{2+}, Ca^{2+}, Bi^{2+}	PME	[32]

Table 1. Continued

Pb^{2+}-1	Dibenzopyridino-18-crown-6	N	10^{-5}-10^{-1}	4.0×10^{-5}	-	PME	[33]
Pb^{2+}-2	1,8-Dihydroxy-2,7-bis(prop-2'-enyl)-9,10-anthraquinone	29.1	2.0×10^{-6}-2.0×10^{-3}	1.1×10^{-6}	Cu^{2+}	PME	[34]
Pb^{2+}-3	5,5'-Dithiobis-(2-nitrobenzoic acid)	29.0	4.0×10^{-6}-10^{-2}	1.5×10^{-6}	Ag^{+}, Tl^{+}, Cd^{2+}, Hg^{2+}	PME	[35]
Pb^{2+}-4	4'-Vinylbenzo-l5-crown-5 homopolymer	29.0	10^{-6}-4.0×10^{-3}	7.0×10^{-7}	Na^{+}, K^{+}, Rb^{+}, Cs^{+}, Ag^{+}	PME	[36]
Pb^{2+}-5	Bis[(1-hydroxy-9,10-anthraquinone)-2-methyl]sulfide	29.0	4.0×10^{-6}-5.6×10^{-3}	7.0×10^{-7}	Cu^{2+}, Hg^{2+}	PME	[37]
Pb^{2+}-6	Benzyl disulphide	29.2	2.0×10^{-5}-5.0×10^{-2}	1.0×10^{-5}	Na^{+}, Ag^{+}, Zn^{2+}, Cd2^{+}	PME	[38]
Pb^{2+}-7	Cryptand (222)	23.0	10^{-5}-10^{-1}	5.0×10^{-6}	K^{+}, Na^{+}, Al^{3+}, Zn^{2+}	PME	[39]
Pb^{2+}-8	1,4-Bis (prop-2'-enyloxy)-9,10-anthraquinone	29.8	2.5×10^{-6}-10^{-2}	1.5×10^{-6}	Ag^{+}, Fe^{3+}	PME	[40]
Pb^{2+}-9	1,10-Dibenzyl-1,10-diaza-18-crown-6	29.3	5.0×10^{-5}-10^{-2}	2.8×10^{-5}	Tl^{+}, NH$_4^{+}$, K^{+}, Li^{+}	PME	[41]
Pb^{2+}-10	Dimethyl-benzo-tetrathia-fulvalene	28.5	10^{-5}-10^{-2}	8.0×10^{-6}	Ni^{2+}, Cu^{2+}	PME	[42]
Pb^{2+}-11	Tetraphenylporphyrin	30.0	10^{-5}-10^{-2}	8.5×10^{-6}	Cu^{2+}, Ca^{2+}, Sr^{2+}	PME	[43]
Pb^{2+}-12	Capric acid	29.0	10^{-5}-10^{-2}	6.0×10^{-6}	Ag^{+}, K^{+}, Na^{+}, Li^{+}	PME	[44]
Pb^{2+}-13	Hexathia-18-crown-6-tetraone	29.0	10^{-6}-8.0×10^{-3}	8.0×10^{-7}	Hg^{2+}	PME	[45]
Pb^{2+}-14	Piroxicam	30.0	10^{-5}-10^{-1}	4.0×10^{-6}	Ag^{+}, Na^{+}, Al^{3+}, Cu^{2+}	PME	[46]
Pb^{2+}-15	Phenyldisulfide	29.3	2.0×10^{-6}-10^{-2}	1.2×10^{-6}	Cu^{2+}, Ag^{+}	PME	[47]
Pb^{2+}-16	N,N'-Dimethylcyanodiaza-18-cown-6	29.0	10^{-7}-10^{-2}	7.0×10^{-8}	-	CGE	[48]
Pb^{2+}-17	N,N-Bis(5-methyl salicylidine)-*p*-diphenylene methane diamine	29.4	2.0×10^{-5}-10^{-1}	2.0×10^{-6}	Zn^{2+}, Fe^{3+}, K^{+}, NH$_4^{+}$	CWE	[49]
Pb^{2+}-18	2-(2-Ethanoloxymethyl)-1-hydroxy-9,10-anthraquinone	29.5	10^{-7}-10^{-2}	8.0×10^{-8}	Hg2+, Ag+,	CGE	[50]
Pb^{2+}-19	1-Hydroxy-{2-2-[2-(2-hydroxy-ethoxy)-ethoxy]-ethoxymethyl}-anthracene-9,10-dione	32.5	10^{-6}-10^{-1}	5.0×10^{-7}	Hg^{2+}, Ag^{+}, Tl^{+}	CGE	[51]
Pb^{2+}-20	2,2'-Dithiodibenzoic acid	29.9	5.0×10^{-6}-4.0×10^{-2}	2.0×10^{-6}	Hg^{2+}, Cu^{2+}	PME	[52]
Pb^{2+}-21	N,N'-Bis(3-methylsalicylidine)-*p*-phenyl methane diamine	30.3	2.0×10^{-5}-10^{-1}	1.0×10^{-5}	Na^{+}, K^{+}, NH$_4^{+}$	CWE	[53]
Pb^{2+}-22	Dibenzodiaza-15-crown-4	29.5	5.0×10^{-6}-10^{-2}	3.5×10^{-6}	Cu^{2+}, Co^{2+}	PME	[54]

Table 1. Continued

Pb^{2+}-23	Oxim phenyl 2-keto methyl quinoline	26.8	10^{-5}-10^{-1}	1.0×10^{-5}	Cu^{2+}, Ag^{+}	PME	[55]
Pb^{2+}-24	1,10-Dibenzyl-1,10-diaza-18-crown-6	29.1 28.9	5.0×10^{-6}-10^{-1}	3.0×10^{-6} 5.0×10^{-6}	Cd^{2+}, Cu^{2+}	Sol-gel CWE	[56]
Pb^{2+}-25	9,10-Anthraquinone derivatives	28.9	10^{-6}-10^{-2}	6.7×10^{-7}	Zn^{2+}, Cd^{2+}	PME	[57]
Pb^{2+}-26	1-Phenyl-2-(2-quinolyl)-1,2-dioxo-2-(4-bromo) phenylhydrazone	28.7	10^{-6}-10^{-1}	6.0×10^{-7}	Hg^{2+}, Ag^{+}, Cu^{2+}	PME	[58]
Pb^{2+}-27	Bis(2-hydroxyacetophenone) ethylenediimine	29.4	10^{-5}-10^{-1}	5.0×10^{-5}	Na^{+}, K^{+}, Cu^{2+}	CWE	[59]
Y^{3+}	(2-({(E)1,2-Diphenyl-2-[(2-2-sulfanylphenyl)imino]ethylidene} amino)-1-benzenethiol	19.2	10^{-7}-10^{-2}	7.0×10^{-8}	Sc^{3+}	PMME	[60]
VO^{2+}-1	1,8-Diaminonaphthalene	29.7	10^{-5}-10^{-1}	7.9×10^{-6}	Fe^{3+}, Ag^{+}	PME	[61]
VO^{2+}-2	1,8-Diaminonaphthalene	28.3	1.4×10^{-7}-1.4×10^{-1}	1.4×10^{-7}	Fe^{3+}, Al^{3+}, UO_2^{2+}	CGE	[62]
VO^{2+}-3	A calix[4]arene derivative	29.9	10^{-5}-10^{-1}	3.9×10^{-6}	Tl^{+}, Na^{+}, Li^{+}, NH_4^{+}, Cs^{+}	PME	[63]
VO^{2+}-4	Vanadyl phosphate	29.5	10^{-6}-10^{-1}	1.0×10^{-7}	Ca^{2+}, K^{+}	PME	[64]
VO^{2+}-5	4-Dimethylaminoazobenzene	19.5	1.66×10^{-6}-10^{-2}	8.0×10^{-7}	Ag^{+}, Mn^{2+}, K^{+}, Fe^{3+}, V^{4+}	PME	[65]
Cr^{3+}-1	4-Hydroxysalicylade-2-mercaptoanil	20.2	3.0×10^{-6}-10^{-1}	1.5×10^{-6}	-	PME	[66]
Cr^{3+}-2	Glyoxal bis(2-hydroxyanil)	19.8	3.0×10^{-6}-10^{-2}	6.3×10^{-7}	$Cu^{2+,Cr6+}$, Zn^{2+}, Co^{2+}	PME	[67]
Cr^{3+}-3	2,3,8,9-Tetraphenyl-1,4,7,10-tetra-azacyclododeca-1,3,7,9-tetraene	19.5	10^{-6}-10^{-1}	7.0×10^{-7}	Ag^{+}	PME	[68]
Cr^{3+}-4	Oxalic acid bis(cyclohexylidene hydrazide)	19.8	10^{-7}-10^{-2}	3.0×10^{-8}	Ni^{2+}, Cd^{2+}	PME	[69]
Cr^{3+}-5	2-Hydroxybenzaldehyde-O,O'-(1,2-dioxetane-1,2-diyl) oxime	19.6 19.2	1.5×10^{-6}-8.0×10^{-3} 4.0×10^{-7}-3.0×10^{-3}	1.5×10^{-6} 2.0×10^{-7}	-	PME CGCE	[70]
Cr^{3+}-6	N-(1-Thien-2-ylethylidene) benzene-1,2-diamine	19.9	10^{-6}-10^{-1}	7.0×10^{-7}	Fe^{3+}	PME	[71]
Cr^{3+}-7	4-Amino-3-hydrazino-6-methyl-1, 2,4-triazin-5-one	19.7	10^{-6}-10^{-1}	5.8×10^{-7}	La^{3+}, Ce^{3+}, Al^{3+}	PME	[72]
Fe^{3+}-1	5,10,15,20-Tetrakis (penta-fluorophenyl)-21H,23H-porphyrin	25.0	10^{-6}-10^{-4}	6.3×10^{-7}	Ag^{+}, Na^{+}, Li^{+}	PME	[73]
Fe^{3+}-2	2-[(2-Hydroxy-1-propenyl-buta-1, 3-dienylimino)-methyl]-4-*p*-tolylazo-phenol	28.5	3.5×10^{-6}-4.0×10^{-2}	6.3×10^{-7}	Cu^{2+}, Zn^{2+}	PME	[74]

Table 1. Continued

Ni^{2+}-1	Dibenzodiaza-15-crown-4	30.3	$7.1\times10^{-7}-1.2\times10^{-2}$	5.6×10^{-7}	Ag^{+}, Cu^{2+}, Co^{2+}, Zn^{2+}, Pb^{2+}, Cd^{2+}	PME	[75]
Ni^{2+}-2	2,5-Thiophenyl bis(5-tert-butyl-1, 3-benzoxazole)	29.5	$10^{-5}-10^{-2}$	8.0×10^{-6}	Co^{2+}, Na^{+}, Pb^{2+}	PME	[76]
Ni^{2+}-3	2-Methyl-4-(4-methoxy phenyl)-2,6-diphenyl-2H-thiopyran	29.5	$2.0\times10^{-5}-5.0\times10^{-2}$	9.0×10^{-6}	Zn^{2+}, Co^{2+}	PME	[77]
Ni^{2+}-4	1,10-Dibenzyl-1,10-diaza-18-crown-6	29.8	$2.0\times10^{-5}-5.5\times10^{-2}$	1.2×10^{-5}	Li^{+}, K^{+}, Cd^{2+}	PME	[78]
Ni^{2+}-5	1,5-Diphenylthiocarbazone	29.5	$5.0\times10^{-6}-10^{-2}$	2.8×10^{-6}	Ba^{2+}, Mg^{2+}	PME	[79]
Ni^{2+}-6	Benzylbis(thiosemicarbazone)	29.0	$10^{-7}-10^{-2}$	4.0×10^{-8}	-	CGE	[80]
Ni^{2+}-7	1,3,7,9,13,15,19,21-Octaazapenta-cyclooctacosane (pentacyclooctaaza)	30.5	$10^{-6}-10^{-1}$	6.0×10^{-7}	Ba^{2+}	CWE	[81]
Ni^{2+}-8	N,N'-Bis-(4-dimethylamino-benzylidene)-benzene-1,2-diamine	30.0	$10^{-7}-10^{-2}$	8.0×10^{-8}	Hg^{2+}, Ag^{+}	PME	[82]
Ni^{2+}-9	Mercapto compound	28-30	$10^{-7}-10^{-2}$	6.0×10^{-8}	Cu^{2+}, Co^{2+}	PME	[83]
Pd^{2+}	Hexadecylpyridinium ion	29.4 29.3	$2.5\times10^{-3}-5.2\times10^{-6}$ $9.3\times10^{-4}-5.5\times10^{-8}$	1.0×10^{-6} 5.0×10^{-8}	Pt^{2+}	PME CWE	[84]
Co^{2+}-1	9-*t*-Butyl-3,9,15,21-tetraaza-4,5;13,14-dibenzo-6,12-dioxabicyclo[15.3.1]henicosa-1(21),17,19-triene-2,16-dione	29.45	$2.0\times10^{-6}-10^{-2}$	6.0×10^{-7}	Ni^{2+}, Cu^{2+}	PME	[85]
Co^{2+}-2	(2-Mercapto-4-methylphenyl)-2-benzamido-3-phenyl-thiopropenoate	30.0	$4.0\times10^{-7}-10^{-2}$	1.0×10^{-7}	Cu^{2+}, Cd^{2+}, Ag^{+}, Tl^{+}	PME	[86]
Co^{2+}-3	9-*t*-Butyl-3,9,15,21-tetraaza-4,5; 13,14-dibenzo-6,12-dioxabicyclo [15.3.1]henicosa-1(21),17,19-triene-2,16-dione	29.1	$7.0\times10^{-7}-10^{-2}$	2.0×10^{-7}	Ag^{+}, Ni^{2+}	CGE	[87]
Co^{2+}-4	5-((4-Nitrophenyl)azo)-N-(2',4'-dimethoxyphenyl)salicylaldimine	29.0	$9.0\times10^{-7}-10^{-2}$	8.0×10^{-7}	Cu^{2+}, Hg^{2+}, Cd^{2+}	PME	[88]
Co^{2+}-5	Oxime of 1-(2-oxocyclohexyl)-1,2-cyclohexanediol	29.8	$10^{-6}-10^{-1}$	9.0×10^{-7}	-	PME	[89]
Cu^{2+}-1	Naphthol-derivative Schiff's base	29.8	$5.0\times10^{-6}-5.0\times10^{-2}$	3.1×10^{-6}	Na^{+}, Ni^{2+}, Hg^{2+}	PME	[90]
Cu^{2+}-2	1,15-Diaza-3,4;12,13-dibenzo-5,8,11,18,21-pentaoxacyclotriei-cosane-2,14-dione	30.0	$3.2\times10^{-5}-10^{-2}$	1.2×10^{-6}	Na^{+}, K^{+}, Sr^{2+}, Cs^{+}	PME	[91]
Cu^{2+}-3	Thiophene-derivative Schiff base	29.3	$6.0\times10^{-8}-10^{-1}$	2.0×10^{-8}	Zn^{2+}, Hg^{2+}	PME	[92]

Table 1. Continued

Cu^{2+}-4	Mixed aza-thioether crowns containing a 1,10-phenanthroline sub-unit	29.4	10^{-5}- 2.0×10^{-1}	8.0×10^{-6}	La^{3+}, Ag^{+}	PME	[93]
Cu^{2+}-5	Bis-2-thiophenal propanediamine	29.1	6.0×10^{-8}-10^{-1}	3.0×10^{-8}	-	CGE	[94]
Cu^{2+}-6	2,2'-Dithiodianiline	30.0	7.0×10^{-7}-5.0×10^{-2}	6.0×10^{-6}	Pd^{2+}	PME	[95]
Cu^{2+}-7	Diphenylisocyanate bis(acetylacetone)ethylenedinnine	29.8	10^{-6}-10^{-1}	6.0×10^{-7}	-	PME	[96]
Cu^{2+}-8	3,6,9,14-Tetrathiabicyclo [9.2.1]tetradeca-11,13-diene	28.0	6.3×10^{-7}-2.5×10^{-1}	3.2×10^{-7}	Ag^{+}	PME	[97]
Cu^{2+}-9	1-Hydroxy-2-(prop-2'-enyl)-4-(prop-2'-enyloxy)-9,10-anthraquinone	27.3 29.1	10^{-5}-10^{-1} 8.0×10^{-8}-5.0×10^{-2}	8.0×10^{-6} 5.0×10^{-8}	Zn^{2+}, Pb^{2+}	PME CGE	[98]
Cu^{2+}-10	2-Quinolyl-2-phenylglyoxal-2-oxime(phenylglyoxal-alpha-monoxime)	28.2	10^{-6}-10^{-1}	5.0×10^{-7}	Fe^{3+}, Al^{3+}, K^{+}	CWE	[99]
Cu^{2+}-11	1,3-Dithiane,2-(4-methoxyphenyl)	29.5	3.0×10^{-6}-5.0×10^{-2}	1.0×10^{-6}	K^{+}, Hg^{2+}, Ag^{+}	PME	[100]
Cu^{2+}-12	2,2'-[4,4'-Diphenyl-methane bis (nitrilomethylidyne)]-bisphenol	29.5	8.0×10^{-6}-10^{-1}	3.0×10^{-6}	Pb^{2+}	PME	[101]
Cu^{2+}-13	1,3-Dithiane,2-(4-methoxy phenyl)	29.5	3.0×10^{-6}-5.0×10^{-2}	1.0×10^{-6}	Ag^{+}, Pb^{2+}, Na^{+}	PME	[102]
Cu^{2+}-14	2-(1'-(4'-(1"-Hydroxy-2"-naphthyl) methyleneamino)butyI iminomethyl)-1-naphthol	29.0	10^{-6}-10^{-1}	8.0×10^{-7}	Tl^{+}	PME	[103]
Cu^{2+}-15	N,N'-Ethylene bis(p-tert-butyl salicylaldiminato)	29.5	4.0×10^{-6}-10^{-1}	1.5×10^{-6}	Pb^{2+}	CWE	[104]
Cu^{2+}-16	Thiosemicarbazone	29.2 28.1	6.0×10^{-6}-10^{-1} 10^{-5}-10^{-1}	6.0×10^{-6} 3.0×10^{-6}	Hg^{2+}, Pb^{2+}	Sol-gel CWE	[105]
Cu^{2+}-17	6-Methyl-4-(1-phenylmethylidene) amino-3-thioxo-1,2,4-triazin-5-one	29.2	10^{-6}-10^{-1}	4.8×10^{-7}	Ca^{2+}, Sr^{2+}	PME	[106]
Cu^{2+}-18	4-Amino-6-methyl-1,2,4-triazin-5-one-3-thione	29.3	10^{-6}-10^{-1}	6.2×10^{-7}	Hg^{2+}, Fe^{3+}, Na^{+}	PME	[107]
Cu^{2+}-19	2-Mercaptobenzoxazole	29.2	5.0×10^{-6}-1.6×10^{-2}	2.0×10^{-6}	Ni^{2+}, Pb^{2+}	PME	[108]
Cu^{2+}-20	2,2-[1,2-Ethandiyl-bis(nitrilo-methylidine)-bis]*meta* cresole(I), 2,2-[1,2-ethandiyl-bis(nitrilo-methylidine)-bis]*para* cresole(II) and 2,2'-[1,2-ethandiyl-bis(nitrite-methylidine)-bis]*ortho* cresole(III)	29.2 29.7 28.2	10^{-5}-10^{-1}	3.6×10^{-6} 3.1×10^{-6} 6.3×10^{-6}	Ni^{2+}, Co^{2+}	PME	[109]

Table 1. Continued

Cu^{2+}-21	2-{1-(E)-2-((Z)-2-{(E)-2-[(Z)-1-(2-Hydroxyphenyl)ethylidene] hydrazono}-1-methylpropylidene) hydrazono]ethyl}phenol	25.9	10^{-11}-10^{-5}	5.0×10^{-12}	-	PMME	[110]
Cu^{2+}-22	1,8-Bis(2-hydroxynaphthal-diminato)-3,6-dioxaoctane	29.0	3.3×10^{-6}- 1.0	1.0×10^{-6}	Ag^+, Na^+, Al^{3+}	CWE	[111]
Cu^{2+}-23	2,2'-[1,9-Nonanediyl bis(nitrilo-ethylidyne)]-bis-(I-naphthol)	29.0	10^{-6}-5.0×10^{-3}	8.0×10^{-7}	Pb^{2+}, Zn^{2+}, Fe^{3+}	PME	[112]
Ag^+-1	hexathia-18-crown-6	59.0	6.0×10^{-6}-3.2×10^{-3}	4.0×10^{-6}	Tl^+, K^+, Na^+, NH_4^+, Pb^{2+}	PME	[113]
Ag^+-2	Mixed aza-thioether crowns containing a 1,10-phenanthroline sub-unit	59.1	10^{-5}-10^{-1} 5.0×10^{-8}-4.0×10^{-2}	8.0×10^{-6} 3.0×10^{-9}	Tl^+, Cu^{2+}	CONISE SCISE	[114]
Ag^+-3	Mixed aza-thioether crowns containing a 1,10-phenanthroline sub-unit	59.1 58.8	1.0×10^{-6}-1.0×10^{-1} 3.0×10^{-8}-5.0×10^{-2}	1.0×10^{-8} 8.0×10^{-7}	Tl^+, Pb^{2+}	PME CGE	[115]
Ag^+-4	2-Mercaptobenzimidazole and 2-mercaptobenzothiazole	60.2 57.8	10^{-6}-10^{-2}	6.3×10^{-7} 4.0×10^{-7}	Hg^{2+}, K^+	CGE	[116]
Ag^+-5	2,c-8,c-14,c-20-Tetrabutyl-4,6,10, 12,16,18,22,24-octaacetyl-resorc[4]arene	58.0	10^{-5}-10^{-1}	3.0×10^{-6}	-	CWE	[117]
Ag^+-6	Thia-substituted macrocyclic diamide	60.2	1.7×10^{-6}-10^{-1}	7.0×10^{-7}	Hg^{2+}	PME	[118]
Ag^+-7	C-Methylcalix[4] resorcareneoctamethyl ester	60.0	10^{-5}-10^{-1}, 10^{-7}-10^{-1}	4.7×10^{-6} 8.5×10^{-8}	Tl^+, Cs^+	PME CGE	[119]
Ag^+-8	Methyl-2-pyridyl ketone oxime, phenyl-2-pyridyl ketone oxime and bis[2-(o-carboxythiophenoxy) methyl]-4-bromo-1-methoxy-benzene	59.8-60	10^{-6}-10^{-1}	5.0×10^{-7}	-	CGE	[120]
Ag^+-9	Octahydroxycalix[4]arene derivative	58.0	3.3×10^{-6}-3.3×10^{-2}	2.1×10^{-6}	K^+	PME	[121]
Ag^+-10	Meso-tetraphenylporphine [$H_2T(4\text{-}OCH_3)PP$]	59.4	10^{-6}-10^{-1}	1.0×10^{-6}	Pb^{2+}	PME	[122]
Ag^+-11	2-[(2-{2-[(2-Carboxyphenyl) sulfanyl]ethoxy}ethyl)sulfanyl] benzoic acid	59.0	2.0×10^{-8}-10^{-2}	1.2×10^{-8}	Hg^{2+}	CWE	[123]
Ag^+-12	N,N'-Bis(2-thienylmethylene)-1,2-diaminobenzene	59.7	10^{-6}-10^{-1}	6.0×10^{-7}	Hg^{2+}, Fe^{3+}	CWE	[124]

Table 1. Continued

Ag^+-13	Cone shaped calix[4]arene	58.2	8.0×10^{-6}-10^{-1}	5.0×10^{-6}	-	PME	[125]
Ag^+-14	2-Methyl-2,4-di(2-thienyl)-2,3-dihydro-1H-1,5-benzodiazepine	58.5	10^{-6}-10^{-1}	5.0×10^{-7}	-	PME	[126]
Ag^+-15	[Bis 5-(4-nitrophenyl azo) salisylaldimine]-1,8-diamino, 3, 6-dioxooctane	56.2 58.4	1.9×10^{-6}-2.7×10^{-2} 9.0×10^{-7}-3.1×10^{-2}	7.8×10^{-7} 4.2×10^{-7}	K^+, NH_4^+	CPE CWE	[127]
Zn^{2+}-1	Cryptand $C2_B22$	24.0	5.0×10^{-5}-5.0×10^{-2}	3.98×10^{-5}	Na^+, K^+, NH_4^+, Tl^+	PME	[128]
Zn^{2+}-2	1,13-Diaza-2,3;11,12;15,18-tribenzo-4,7,10-trioxacyclononaoctane-14,19-dione	30.0	9.0×10^{-5}-10^{-1}	5.0×10^{-5}	K^+, Na^+, Li^+	PME	[129]
Zn^{2+}-3	5,6,14,15-Dibenzo-1,4-dioxa-8,12-diazacyclopentadecane-5,14-diene	22.0	5.0×10^{-5}-10^{-1}	3.0×10^{-5}	Ag^+, Cu^{2+}, Cd^{2+}	PME	[130]
Zn^{2+}-4	Tetra(2-aminophenyl) porphyrin	26.5	5.0×10^{-5}-10^{-1}	3.0×10^{-5}	Ni^{2+}	PME	[131]
Zn^{2+}-5	Bis(2-nitrophenyl)disulfide	29.9	2.9×10^{-7}-3.2×10^{-2}	2.0×10^{-7}	Li^+, Na^+, K^+, Pb^{2+}, Cr^{3+}	PME	[132]
Zn^{2+}-6	3-[(2-Furylmethylene)amino]-2-thioxo-1,3-thiazolidin-4-one	29.3	10^{-6}-10^{-2}	8.5×10^{-7}	-	PME	[133]
Zn^{2+}-7	5,6-Benzo-4,7,13,16,21,24-hexaoxa-1,10-diazabicyclo [8,8,8]hexacos-5-ene	29.1	10^{-6}-10^{-1}	6.3×10^{-7}	-	PME	[134]
Cd^{2+}-1	[1,1'-Bicyclohexyl]-1,1',2,2'-tetrol	27.8	10^{-5}-10^{-1}	9.0×10^{-6}	-	PME	[135]
Cd^{2+}-2	Tetrathia-12-crown-4	29.0	4.0×10^{-7}-10^{-1}	1.0×10^{-7}	Ag^+, Tl^+, Pb^{2+}, K^+	PME	[136]
Cd^{2+}-3	5-[((4-Methyl phenyl) azo)-N-(6-amino-2-pyridin) salicylaldimine] and 5-[((4-methyl phenyl) azo)-N-(2-diamino-2-cyano-1-ethyl cyanide) salicylaldehyde]	28.0 22.0	7.5×10^{-7}-1.5×10^{-1} 4.0×10^{-7}-2.0×10^{-1}	7.5×10^{-7} 4.0×10^{-7}	Pb^{2+}, Ni^{2+}	PME	[137]
Cd^{2+}-4	N'-[1-(2-Furyl)methylidene]-2-furohydrazide	29.4	10^{-6}-10^{-1}	7.3×10^{-7}	-	PME	[138]
Hg^{2+}-1	Hexathia-18-crown-6-tetraone	29.0	4.0×10^{-6}-10^{-3}	1.3×10^{-6}	Tl^+, Ag^+	PME	[139]
Hg^{2+}-2	Dibenzodiazathia-18-crown-6-dione	29.0	8.0×10^{-6}-10^{-2}	6.0×10^{-6}	Ag^+, Pb^{2+}, Cd^{2+}	PME	[140]

Table 1. Continued

Hg^{2+}-3	2-Mercaptobenzimidazole, 2-mercaptobenzothiazole and hexathiacyclooctadecane	28.5 28.5 29.6	10^{-5}-10^{-1} 10^{-6}-10^{-1} 10^{-5}-10^{-1}	6.0×10^{-7}	Ag^{+}, NH_4^{+}, Ba^{2+}, Pb^{2+}	PME	[141]
Hg^{2+}-4	Bis[5-((4-nitrophenyl)azo salicylaldehyde)]	30.0	7.0×10^{-7}-5.0×10^{-2}	2.0×10^{-7}	-	PME	[142]
Hg^{2+}-5	2-Benzoylamino-3-(4-chloro-phenyl)-thioacrylic acid S-(2-mercapto-4-methyl-phenyl) ester	29.0	2.0×10^{-7}-3.0×10^{-2}	5.0×10^{-8}	Ni^{2+}	PME	[143]
La^{3+}-1	1,3,5-Trithiacyclohexane	19.8	8.0×10^{-6}-5.0×10^{-2} 4.0×10^{-8}-10^{-2}	5.0×10^{-6} 2.0×10^{-8}	-	PME CGE	[144]
La^{3+}-2	N-[Hexahydrocyclopentapyrol-2((1H)yl)amino]carbonyl]-4-methyl benzene sulfonamide	20.1	10^{-6}-10^{-1}	8.0×10^{-7}	Sm^{3+}, Ce^{3+}	PME	[145]
La^{3+}-3	Bis(2-mercaptoanil) diacetyl	19.7	10^{-5}-10^{-1} 10^{-6}-10^{-1}	6.5×10^{-6} 5.0×10^{-7}	Ce^{3+}, Gd^{3+}	PME CGE	[146]
La^{3+}-4	Bis(thiophenal)phenylen-1,3-diamine	19.6	10^{-7}-10^{-1}	2.0×10^{-8}	Sm^{3+}, Ce^{3+}	PME	[147]
La^{3+}-5	2,2'-Dithiodipyridine	20.0	7.1×10^{-6}-2.2×10^{-2}	3.1×10^{-6}	Pb^{2+}, Ce^{3+}	PME	[148]
La^{3+}-6	N-2,4-Dimethylphenyl-N'-ethylformamidine	19.8	10^{-7}-10^{-1}	8.0×10^{-8}	-	PME	[149]
La^{3+}-7	Bis(2-methylbenzaldehyde) butane-2,3-dihydrazone	19.8	10^{-5}-10^{-1}	7.0×10^{-6}	Ce^{3+}, Pr^{3+}, Eu^{3+}	PME	[150]
La^{3+}-8	N,N'-Adipylbis(5-plenylazo salicylaldehyde hydrazone)	19.4	10^{-6}-10^{-2}	4.0×10^{-7}	Yb	PME	[151]
La^{3+}-9	Bis(5-nitro-2-furaldehyde)butane-2,3-dihydrazone	19.8	10^{-7}-10^{-1}	4.0×10^{-8}	-	PME	[152]
La^{3+}-10	N-(2-Pyridyl)-N'-(4-methoxy-phenyl)-thiourea	19.6	4.0×10^{-8}-10^{-1}	2.0×10^{-8}	Pr^{3+}, Ce^{3+}	PME	[153]
La^{3+}-11	4-Methyl-2-hydrazino-benzo-thiazole	19.8	10^{-7}-10^{-1}	2.5×10^{-8}	Ce^{3+}	PME	[154]
La^{3+}-12	8-Amino-N-(2-hydroxy-benzylidene) naphthylamine	20.3	10^{-7}-10^{-1}	8.0×10^{-8}	Pr^{3+}	PME	[155]
La^{3+}-13	3-Hydroxy-N'-(pyridin-2-ylmethylene)-2-naphthohydrazide	19.2	10^{-7}-10^{-2}	7.0×10^{-8}	-	PME	[156]
La^{3+}-14	N'-(1-Pyridin-2-ylmethylene)-2-furohydrazide	19.2	10^{-6}-10^{-1}	7.0×10^{-7}	Sm^{3+}, Nd^{3+}, Dy^{3+}	PME	[157]
Ce^{3+}-1	1,3,5-Trithiane	19.2	2.5×10^{-8}-4.8×10^{-4}	2.0×10^{-8}	La^{3+}, Pb^{2+}	GCE	[158]

Table 1. Continued

Ce^{3+}-2	1,3,5-Trithiane	19.4	5.0×10^{-5}-10^{-1}	3.0×10^{-5}	Cd^{3+}, Zn^{2+}, La^{3+}	PME	[159]
Ce^{3+}-3	N-[(Z)-2-Chloro-2-(1-hydroxy-1,1,1-triphenyl phosphoranyl)-1-ethenyl]-4-ethyl-1-benzene sulfonamide	19.5	6.6×10^{-7}-6.2×10^{-2}	2.3×10^{-7}	La^{3+}, Sm^{3+}	PME	[160]
Ce^{3+}-4	2-Aminobenzothiazole	19.6	2.0×10^{-6}-2.0×10^{-2}	1.8×10^{-6}	La^{3+}, Al^{3+}, Fe^{2+}	PME	[161]
Ce^{3+}-5	N′-[(2-Hydroxyphenyl) methylidene]-2-furohydrazide	19.4	10^{-5}-10^{-2}	7.6×10^{-6}	-	PME	[162]
Pr^{3+}	N'-(Pyridin-2-ylmethylene) benzo-hydrazide	21.1	10-6-10^{-2}	8.0×10^{-7}	Er^{3+}, Sm^{3+}, Lu^{3+}	PME	[163]
Nd^{3+}-1	5-Pyridino-2,8-dithia[9](2,9)-1,10-phenanthroline-phane	20.1	10-6-10^{-2}	7.9×10^{-7}	Yb^{3+}, Ce^{3+}, Gd^{3+}	PME	[164]
Nd^{3+}-2	N-(2-Furylmethylene) pyridine-2, 6-diamine	19.6	10^{-5}-10^{-2}	7.0×10^{-6}	La^{3+}, Gd^{3+}, Sm^{3+}	PME	[165]
Nd^{3+}-3	2-{[(6-Aminopyridin-2-yl)imino] methyl}-phenol	19.6	10^{-5}-10^{-2}	2.0×10^{-6}	Gd^{3+}, La^{3+}, Sm^{3+}	PME	[166]
Sm^{3+}-1	4,5,6,7-Tetrathiocino[1,2-b:3,4-b'] diimidazolyl-1,3,8,10-tetraethyl-2, 9-dithione (Et(4)todit)	19.6	10^{-5}-10^{-1} 10^{-7}-10^{-1}	8.0×10^{-6} 1.6×10^{-8}	Pb^{2+}, Ce^{3+}, Gd^{3+}	PME CGE	[167]
Sm^{3+}-2	Isopropyl 2-[(isopropoxy-carbothioyl) disulfanyl] ethanethioate	19.2	10^{-5}-10^{-1} 10^{-6}-10^{-1}	3.1×10^{-6} 5.0×10^{-7}	Gd^{3+}, Cd^{3+}, Hg^{2+}	PME CGE	[168]
Sm^{3+}-3	N-[2-[4-[[[(Cyclohexylamino) carbonyl] an-lino] sulfonyllphenyll ethyl]-5-methyl pyrazine carboxamide	19.8	10^{-6}-10^{-1}	6.7×10^{-7}	Ag^{+}, Pb^{2+}, Ce^{3+}	PME	[169]
Sm^{3+}-4	N- [2-[4-[[[(Cyclohexylamino) carbonyl] amino] sulfonyl] phenyl] ethyl]-5-methyl pyrazine carboxamide	19.3	10^{-10}-10^{-5}	8.0×10^{-11}	-	CGE	[170]
Eu^{3+}-1	N,N-Diethyl-N-(4-hydroxy-6-methylpyfidin-2-yl)guanidine	19.8	7.0×10^{-5}- 10^{-1}	7.0×10^{-5}	Gd^{3+}, Ce^{3+}, Tb^{3+}	PME	[171]
Eu^{3+}-2	Bis(thiophenol)butane2,3-dihydrazone	19.8	10^{-5}-10^{-2}	5.0×10^{-6}	La^{3+}, Gd^{3+}, Sm^{3+}	PME	[172]
Gd^{3+}-1	(2-[{3-[(2-Sulfanylphenyl)imino)-1-methylbutylidene}amino]phenyl hydrosulfide	19.8	10^{-5}-10^{-1}	3.0×10^{-6}	Tb^{3+}, Dy^{3+}, Eu^{3+}	PME	[173]
Gd^{3+}-2	Omeprazole	19.3	10^{-5}-10^{-1}	5.0×10^{-6}	Ce^{3+}, Cd^{2+}	PME	[174]

Table 1. Continued

Gd^{3+}-3	Bis(thiophenal) pyridine-2,6-diamine	19.4	10^{-6}-10^{-1}	7.0×10^{-7}	La^{3+}, Sm^{3+}	PME	[175]
Gd^{3+}-4	N-(2-Pyridyl)-N′-(4-nitrophenyl) thiourea	19.95	3.0×10^{-7}-10^{-1}	3.0×10^{-7}	-	PME	[176]
Tb^{3+}-1	N,N-Bis(pyrrolidene) benzene-1,2-diamine	19.8	10^{-5}-10^{-1}	7.0×10^{-6}	Yb^{3+}, Sm^{3+}, Dy^{3+}	PME	[177]
Tb^{3+}-2	4-Amino-3-{2-[4-amino-6-methyl-5-oxo-4,5-dihydro-1,2,4-triazin-3(2H)-yliden]hydrazono}-6-methyl-3,4-dihydro-1,2,4-triazin-5(2H)-one	19.4	10^{-6}-10^{-1}	8.6×10^{-7}	Gd^{3+}	PME	[178]
Dy^{3+}-1	N,N-Bis(pyrrolidene) benzene-1,2-diamine, poly(vinyl chloride)	20.6	10^{-5}-10^{-1}	6.0×10^{-6}	Ce^{3+}, La^{3+}	PME	[179]
Dy^{3+}-2	[(E)-N-(2-Hydroxybenzylidene) benzohydraide]	20.1	10^{-6}-10^{-2}	8.0×10^{-7}	Yb^{3+}	PME	[180]
Ho^{3+}-1	N,N'-Bis(2-pyridinecarboxamide)-1,2-benzene	19.6	10^{-5}-10^{-2}	8.0×10^{-6}	Dy^{3+}, Sm^{3+}, Er^{3+}	PME	[181]
Ho^{3+}-2	N-(1-Thien-2-ylmethylene)-1,3-benzothiazol-2-amine	19.7	10^{-5}-10^{-2}	7.0×10^{-6}	Dy^{3+}, Gd^{3+}, Lu^{3+}	PME	[182]
Er^{3+}	N′-(2-Hydroxy-1,2-diphenyl-ethylidene) benzohydrazide	21.0	10^{-7}-10^{-2}	7.0×10^{-8}	-	PME	[183]
Tm^{3+}-1	Thiophene-2-carbaldehyde-(7-methyl-1,3-benzothiazol-2yl)hydrazone	19.5	10^{-5}-10^{-2}	8.0×10^{-6}	Nd^{3+}, Ho^{3+}, Er^{3+}	PME	184]
Tm^{3+}-2	2,2'-Dianiline disulfide	19.5	10^{-6}-10^{-2}	4.0×10^{-7}	Yb^{3+}, Pr^{3+}, Lu^{3+}	PME	[185]
Yb^{3+}-1	Cefixime	19.5	10^{-6}-10^{-2}	7.0×10^{-7}	Ce^{3+}, Cu^{3+}	PME	[186]
Yb^{3+}-2	N-(2-Pyridyl)-N'-(2methoxyphenyl)-thiourea	19.3	10^{-6}-10^{-2}	5.0×10^{-7}	Dy^{3+}, Gd^{3+}, Nd^{3+}	PME	[187]
Yb^{3+}-3	3-Hydroxy-N-[(2-hydroxyphenyl) methylene]-2-naphthohydrazide	19.2	10^{-7}-10^{-2}	4.0×10^{-8}	Gd^{3+}, Nd^{3+}	PME	[188]
Lu^{3+}	N-(Thien-2-ylmethylene)pyridine-2, 6-diamine	20.5	10^{-6}-10^{-2}	8.0×10^{-7}	Nd^{3+}	PME	[189]
UO_2^{2+}-1	1,18-Diaza-3,4,15,16-dibenzo-5,8,11, 14,21,24-hexaoxacyclo hexaeicosane-2,17-dione	29.8	3.0×10^{-6}-8.2×10^{-3} 5.0×10^{-7}-1.5×10^{-3}	2.2×10^{-6} 1.5×10^{-7}	K^{+}, NH_4^{+}, Mn^{2+}, Ni^{2+}	PME CGE	[190]
UO_2^{2+}-2	2,2'-[1,2-Ethandiyl bis(nitriloethyl-idene)]bis(1-naphthalene)	28.5	10^{-7}-10^{-1}	7.0×10^{-8}	Mg^{2+}, Cu^{2+}	PME	[191]

diamine [82], and a mercapto compound [83]. The minimum detection limit among these Ni^{2+} sensors was 6.0 × 10^{-8} M [75-83].

The highest sensitivity was observed in the case of a 1,3,7,9,13,15,19,21-octaazapentacyclooctacosane (penta cyclooctaaza) based Ni^{2+} sensor showing a slope of 30.5 mV dec^{-1} of concentration [81].

The only Pd^{2+} sensor (hexadecylpyridinium cation-based) was designed in the form of both a polymeric membrane electrpode PME (DL = 1.0 × 10^{-6}), and a coated wire electrode (CWE) (DL = 5.0 × 10^{-8}). This sensor showed a good selectivity behavior and sufered interferences only from Pt^{2+} [84].

The detection limits of the Co^{2+} sensors which were based on 18-membered macrocyclic diamide [85], (2-mercapto-4-methylphenyl)-2-benzamido-3-phenyl-thiopropenoate [86], dibenzopyridino-substituted macrocyclic diamide 5-((4-nitrophenyl)azo)-N-(2',4'-dimethoxy phenyl) salicylaldimine [88] and oxime of 1-(2-oxocyclohexyl)-1,2-cyclohexanediol [87] as the ionophores were in the range of 10^{-7}-10^{-6} M and they showed almost Nernstian potential slopes [85-89].

Numerous Cu^{2+} sensors have been constructed by Iranian scientists including CGEs [94,98], CWEs [99,104,111], sol-gel electrode [105] and mostly PMEs [90-112]. Almost all of these sensors have Nernstian behaviors and the minimum detection limit is reported in the case of a 2-{1-(E)-2-((Z)-2-{(E)-2-[(Z)-1-(2-hydroxyphenyl) ethylidene] hydrazono}-1-methylpropylidene) hydrazono]ethyl}phenol based PME [110].

A large number of Ag^{+} sensors based on hexathia-18-crown-6 [113], mixed aza-thioether crowns containing a 1,10-phenanthroline sub-unit, 2-mercaptobenzimidazole [114,115], 2-mercaptobenzothiazole [116], 2,c-8,c-14,c-20-tetrabutyl-4,6,10, 12,16,18,22,24-octaacetyl-resorc[4]arene [117], thia-substituted macrocyclic diamide [118], C-methylcalix[4]resorcareneocta-methyl ester [119], methyl-2-pyridyl ketone oxime [120], phenyl-2-pyridyl ketone oxime [120] and bis[2-(*o*-carboxythiophenoxy) methyl]-4-bromo-1-methoxybenzene [120], octahydroxycalix [4]arene derivative meso-tetraphenylporphine [H2T(4-OCH_3)PP] [121,122], 2-[(2-{2-[(2-carboxyphenyl)sulfanyl]ethoxy} ethyl) sulfanyl] benzoic acid [123], N,N'-bis(2-thienylmethylene)-1,2-diaminobenzene [124], cone shaped calix[4]arene [125], 2-methyl-2,4-di(2-thienyl)-2,3-dihydro-1H-1,5-benzodiazepine [126], [bis 5-(4-nitrophenyl azo) salisylaldimine]-1,8-diamino [127], 3,6-dioxooctane have been constructed [113-127]. The major interferences in the case of these sensors are caused by Tl^{+}, K^{+}, Na^{+}, NH_4^{+}, Pb^{2+}, Cu^{2+}, Hg^{2+}, Fe^{3+}, and the minimum detection limit among the is reported to be around 1.2 × 10^{-8} [123].

Cryptand $C2_B22$ [128], 1,13-diaza-2,3;11,12;15,18-tribenzo-4,7,10-trioxacyclononaoctane-14,19-dione [129], 5,6,14,15-dibenzo-1,4-dioxa-8,12-diazacyclopentadecane-5,14-diene [130], tetra(2-aminophenyl) porphyrin [131], bis(2-nitrophenyl) disulfide [132], 3-[(2-furylmethylene)amino]-2-thioxo-1,3-thiazolidin-4-one [133] and 5,6-benzo-4,7,13,16,21, 24-hexaoxa-1,10-diazabicyclo[8,8,8]hexacos-5-ene [134] have been used in the construction of PMEs for Zn^{2+} ions [128-134], three of which showed sub-Nerstian responses [128,130,131]. The lowest detection limit reported for a Zn^{2+} sensor was 2 × 10^{-7} M [132].

Other transition metal ion selective electrodes include [1,1'-bicyclohexyl]-1,1',2,2'-tetrol [135], tetrathia-12-crown-4 [136], 5-[((4-methylphenyl)azo)-N-(6-amino-2-pyridin) salicylaldimine] [137] and 5-[((4-methylphenyl)azo)-N-(2-diamino-2-cyano-1-ethyl cyanide) salicylaldehyde] [137], and N'-[1-(2-furyl)methylidene]-2-furohydrazide based PMEs for Cd^{2+} [135-138] and Hg^{2+} ions [139-143].

There have also been several reports by Iranian researchers on ion selective sensors for lanthanide and actinide ions including 14 La^{3+} sensors that are mostly PMEs [144-157]. The reports also encompass 1,3,5-trithiane, N-[(Z)-2-chloro-2-(1-hydroxy-1,1,1-triphenyl phosphoranyl)-1-ethenyl]-4-ethyl-1-benzene sulfonamide, 2-aminobenzothiazole, N′-[(2-hydroxyphenyl)methylidene]-2-furohydrazide based cerium sensors [158-162].

Only Pr^{3+} sensor based on N'-(pyridin-2-ylmethylene) benzohydrazide, sensor with a slope of 21.1 mV dec^{-1} of concentration and a detection limit of 8.0 × 10^{-7} M has been developed, the major interfeing ions of which are Er^{3+}, Sm^{3+} [163].

The other sensors in this group include Nd^{3+} PMEs [164-166], with major interfering ions of Yb^{3+}, Ce^{3+}, Gd^{3+}, La^{3+}, Sm^{3+}, and the minimum detection limit of 7.9 × 10^{-7}. There have also been reports on Sm^{3+} sensors based on ionophores with N, and S donor atoms like the other lanthanide and transition metal ion sensors. These Sm^{3+} sensors [167-170], are mostly CGEs and PMEs and the minimum detection limit is reported to be 8.0 ×10^{-11} M [170].

Other sensors include Eu^{3+} [171,172], Gd^{3+} [173-176], Tb^{3+} [177,178], Dy^{3+} [179,180], Ho^{3+} [181,182], Er^{3+} [183], Tm^{3+} [184,185], Yb^{3+} [186-188] PMEs, in addition to one Lu^{3+} PME [189] and two uranyl PMEs and GCE [190,191]. The minimum detection limit among all of these sensors is reported to be 7.0 × 10^{-8} for uranyl ion [191], which is a 2,2'-[1,2-ethandiylbis (nitriloethylidene)]bis(1-naphthalene) based UO_2^{2+} polymeric membrane sensor with a composition of PVC:dioctylphthalatesionophore:sodium tetraphenylborate percent ratio of 30.5:63.5:4.0:2.0.

ANION SELECTIVE ELECTRODES

Anion selective electrodes, just like cation selective ones, are an important group of ion selective electrodes. The number of an ion selective electrodes is lower than that of the cationic sensors, due to reasons like the relative larger size of anions, their various shapes, and their high hydration energies; however, there have been a relatively large number of sensors for anionic species by Iranian researchers during the past decade.

NO_3^- CWE and PMEs [192-194] and NO_2^- CGE and PMEs [195-197] have been designed, which overally, suffer from ClO_4^-, ClO_3^-, salicylate, I^-, and SCN^- interferences. The lowest detection limit among these sensors belongs to a derivative of (tetraphenylporphyrinato)cobalt(III) acetate based CGE and is about 2.0 × 10^{-8} M [195].

The HPO_4^{2-} sensors that have been reported were based on vanadyl [198,199] and molybdenum [200,201] complexes and showed almost Nernstian potential slopes.

There have been quite a lot reports on PMEs [202-217] and a few CGEs [208,212] for SCN^- ion. Thses sensors have been based on different complexes, as well as 1,8-dibenzyl-1,3,6,8,10,13-hexaazacyclotetradecane [210]. The major interfering ions include I^-, Br^-, Cl^-, SCN^-, ClO_4^-, salicylate, MnO_4^-, and the least dection limit was reported to be 4.8 ×10^{-8} M [208]. SO_4^{2-} sensors have also been reported based on different complexes of zinc [218,223,224] and nickel [219-222,225-229], and also some pyrylium derivatives [219-221,225-229]. The minimum detection limit was found to be in the range of 1.0 × 10^{-8}. However, the best sensor for this anion was reported to have a composition of 30% PVC, 61% Nitophenyloctyl ether, 5% ionophore, 4% Hexadecyl-trimethylammonium bromide [225].

Sensors for the lipophilic ClO_4^- have also been constructed based on Ni(II)-hexaazacyclotetradecane [230], phosphorus(V)-tetraphenylporphyrin [231], cobaloxime [232], 1,3,5,8,10,13-hexa-azacyclotetradecane [233], 1,8-tert-butyl-1,3,5,8,10,13-hexa-azacyclotetradecane [233], and two nickel-hexaazamacrocycles [234]. The only Cl^- sensor was based on a thalium(III) Schiff's base [245] with no considerable interferences, which had a detection limit of 2.0 × 10^{-6} M. The other halogen sensors include Br^- ion PMEs [246-248], based on 14-phenyldibenzo[a]xantheniumbromide [236], bis(4-hydroxyphenyl)-1,4-diaza-1,3-butadiene-Hg(II) [237], iron(III)-salen [238], which suffer interferences only from NO_3^-, Cl^-, I^-, SCN^-. Iodine sensors were more in number [249-248], and have been mostly PMEs, although they include some CGEs. The sensors had detection limits in the range of 10^{-7}-10^{-5} M, the lowest among which was reported to be 3 × 10^{-7} M [248].

There have been reports on triodide anion, based on 2,4,6,8-tetraphenyl-2,4,6,8-tetraazabicyclo[3.3.0]octane [249], tetra(*p*-chlorophenyl) porphyrinatomanganese(III) acetate [250], ketoconazole-triiodide ion pair [251], charge-transfer complexes and amino crown ether [252], complexes of Schiff base 2,2'[4,4'-diphenylmethane bis(nitromethylidyne)] bisphenol [253], iodine charge-transfer complex and bis(2-hydroxyacetophenone)butane-2,3-dihydrazone [254], 7,16-dibenzyl-1,4,10,13-tetraoxa-7,16-diazacyclooctadecane [255], mercury-salen [256], copper (II)-Schiff base [257], charge-transfer complex of bis(2,4-dimethoxybenzaldehyde)butane-2,3-dihydrazone with iodine, 2-(((2-(((E)-1-(2-hydroxyphenyl) methylidine) amino) phenyl) imino) methyl) phenol [258,259], N,N'-1,2-propylene-bis-(5-methyl salicylidene iminato) copper [260], bis(2-hydroxybenzophenone) butane-2,3-dihydrazone as the ionophores.

There have also been some reports on CrO_4^{2-} CWEs based on nickel, cobalt, manganese, copper, zinc, and rhodium bis(acetylacetonato)copper(II) [262], bis(acetylacetonato) cadmium(II) [263], witrh detection limits of about 1.0 × 10^{-6} and interferences only from I^- and ClO_4^-. The only MoO_4^{2-} sensor was based on cerium phosphate [264]. In Table 2 are

Table 2. Anionic Sensors Published by the Iranian Researchers in the Past Decade

Anion	Ionophore	Slope	LR (M)	DL (M)	Anion with $\log K_{Sel} > -2$	TS	Ref.
NO_3^--1	Bis(2-hydroxyanil)acetylacetone lead(II)	-58.8	2.0×10^{-5}-1.0×10^{-1}	1.0×10^{-6}	ClO_4^-, ClO_3^-, Salicylate	PME	[192]
NO_3^--2	Bis(2-hydroxyacetophenone) ethylenedimine vanadyl(IV)	-58.5	5.0×10^{-6}-1	1.0×10^{-6}	Salicylate, I, SCN^-	PME	[193]
NO_3^--3	Tetramethyl cyclotetra-decanato-nickel(II) complex	-57.8	10^{-5}-1	5.0×10^{-6}	ClO_4^-, SCN^-, I^-	CWE	[194]
NO_2^--1	Derivatives of (Tetraphenylporphyrinato) cobalt(III) acetate	-60.3 -60.3	10^{-6}-10^{-1} 5.0×10^{-8}-5.0×10^{-2}	8.0×10^{-7} 2.0×10^{-8}	SCN^-	PME CGE	[195]
NO_2^--2	Cobalt(II)-salen	-58.2	10^{-6}-10^{-1}	5.0×10^{-7}	-	PME	[196]
NO_2^--3	Cobalt(II) salophen	-59.8	10^{-6}-10^{-1}	8.0×10^{-7}	-	PME	[197]
HPO_4^{2-}-1	Vanadyl salophen	-24.3	10^{-6}-10^{-1}	5.0×10^{-7}	-	PME	[198]
HPO_4^{2-}-2	Vanadyl salen	-28.8	5.0×10^{-6}-10^{-1}	3.0×10^{-6}	-	PME	[199]
HPO_4^{2-}-3	Molybdenum bis(2-hydroxyanil) acetylacetonate	-29.5	10^{-7}-10^{-1}	6.0×10^{-8}	-	PME	[200]
HPO_4^{2-}-4	Oxo-molybdenum methyl-salen	-28.6	4.0×10^{-7}-10^{-1}	2.0×10^{-7}	-	PME	[201]
SCN^--1	(Octabromotetraphenyl porphyrinato)manganese(III) chloride	-58.3	4.8×10^{-7}-1	3.2×10^{-7}	N_3^-, I^-, Br^-	PME	[202]
SCN^--2	Nickel and iron phthalocyanines	-58.4	5.0×10^{-7}-10^{-1}	5.0×10^{-7}	SCN^-, ClO_4^-, I^-	CGE	[203]
SCN^--3	Cobalt and manganese phthalocyanine	-59.0	10^{-6}-10^{-1}	5.0×10^{-7}	I^-, CN^-	CGE	[204]
SCN^--4	Copper-1,8-dimethyl-1,3,6,8,10, 13-azacyclotetradecane	57.2	7.0×10^{-6}-10^{-1}	4.0×10^{-6}	ClO_4^-, CN^-	PME	[205]
SCN^--5	Manganese porphyrin derivatives	59.5	5.0×10^{-7}-10^{-1}	5.0×10^{-8}	SCN^-, ClO_4^-, Salicylate	PME	[206]
SCN^--6	Cadmium salen	59.1	10^{-6} -10^{-1}	7.0×10^{-7}	MnO_4^-, I^-	PME	[207]
SCN^--7	Nickel(II)-azamacrocycle complex	-57.8	10^{-7}-10^{-1}	4.8×10^{-8}	-	CGE	[208]
SCN^--8	Unsymmetrical benzo N(4) nickel(H) macrocyclic complexes	-59.7	1.4×10^{-7}-10^{-1}	1.4×10^{-7}	SCN^-, ClO_4^-, I^-	PME	[209]
SCN^--9	1,8-Dibenzyl-1,3,6,8,10,13-hexa-azacyclotetradecane	-58.4	3.3×10^{-6}-10^{-1}	3.0×10^{-6}	-	PME	[210]
SCN^--10	Bis(2-mercaptobenzoxazolato) mercury(II) and bis(2-pyridinethiolato)mercury(II)	-60.6 -57.5	10^{-6}-10^{-1}	6.0×10^{-7}	ClO_4^-, Cl^-	PME	[211]

Table 2. Continued

SCN^--11	Cu(L)](NO$_3$)(2) (L = 4,7-bis(3-aminopropyl)-1-thia-4,7-diaza-cyclononane)	-57.6 -58.8	10^{-6}-10^{-1} 5.0×10^{-7}-10^{-2}	8.5×10^{-7} 8.0×10^{-8}	ClO_4^-, I^-, Salicylate	PME CGE	[212]
SCN^--12	2,2-[(1,3-Dimethyl-1,3-propanediylidene)dinitrilo]bis-benzenethiolato cadmium(II)	-58.9	10^{-6}-10^{-1}	5.0×10^{-7}	MnO_4^-, ClO_4^-, Br^-	PME	[213]
SCN^--13	Butane-2,3-dione bis(salicyl-hydrazonato)zinc(II)	-56.5	10^{-6}-10^{-1}	7.0×10^{-7}	ClO_4^-	PME	[214]
SCN^--14	Rh(III) complex	-58.7	10^{-5}-10^{-1}	4.0×10^{-6}	ClO_4^-	PME	[215
SCN^--15	Rhodium(II) phthalocyanine	-56.3	10^{-6}-10^{-1}	7.9×10^{-7}	ClO_4^-, Salicylate, I^-	PME	[216]
SCN^--16	Nickel(II)-1,4-,8,11,15,18,22,25-octabutoxyphthalocyanine	-58.7	10^{-6}-10^{-1}	5.7×10^{-7}	-	PME	[217]
SO_4^{2-}-1	Complex of Zn(II)	-29.7 -29.3	5.0×10^{-5}-10^{-1} 10^{-7}-10^{-1}	2.8×10^{-5} 8.5×10^{-8}	SCN^-, ClO_4^-	PME CGE	[218]
SO_4^{2-}-2	2,6-Dianisol-4-phenyl-pyrilium perchlorate	-28.8	10^{-6}- 10^{-1}	8.0×10^{-7}	SO_3^{2-}, NO_3^-	PME	[219]
SO_4^{2-}-3	Pyrilium perchlorate derivative	-28.9	10^{-6}-10^{-1}	8.0×10^{-7}	SO_3^{2-}, Br^-, SCN^-	PME	[220]
SO_4^{2-}-4	2,5-Diphenyl-1,2,4,5-tetraaza-bicyclo[2.2.1]heptane	-28.8	9.0×10^{-6}-10^{-1}	7.0×10^{-6}	SO_3^{2-}, I^-	PME	[221]
SO_4^{2-}-5	Strontium Schiff's base	-29.2	10^{-6}-10^{-2}	5.0×10^{-7}	SO_3^{2-}, CO_3^{2-}, Cl^-	PME	[222]
SO_4^{2-}-6	Zinc-phthalocyanine	-29.2	10^{-6}-10^{-2}	8.0×10^{-7}	SO_3^{2-}, CH_3COO^-	PME	[223]
SO_4^{2-}-7	Zinc-Schiff base	-29.2	10^{-6}-10^{-2}	9.0×10^{-7}	-	PME	[224]
SO_4^{2-}-8	Bis-pyrylium derivative	-29.5	10^{-7}-10^{-1}	5.0×10^{-8}	-	PME	[225]
SO_4^{2-}-9	2,6-Diphenylpyrylium fluoroborate	-29.5	5.0×10^{-6}-10^{-1}	3.0×10^{-6}	SO_3^{2-}, Cl^-	PME	[226]
SO_4^{2-}-10	1,3,5-Triphenylpyrylium perchlorate	-29.7	6.3×10^{-6}- 10^{-1}	4.0×10^{-6}	ClO_4^-, F^-, HPO_4^{2-}	PME	[227]
SO_4^{2-}-11	2,6-Diphenyl 4-(4-methoxy-phenyl) pyrylium perchlorate	-29.7	8.0×10^{-7}-10^{-1}	4.0×10^{-7}	-	PME	[228]
SO_4^{2-}-12	N,N'-Bis(2-amino-1-oxo-phenelenyl)phenylenediamine copper(II)	-29.5	10^{-7}-10^{-1}	1.0×10^{-8}	CH_3COO^-, $S_2O_3^{2-}$, SCN^-	PME	[229]
ClO_4^--1	Ni(II)-hexaazacyclotetradecane	N	5.0×10^{-7}-10^{-1}	2.0×10^{-7}	MnO_4^-, SCN^-	PME	[230]
ClO_4^--2	Phosphorus(V)-tetraphenyl-porphyrin	-57.8 -53.6	8.0×10^{-6}-1.6×10^{-1} 10^{-6}-3.0×10^{-2}	5.0×10^{-6} 7.0×10^{-7}	I^-, SCN^-, CH_3COO^-	PME CGE	[231]

Table 2. Continued

ClO_4^--3	Cobaloxime	-56.8	$10^{-6}-10^{-1}$	8.3×10^{-7}	HPO_4^{2-}, SO_4^{2-}, SCN^-	PME	[232]
ClO_4^--4	1,3,5,8,10,13-Hexaazacyclotetradecane and 1,8-tert-butyl-1,3,5,8,10,13-hexaazacyclotetradecane	-59.1 -59.5	$9.0\times10^{-7}-10^{-1}$ $5.0\times10^{-7}-10^{-1}$	5.0×10^{-6} 7.0×10^{-7}	SCN^-, MnO_4^-, IO_4^-	PME	[233]
ClO_4^--5	Two nickel-hexaazamacrocycles	-60.6	$10^{-6}-1$	8.0×10^{-7}	F^-, Cl^-, NO_2^-	PME	[234]
Cl^-	Ruthenium(III) Schiff's base	-29.5	$3.0\times10^{-5}-10^{-1}$	2.0×10^{-6}	-	PME	[235]
Br^--1	14-Phenyldibenzo[a]xanthenium bromide	-61.1	$3.2\times10^{-5}-10^{-1}$	2.0×10^{-5}	NO_3^-, Cl^-, I^-	PME	[236]
Br^--2	Bis(4-hydroxyphenyl)-1,4-diaza-1,3-butadiene-Hg(II)	-59.1	$10^{-5}-10^{-1}$	5.0×10^{-6}	-	PME	[237]
Br^--3	Iron(III)-salen	-59.0	$7.0\times10^{-6}-10^{-1}$	6.0×10^{-6}	SCN^-, I^-, Cl^-	PME	[238]
I^--1	Mn(II)-salen	-59.0	$3.4\times10^{-5}-10^{-1}$	1.0×10^{-5}	CN^-	PME	[239]
I^--2	Fe(III) Schiff base	-71.0	$10^{-6}-5.0\times10^{-1}$	6.5×10^{-7}	SCN^-, F^-, NO_2^-	CPE	[240]
I^--3	Copper phthalocyanine	57.1	$5.0\times10^{-6}-10^{-1}$	1.0×10^{-6}	SCN^-, ClO_4^-	CGE	[241]
I^--4	Thiopyrilium ion derivative	-60.2	$8.0\times10^{-7}-10^{-1}$	2.0×10^{-7}	SCN^-, CN^-	PME	[242]
I^--5	Cerium salen-based	-57.5	$8.0\times10^{-6}-5.0\times10^{-2}$	6.0×10^{-6}	SCN^-	PME	[243]
I^--6	Bis(2-mercaptobenzothiazolato) mercury(II)/bis(4-chlorothiophenolato) mercury(II)	-57.6 -58.4	$10^{-6}-10^{-1}$	6.0×10^{-7} 4.0×10^{-7}	SCN^-, Br^-, ClO_4^-	PME	[244]
I^--7	Titanium acetylacetonate-based	-59.1	$5.0\times10^{-6}-10^{-1}$	3.0×10^{-6}	SCN^-, Cl^-	PME	[245]
I^--8	[Tetrakis(4-N,N-dimethylamino-benzene)porphyrinato]-manganese(III) acetate	-59.4	$7.5\times10^{-6}-10^{-2}$	5.0×10^{-6}	Salicylate, SCN^-, ClO_4^-	PME	[246]
I^--9	Bis[N-(2-methyl-phenyl)-4-nitro-thiobenzamidato]mercury(II)/bis[N-phenyl -3,5-dinitro-thiobenzamidato] mercury(II)	-59.6 -58.9	$7.0\times10^{-7}-10^{-1}$ $10^{-6}-10^{-1}$	3.0×10^{-7} 7.0×10^{-7}	SCN^-, ClO_4^-	PME	[247]
I^--10	Cobalt salophen	-58.9	$5.0\times10^{-7}-10^{-1}$	3.0×10^{-7}	-	PME	[248]
I_3^--1	2,4,6,8-Tetraphenyl-2,4,6,8-tetraaza-bicyclo[3.3.0]octane	-54.7	$3.5\times10^{-6}-5.0\times10^{-2}$	2.0×10^{-6}	-	PME	[249]
I_3^--2	Tetra(*p*-chlorophenyl)porphyrinato manganese(III) acetate	-59.6	$7.0\times10^{-6}-10^{-2}$	5.0×10^{-6}	I^-, ClO_4^-	PME	[250]
I_3^--3	Ketoconazole-triiodide ion pair	-59.9	$7.0\times10^{-6}-2.0\times10^{-3}$	3.0×10^{-6}	SCN^-, IO_3^-, NO_2^-	PME	[251]
I_3^--4	Charge-transfer complexes and amino crown ether	-59.0	$10^{-5}-10^{-1}$	1.0×10^{-6}	-	PME	[252]

Table 2. Continued

I_3^--5	Two complexes of Schiff base 2,2'-[4,4'-diphenylmethane bis (nitromethylidyne)] bisphenol	-60.0	8.0×10^{-6}-6.0×10^{-1} 10^{-5}-5.0×10^{-1}	4.0×10^{-6} 6.0×10^{-6}	SCN^-, Salicylate	PME	[253]
I_3^--6	Iodine charge-transfer complex with bis(2-hydroxyaceto-phenone) butane-2,3-dihydrazone	-59.0	5.0×10^{-7}-10^{-2}	3.0×10^{-7}	-	PME	[254]
I_3^--7	7,16-Dibenzyl-1,4,10,13-tetraoxa-7,16-diazacyclooctadecane	-59.3	10^{-5}-10^{-1}	6.3×10^{-6}	-	PME	[255]
I_3^--8	Mercury-salen	-59.0	5.0×10^{-5}-10^{-2}	2.0×10^{-5}	-	PME	[256]
I_3^--9	Copper(II)-Schiff base	-57.0	10^{-5}-10^{-1}	4.8×10^{-6}	I^-	CGE	[257]
I_3^--10	Charge-transfer complex of bis(2,4-dimethoxybenzaldehyde) butane-2,3-dihydrazone with iodine	60.6	10^{-7}-10^{-2}	6.3×10^{-8}	-	PME	[258]
I_3^--11	2-(((2-(((E)-1-(2-Hydroxyphenyl) methylidine) amino) phenyl) imino) methyl) phenol	-59.0	5.0×10^{-8}-10^{-2}	3.0×10^{-8}	-	PME	[259]
I_3^--12	N,N'-1,2-Propylene-bis-(5-methyl salicylidene iminato) copper	-61.4	4.0×10^{-5}-7.0×10^{-1}	1.0×10^{-5}	I^-, SCN^-, ClO_4^-	PME	[260]
I_3^--13	Bis(2-hydroxybenzophenone) butane-2,3-dihydrazone	-59.3	10^{-7}-10^{-1}	7.0×10^{-8}	-	PME	[261]
CrO_4^{2-}-1	Bis(acetylacetonato)copper(II)	-29.4 -29.2	5.0×10^{-6}-10^{-1}	1.0×10^{-6}	I^-, ClO_4^-	CWE	[262]
CrO_4^{2-}-2	Bis(acetylacetonato) cadmium(II)	-28.8	2.5×10^{-6}-10^{-1}	1.0×10^{-6}	I^-, ClO_4^-	CWE	[263]
MoO_4^{2-}	Cerium phosphate	-29.0	1.98×10^{-5}-10^{-1}	1.0×10^{-5}	SCN^-, ClO_4^-	PME	[264]

summarized information on different anionic sensors reported over the last decade. Normally the detection limits of these sensors have been in the range of 10^{-7}-10^{-6} M. The lowest detection limit reported up to now is about 1.0×10^{-8} M [229].

SELECTIVE ELECTRODES FOR DRUGS AND ORGANIC SPECIES

There have been plenty of PMEs, CGEs, and CWEs for organic species and drugs which have been summarized in Table 3.

Histamine [265], histidine [266], imidazole [267,268], ketamine [269], ascorbic acid [270], oxalate [271], triamterene [272], naphazoline [273], valproate [274], cystein [275], theophiline [276], sulfosalicylic acid [277], thiosalicylic acid [278], salicylate [279,280], ketoconazole [281], clotrimazole [282], cimetidine [283], diclofenac [284], atenolol [285], picrate [286], linear alkylbenzene sulfonate [287,288], sodium dodecylsulfate [289-291], dodecylbenzene sulfonate [292] aresepecies the sensors of which have been introduced by Iranian researchers.

Almost all of the developed sensors have proven to show Nernstian responses and relatively low detection limits, and good selectivity behaviors. As it is seen from Table 3, these sensors were based on ionophores like different complexes of iron(III) [265], iron(II) [270], copper(II) [271], zirconyl(IV) [277], nickel(II) [279], tin(IV) [280], lead(II) [275], aluminum(III) [278] and manganese(III) [265], 2,4,6-

Table 3. Organic Molecule and Drug Sensors Published by the Iranian Researchers in the Past Decade

Drug	Ionophore	Slope	LR	DL	$\log K_{Sel} > -2$	TS	Ref.
Histamine	Iron(III) and manganese(III) tetraphenyl-porphyrins	56.0	10^{-6}-10^{-1}	5.0×10^{-7}	N_3^-, SCN^-, Imidazole	PME	[265]
Histidine	Chloro(5,10,15,20-tetra-phenylporphyrinato) anganese(III)	-55.4	10^{-5}-10^{-1}	5.0×10^{-6}	L-Histidine	PME	[266]
Imidazole-1	2,4,6-Triphenyl thiopyrilium perchlorate	33.5	10^{-5}-10^{-1}	3.0×10^{-6}	Histamine, L-Histidin	PME	[267]
Imidazole-2	4-Methyl-2,6-diphenylthio-pyrylium	36.2	10^{-5}-10^{-1}	2.0×10^{-6}	L-Histidine, SCN^-	PME	[268]
Ketamine	Ion-exchanger sites	59.0	10^{-5}-10^{-1}	5.0×10^{-6}	Propranolol, Naphazoline, Atropine	PME	[269]
Ascorbic acid	Iron(II) phthalocyanine	58.0	10^{-6}-10^{-2}	5.0×10^{-7}	-	CPE	[270]
Oxalate	2,2'-[1,4-Butandiyle bis(nitrilopropylidine)]bis-1-naphtholato copper(II)	-29.2	5.0×10^{-8}-10^{-1}	5.0×10^{-8}	ClO_4^-, CH_3COO^-, PO_4^{3-}	PME	[271]
Triamterene	Tetraphenylborate ion	57.1	10^{-6}-3.5×10^{-2}	5.8×10^{-7}	Chlordiazepoxide, Primidone, Hydrochloro-thiazide	CWE	[272]
Naphazoline	Tetraphenylborate	58.4 57.0	10^{-5}-5.0×10^{-2}/ 5.0×10^{-6}-5.0×10^{-2}	5.0×10^{-6} 4.0×10^{-6}	Phenylephrine, Betaxolol	PME/ CGE	[273]
Valproate	Conducting polypyrrole films	35.8-47.7	4.0×10^{-5}-4.0×10^{-2}	1.0×10^{-5}	$PhCOO^-$, CH_3COO^-	SSE	[274]
Cystein	Lead phthalocyanine	N	10^{-6}-5.0×10^{-2}	1.0×10^{-6}	-	CGE	[275]
Theophiline	2,6-Bis(phenyl)-4(phenyl)-3H-thiopyran	54.5	10^{-6}-10^{-2}	5.5×10^{-7}	Caffeine, Imidazole, Histidine	PME	[276]
Sulfo-salicylic acid	Zirconyl(IV) phthalocyanine	-29.3	10^{-6}-10^{-1}	8.9×10^{-7}	ClO_4^-, SCN^-, Salicylate	PME	[277]
Thio-salicylic acid	Phthalocyanine complexes of aluminum, nickel and copper	-49.9 -59.5 -60.2	10^{-5}-10^{-2} 10^{-5}- 10^{-2} 10^{-6}-10^{-2}	3.5×10^{-6} 1.0×10^{-6} 1.0×10^{-6}	SCN^-, ClO_4^-, Salicylate	PME	[278]
Salicylate-1	Bis(trans-cinnamaldehyde) ethylenediimine dibromonickel(II)	59.2	10^{-5}-10^{-1} 10^{-6}-10^{-2}	5.0×10^{-6} 7.0×10^{-7}	ClO_4^-, SCN^-	PME/ CGE	[279]

Table 3. Continued

Salicylate-2	Original tin(IV) complex	58.5	10^{-6}-10^{-1}	8.0×10^{-7}	SCN^{-}	PME	[280]
Ketoconazole	Ketoconazole-tetraphenyl-borate ion pair	72.0	7.1×10^{-6}-6.3×10^{-3}	5.0×10^{-6}	-	PME	[281]
Clotrimazole	Phosphomolybdate	59.0	1.38×10^{-5}-10^{-3}	1.0×10^{-5}	NH_4^+, Glycine	PME	[282]
Cimetidine	Phospohotungstate	58.0	10^{-5}-10^{-2}	5.0×10^{-6}	K, Na, NH_4	PME	[283]
Diclofenac	Hexadecylpyridinium bromide	-59.0	10^{-5}-10^{-2}	4.0×10^{-6}	Na, NO_3^-	PME	[284]
Atenolol	Tetrakis(*p*-chlorophenyl) borate	56.5	3.0×10^{-5}-8.0×10^{-2}	1.0×10^{-5}	K, Na, Urea	PME	[285]
Picrate	CulHglHg-2(Pic)(2)	56.8	2.5×10^{-5}-10^{-2}	1.3×10^{-5}	Cl^{-}, Salicylate, Benzoate	CGE	[286]
Linear alkybenzene-sulfonate-1	Polypyrrole	57.2	3.0×10^{-5}-3.0×10^{-3}	2.0×10^{-5}	Tetradecyl-sulfate, dodecylsulfate	PME	[287]
Linear alkybenzene-sulfonate-2	Polypyrrole and hyamine	59.7 56.8	8.5×10^{-6}-1.3×10^{-3} /5.0×10^{-6}-1.1×10^{-3}	5.6×10^{-6} 2.5×10^{-6}	Tetradecyl-sulfate, dodecylsulfate	CWE	[288]
Sodium dodecyl - sulfate-1	Polyaniline-dodecyle sulfate	59.0	10^{-9}-3.0×10^{-6}	1.0×10^{-9}	Dodecyl benzene sulfate	Pt	[289]
Sodium dodecyl - sulfate-2	Polypyrrole	57.5	10^{-5}-7.0×10^{-3}	5.0×10^{-6}	Tetradecyl-sulfonate, dodecylbenzenesulfonate	PME	[290]
Sodium dodecyl-sulfate-3	Cetylpyridinium cation	61.0	10^{-6}-8.3×10^{-3}	6.3×10^{-7}	Dodecylbenzenesulfonate	PME	[291]
Dodecyl benzene-sulfonate	Polyaniline	-59.1	5.0×10^{-6}-4.1×10^{-3}	1.0×10^{-6}	Paratoluene sulfonate	Pt	[292]

triphenylthiopyrilium perchlorate [267], 4-methyl-2,6-diphenylthiopyrylium [268], ion-exchanger sites [269], tetraphenylborate ion [272], tetraphenylborate [273], conducting polypyrrole films [274], 2,6-bis(phenyl)-4(phenyl) 3H-thiopyran [276], phthalocyanine [278], ketoconazole-tetraphenyl borate ion pair [281], phosphomolybdate [282], phospoho tungstate [283], hexadecylpyridinium bromide [284], tetrakis(*p*-chlorophenyl) borate [285], polypyrrole [287,290], and hyamine [288], polyaniline-dodecylsulfate [289], cetylpyridinium cation [291], polyaniline [292], which have different natures and hence different selection mechanisms.

CONCLUSIONS

In the past decade, Iranian researchers have had an exceptional impact in the developmet of the field of ion sensors in the world, both in quantity and quality. Especially, the contribution of Iranian researchers on the design of ion selective electrodes for lanthanide and actinide ions has been substantial.

Statistically speaking, the sensors designed and reported by Iranian scientists reach to more than 12% of the total number of sensors reported globally. This shows the importance of the Iranian scientists on this vital field of research and the prominent influence of these studies on the global trend of developing chemical sensors.

REFERENCES

[1] N. Tavakkoli, M. Shamsipur, Bull. Korean Chem. Soc. 25 (2004) 1474.

[2] M.R. Ganjali, A. Moghimi, G.W. Buchanan, M. Shamsipur, J. Incl. Phenom. Mol. Recog. Chem. 30 (1998) 29.

[3] M. Shamsipur, N. Tavakkoli, E. Eslami, H. Sharghi, Iran. J. Chem. & Chem. Eng. 20 (2001) 53.

[4] A. Khandar, A.L. Shabanov, R. Medzhidi, G.G. Asadov, C.I. Mamedov, J. Anal. Chem. 58 (2003) 183.

[5] M. Shamsipur, K. Alizadeh, M. Hosseini, M.F. Mousavi, M.R. Ganjali, Anal. Lett. 38 (2005) 573.

[6] H. Ashassi-Sorkhabi, T. Rostamikia, A. Shahrisa, A. Banaei, Bull. Electrochem. 17 (2001) 545.

[7] M. Shamsipur, S.Y. Kazemi, H. Sharghi, K. Niknam, Fresen. J. Anal. Chem. 371 (2001) 1104.

[8] M. Arvand-Barmchi, M.F. Mousavi, M.A. Zanjanchi, S. Taghvaei, Anal. Lett. 35 (2002) 767.

[9] M. Arvand-Barmchi, M.F. Mousavi, M.A. Zanjanchi, M. Shamsipur, Sens. Actuators B 96 (2003) 560.

[10] M.R. Ganjali, P. Nourouzi, M. Emami, M. Golmohammadi, A. Moradzadegun, J. Chin. Chem. Soc. 53 (2006) 1209.

[11] M.R. Ganjali, A. Moghimi, M. Shamsipur, Anal. Chem. 70 (1998) 5259.

[12] M. Shamsipur, M.R. Ganjali, A. Rouhollahi, A. Moghimi, Anal. Chim. Acta 434 (2001) 23.

[13] M.R. Ganjali, A. Daftari, M.R. Pourjavid, M.F. Rastegar, A. Moghimi, Main Group Metal Chem. 25 (2002) 669.

[14] M.R. Ganjali, A. Daftari, M. Faal-Rastegar, A. Moghimi, Anal. Sci. 19 (2003) 353.

[15] M.R. Ganjali, A. Daftari, M.F. Rastegar, A. Moghimi, Anal. Lett. 36 (2003) 317.

[16] M.R. Ganjali, M. Rahimi-Nasrabadi, B. Maddah, A. Moghimi, M. Faal-Rastegar, S. Borhany, M. Namazian, Talanta 63 (2004) 899.

[17] M.R. Ganjali, M. Ghorbani, P. Norouzi, A. Daftari, M. Faal-Rastegar, A. Moghimi, Sens. Actuators B 100 (2004) 315.

[18] M. Shamsipur, A. Soleymanpour, M. Akhond, H. Sharghi, Electroanalysis 16 (2004) 282.

[19] M.R. Ganjali, V. Akbar, P. Norouzi, A. Moghimi, A. Sepehrifard, Electroanalysis 17 (2005) 895.

[20] M. Shamsipur, G. Khayatian, S.Y. Kazemi, K. Niknam, H. Sharghi, J. Incl. Phenom. Mol. Recog. Chem. 40 (2001) 303.

[21] M.R. Ganjali, H.A. Zamani, P. Norouzi, M. Adib, M. Accedy, Acta Chim. Sloven. 52 (2005) 309.

[22] H.A. Zamani, J. Abedini-Torghabeh, M.R. Ganjali, Bull. Korean Chem. Soc. 27 (2006) 835.

[23] M. Shamsipur, S. Rouhani, H. Shaghi, M.R. Ganjali, H. Eshghi, Anal. Chem. 71 (1999) 4938.

[24] M.R. Ganjali, R. Kiani, M. Yousefi, M. Faal-Rastegar, Anal. Lett. 36 (2003) 2123.

[25] H.A. Zamani, J. Abedini-Torghabeh, M.R. Ganjali, Electroanalysis 18 (2006) 888.

[26] M.F. Mousavi, M. Arvand-Barmchi, M.A. Zanjanchi, Electroanalysis 13 (2001) 1125.

[27] A. Abbaspour, A.R. Esmaeilbeig, A.A. Jarrahpour, B. Khajeh, R. Kia, Talanta 58 (2002) 397.

[28] M. Shamsipur, S. Ershad, A. Yari, H. Sharghi, A.R. Salimi, Anal. Sci. 20 (2004) 301.

[29] A. Yari, L. Darvishi, M. Shamsipur, Anal. Chim. Acta 555 (2006) 329.

[30] M.R. Ganjali, M.R. Pourjavid, K. Mouradzadegun, M. Hosseini, F. Mizani, Bull. Korean Chem. Soc. 24 (2003) 1585.

[31] G. Khayatian, S. Shariati, A. Salimi, Bull. Korean Chem. Soc. 24 (2003) 421.

[32] H. Aghaie, A. Giahi, M. Monajjemi, A. Arvand, G.H. Nafissi, M. Aghaie, Sens. Actuators B 107 (2005) 756.

[33] N. Tavakkoli, M. Shamsipur, Anal. Lett. 29 (1996) 2269.

[34] N. Tavakkoli, Z. Khojasteh, H. Sharghi, M. Shamsipur, Anal. Chim. Acta 360 (1998) 203.

[35] A. Rouhollahi, M.R. Ganjali, M. Shamsipur, Talanta 46 (1998) 1341.

[36] M.R. Ganjali, A. Roubollahi, A.R. Mardan, M. Hamzeloo, A. Mogimi, M. Shamsipur, Microchem. J 60 (1998) 122.

[37] H.R. Pouretedal, A. Forghaniha, H. Sharghi, M. Shamsipur, Anal. Lett. 31 (1998) 2591.

[38] A. Abbaspour, F. Tavakol, Anal. Chim. Acta 378 (1999) 145.

[39] M.K. Amini, M. Mazloum, A.A. Ensafi, Fresen. J. Anal. Chem. 364 (1999) 690.

[40] A. Rahmani, M. Barzegar, M. Shamsipur, H. Sharghi, M.F. Mousavi, Anal. Lett. 33 (2000) 2611.

[41] M.F. Mousavi, S. Sahari, N. Alizadeh, M. Shamsipur, Anal. Chim. Acta 414 (2000) 189.

[42] M.R. Fathi, F. Darviche, M.R. Ganjali, Anal. Lett. 33 (2000) 1025.

[43] S. Sadeghi, M. Shamsipur, Anal. Lett. 33 (2000) 17.

[44] M.F. Mousavi, M.B. Barzegar, S. Sahari, Sens. Actuators B 73 (2001) 199.

[45] M. Shamsipur, M.R. Ganjali, A. Rouhollahi, Anal. Sci. 17 (2001) 935.

[46] S. Sadeghi, G.R. Dashti, M. Shamsipur, Sens. Actuators B 81 (2002) 223.

[47] A. Abbaspour, B. Khajeh, Anal. Sci. 18 (2002) 987.

[48] M.R. Ganjali, M. Hosseini, F. Basiripour, M. Javanbakht, O.R. Hashemi, M.F. Rastegar, M. Shamsipur, G.W. Buchanen, Anal. Chim. Acta 464 (2002) 181.

[49] M.M. Ardakany, A.A. Ensafi, H. Naeimi, A. Dastanpour, A. Shamlli, Sens. Actuators B 96 (2003) 441.

[50] S. Riahi, M.F. Mousavi, M. Shamsipur, H. Sharghi, Electroanalysis 15 (2003) 1561.

[51] [51] H. Karami, M.F. Mousavi, M. Shamsipur, Talanta 60 (2003) 775.

[52] [52] M.B. Gholivand, A. Mohammadi, Chem. Anal. 48 (2003) 305.

[53] M.M. Ardakany, A.A. Ensafi, H. Naeimi, A. Dastanpour, A. Shamlli, Russian J. Electrochem. 39 (2003) 269.

[54] H.R. Pouretedal, M.H. Keshavarz, Asian J. Chem. 16 (2004) 1319.

[55] M.M. Ardakani, H.R. Zare, N. Nasirizadeh, J. Safari, Canadian J. Anal. Sci. Spect. 49 (2004) 226.

[56] M.M. Ardakani, M.K. Kashani, M. Salavati-Niasari, A.A. Ensafi, Sens. Actuators B 107 (2005) 438.

[57] M. Barzegar, M.F. Mousavi, H. Khajehsharifi, M. Shamsipur, H. Sharghi, IEEE Sens. J. 5 (2005) 392.

[58] H.R. Zare, M.M. Ardakani, N. Nasirizadeh, J. Safari, Bull. Korean Chem. Soc. 26 (2005) 51.

[59] M.M. Ardakani, P. Pourhakak, M. Salavati-Niasari, Anal. Sci. 22 (2006) 865.

[60] M.R. Ganjali, A. Daftari, P. Nourozi, M. Salavati-Niasari, Anal. Lett. 36 (2003) 1511.

[61] A. Akbari, M.F. Mousavi, M. Shamsipur, M.S. Rahmanifar, Talanta 60 (2003) 853.

[62] H. Karami, M.F. Mousavi, M. Shamsipur, Anal. Chim. Acta 481 (2003) 213.

[63] M. Moghimi, M.A. Bagherinia, M. Arvand, M.A. Zanjanchi, Anal. Chim. Acta 527 (2004) 169.

[64] A. Akbari, M.F. Mousavi, M.S. Rahmanifar, M. Barzegar, Anal. Lett. 37 (2004) 203.

[65] A. Abbaspour, A. Izadyar, Talanta 53 (2001) 1009.

[66] M.R. Ganjali, M. Emami, M. Salavati-Niasari, M. Yousefi, Anal. Lett. 36 (2003) 2735.

[67] M.B. Gholivand, F. Sharifpour, Talanta 60 (2003) 707.

[68] M.R. Ganjali, F. Mizani, M. Salavati-Niasari, M. Javanbakht, Anal. Sci. 19 (2003) 235.

[69] M.B. Gholivand, F. Raheedayat, Electroanalysis 16 (2004) 1330.

[70] M. Shamsipur, A. Soleymanpour, M. Akhond, H. Sharghi, M.H. Sarvari, Electroanalysis 17 (2005) 776.

[71] M.R. Ganjali, P. Norouzi, F. Faridbod, M. Ghorbani, M. Adib, Anal. Chim. Acta 569 (2006) 35.

[72] H.A. Zamani, G. Rajabzadeh, M.R. Ganjali, Sens. Actuators B 119 (2006) 41.

[73] A.R. Fakhari, M. Alaghemand, M. Shamsipur, Anal. Lett. 34 (2001) 1097.

[74] M.H. Mashhadizadeh, I.S. Shoaei, N. Monadi, Talanta 64 (2004) 1048.

[75] M. Shamsipur, S.Y. Kazemi, Electroanalysis 12 (2000) 1472.

[76] M.R. Ganjali, S.M. Hosseini, M. Javanbakht, O.R.

Hashemi, Anal. Lett. 33 (2000) 3139.

[77] M.R. Ganjali, M.R. Fathi, H. Rahmani, H. Pirelahi, Electroanalysis 12 (2000) 1138.

[78] M.F. Mousavi, N. Alizadeh, M. Shamsipur, N. Zohari, Sens. Actuators B 66 (2000) 98.

[79] A. Abbaspour, A. Izadyar, Microchem. J. 69 (2001) 7.

[80] M.R. Ganjali, M. Hosseini, M. Salavati-Niasari, T. Poursaberi, M. Shamsipur, M. Javanbakht, O.R. Hashemi, Electroanalysis 14 (2002) 526.

[81] M. Mazloum, M. Salavati-Niasari, M.K. Amini, Sens. Actuators B 82 (2002) 259.

[82] M.H. Mashhadizadeh, I. Sheikhshoaie, S. Saeid-Nia, Sens. Actuators B 94 (2003) 241.

[83] M.H. Mashhadizadeh, A. Momeni, Talanta 59 (2003) 47.

[84] M. Aghamohammadi, N. Alizadeh, Anal. Chim. Acta 480 (2003) 299.

[85] M. Shamsipur, T. Poursaberi, S. Rouhani, K. Niknam, H. Sharghi, M.R. Ganjali, Anal. Sci. 17 (2001) 1049.

[86] M.H. Mashhadizadeh, A. Momeni, R. Razavi, Anal. Chim. Acta 462 (2002) 245.

[87] M. Shamsipur, S. Rouhani, T. Poursaberi, M.R. Ganjali, H. Sharghi, K. Niknam, Electroanalysis 14 (2002) 729.

[88] M.H. Mashhadizadeh, I. Sheikhshoaie, Anal. Bioanal. Chem. 375 (2003) 708.

[89] M.R. Ganjali, F. Mizani, M. Emami, M. Darjezini, M.R. Darvich, M. Yousefi, Anal. Sci. 20 (2004) 531.

[90] N. Alizadeh, S. Ershad, H. Naeimi, H. Sharghi, M. Shamsipur, Fresen. J. Anal. Chem. 365 (1999) 511.

[91] M. Shamsipur, S. Rouhani, M.R. Ganjali, H. Eshghi, H. Sharghi, Microchem. J. 63 (1999) 202.

[92] T. Poursaberi, L. Hajiagha-Babaei, M. Yousefi, S. Rouhani, M. Shamsipur, M. Kargar-Razi, A. Moghimi, H. Aghabozorg, M.R. Ganjali, Electroanalysis 13 (2001) 1513.

[93] M. Shamsipur, M. Javanbakht, M.F. Mousavi, M.R. Ganjali, V. Lippolis, A. Garau, L. Tei, Talanta 55 (2001) 1047.

[94] M.R. Ganjali, T. Poursaberi, L.H.A. Babaei, S. Rouhani, M. Yousefi, M. Kargar-Razi, A. Moghimi, H. Aghabozorg, M. Shamsipur, Anal. Chim. Acta 440 (2001) 81.

[95] M.B. Gholivand, N. Nozari, Talanta 54 (2001) 597.

[96] M.R. Ganjali, M. Emami, M. Salavati-Niasari, Bull. Korean Chem. Soc. 23 (2002) 1394.

[97] M.H. Mashhadizadeh, A. Mostafavi, R. Razavi, M. Shamsipur, Sens. Actuators B 86 (2002) 222.

[98] M. Shamsipur, A. Avanes, M. Javanbakht, M.R. Ganjali, H. Sharghi, Anal. Sci. 18 (2002) 875.

[99] A.R. Firooz, M. Mazloum, J. Safari, M.K. Amini, Anal. Bioanal. Chem. 372 (2002) 718.

[100] A. Abbaspour, M.A. Kamyabi, Anal. Chim. Acta 455 (2002) 225.

[101] S. Sadeghi, M. Eslahi, M.A. Naseri, H. Naeimi, H. Sharghi, A. Shameli, Electroanalysis 15 (2003) 1327.

[102] M.M. Ardakani, J. safaei-Ghomi, M. Mehdipoor, New J. Chem. 27 (2003) 1140.

[103] M.R. Ganjali, M. Golmohammadi, M. Yousefi, P. Norouzi, M. Salavati-Niasari, M. Javanbakht, Anal. Sci. 19 (2003) 223.

[104] M.M. Ardakani, M. Salavati-Niasari, P. Pourhakkak, Bull. Electrochem. 20 (2004) 213.

[105] M.M. Ardakani, M. Salavati-Niasari, M.K. Kashani, S.M. Ghoreishi, Anal. Bioanal. Chem. 378 (2004) 1659.

[106] H.A. Zamani, G. Rajabzadeh, M.R. Ganjali, S.M. Khatami, Electroanalysis 17 (2005) 2260.

[107] H.A. Zamani, G. Rajabzadeh, A. Firouz, A.A. Ariaii-Rad, J. Brazil. Chem. Soc. 16 (2005) 1061.

[108] M. Akhond, M. Ghaedi, J. Tashkhourian, Bull. Korean Chem. Soc. 26 (2005) 882.

[109] A.R. Fakhari, T.A. Raji, H. Naeimi, Sens. Actuators B 104 (2005) 317.

[110] P. Norouzi, M.R. Ganjali, F. Faridbod, M. Salavati-Niasari, Bull. Korean Chem. Soc. 27 (2006) 1439.

[111] M.M. Ardakani, S.H. Mirhoseini, M. Salavati-Niasari, Acta Chim. Sloven. 53 (2006) 197.

[112] S. Sadeghi, M.T. Vardini, H. Naeimi, Annali Di Chim. 96 (2006) 65.

[113] M.H. Mashhadizadeh, M. Shamsipur, Anal. Chim. Acta 381 (1999) 111.

[114] M. Shamsipur, M. Javanbakht, M.R. Ganjali, M.F. Mousavi, V. Lippolis, A. Garau, Electroanalysis 14 (2002) 1691.

[115] M. Shamsipur, M. Javanbakht, V. Lippolis, A. Garau, D. Filippo, M.R. Ganjali, A. Yari, Anal. Chim. Acta 462 (2002) 225.

[116] M.K. Amini, A. Rafi, I. Mohammadpoor-Baltork, Anal. Lett. 35 (2002) 1795.

[117] M. Mazloum, M. Salavati-Niasari, S.H.M. Chahooki, M.K. Amini, Electroanalysis 14 (2002) 376.

[118] M. Shamsipur, S.Y. Kazemi, K. Niknam, H. Sharghi, Bull. Korean Chem. Soc. 23 (2002) 53.

[119] M. Shamsipur, S. Rouhani, A. Mohajeri, M.R. Ganjali, T. Poursaberi, Chem. Anal. (Warsa) 48 (2003) 947.

[120] M.K. Amini, M. Ghaedi, A. Rafi, I. Mohamadpoor-Baltork, K. Niknam Sens. Actuators B 96 (2003) 669.

[121] M.M. Ardakani, A.A. Ensafi, M. Salavati-Niasari, H. Mirhoseini, Anal. Sci. 19 (2003) 1187.

[122] M.M. Ardakani, H.R. Zare, H. Dehghani, M. Jalayer, Bull. Electrochem. 20 (2004) 385.

[123] A. Abbaspour, A. Izadyar, H. Sharghi, Anal. Chim. Acta 525 (2004) 91.

[124] H.R. Zare, M. Salavati-Niasari, F. Memarzadeh, M. Mazloum, N. Nasirizadeh, Anal. Sci. 20 (2004) 815.

[125] M.R. Ganjali, L.H. Babaei, S. Taghvaei-Ganjali, A. Modjallal, M. Shamsipur, M. Hosseini, M. Javanbakht, Bull. Korean Chem. Soc. 25 (2004) 177.

[126] M.R. Ganjali, P. Norouzi, T. Alizadeh, M. Adib, J. Brazil. Chem. Soc. 17(2006) 1217.

[127] M.H. Mashhadizadeh, A. Mostafavi, H. Allah-Abadi, I. Sheikhshoai, Sen. Actuators B 113 (2006) 930.

[128] [128] H.R. Pouretedal, M. Shamsipur, Fresen. J. Anal. Chem. 362 (1998) 415.

[129] M. Shamsipur, S. Rouhani, M.R. Ganjali, H. Sharghi, H. Eshghi, Sens. Actuators B 59 (1999) 30.

[130] A.R. Fakhari, M. Alaghemand, M. Shamsipur, Anal. Lett. 33 (2000) 2169.

[131] A.R. Fakhari, M. Shamsipur, K. Ghanbari, Anal. Chim. Acta 460 (2002) 177.

[132] M.B. Gholivand, Y. Mozaffari, Talanta 59 (2003) 399.

[133] M.R. Ganjali, H.A. Zamani, P. Norouzi, M. Adib, M. Rezapour, M. Aceedy, Bull. Korean Chem. Sci. 26 (2005) 579.

[134] H.A. Zamani, M.R. Ganjali, M.J. Pooyamanesh, J. Brazil. Chem. Soc. 17 (2006) 149.

[135] M. Javanbakht, A. Shabani-Kia, M.R. Darvich, M.R. Ganjali, M. Shamsipur, Anal. Chim. Acta 408 (2000) 75.

[136] M. Shamsipur, M.H. Mashhadizadeh, Talanta 53 (2001) 1065.

[137] M.H. Mashhadizadeh, I. Sheikhshoaie, S. Saeid-Nia, Electroanalysis 17 (2005) 648.

[138] H.A. Zamani, M.R. Ganjali, M. Adib, Sensor Letters 4 (2006) 345.

[139] A.R. Fakhari, M.R. Ganjali, M. Shamsipur, Anal. Chem. 69 (1997) 3693.

[140] M. Javanbakht, M.R. Ganjali, H. Eshghi, H. Sharghi, M. Shamsipur, Electroanalysis 11 (1999) 81.

[141] M. Mazloum, M.K. Amini, I. Mohammadpoor-Baltork, Sens. Actuators B 63 (2000) 80.

[142] M.H. Mashhadizadeh, I. Sheikhshoaie, Talanta 60 (2003) 73.

[143] M. Bagheri, M.H. Mashhadizadeh, S. Razee, A. Momeni, Electroanalysis 15 (2003) 1824.

[144] M. Shamsipur, M. Yousefi, M. Hosseini, M.R. Ganjali, Anal. Chem. 74 (2002) 5538.

[145] M.R. Ganjali, A. Daftari, M. Rezapour, T. Puorsaberi, S. Haghgoo, Talanta 59 (2003) 613.

[146] M.R. Ganjali, R. Kiani-Anbouhi, M. Shamsipur, T. Poursaberi, M. Salavati-Niasari, Z. Talebpour, M. Emami, Electroanalysis 16 (2004) 1002.

[147] M.R. Ganjali, M. Qomi, A. Daftari, P. Norouzi, M. Salavati-Niasari, M. Rabbani, Sens. Actuators B 98 (2004) 92.

[148] [148] M. Akhond, M.B. Najafi, J. Tashkhourian, Anal. Chim. Acta 531 (2005) 179.

[149] M.R. Ganjali, V. Akbar, M. Ghorbani, P. Norouzi, A. Ahmadi, Anal. Chim. Acta 531 (2005) 185.

[150] M.R. Ganjali, P. Matloobi, M. Ghorbani, P. Norouzi, M. Salavati-Niasari, Bull Korean Chem. Soc. 26 (2005) 38.

[151] M. Shamsipur, S. Ershad, N. Samadi, A.R. Esmaeilbeig, R. Kia, A. Abdolmaleki, Electroanalysis 17 (2005) 1828.

[152] M.R. Ganjali, M.B. Gholivand, M. Rahimi-Nasrabadi, B. Maddah, M. Salavati-Niasari, F. Ahmadi, Sensor Letters 4 (2006) 360.

[153] M.R. Ganjali, P. Norouzi, T. Alizadeh, A. Tadjarodi, Y. Hanifehpour, M. Adib, Electroanalysis 18 (2006) 1091.

[154] M.R. Ganjali, P. Norouzi, L. Shamsolahrari, A. Ahmadi, Sens. Actuators B 114 (2006) 713.

[155] M.R. Ganjali, P. Norouzi, T. Alizadeh, M. Adib, Anal.

Chim. Acta 576 (2006) 275.

[156] M.R. Ganjali, P. Norouzi, N. Yousefian, F. Faridbod, M. Adib, Bull. Korean Chem. Soc. 27 (2006) 1518.

[157] H. A. Zamani, M.R. Ganjali, P. Norouzi, M. Adib, M. Aceedy, Anal. Sci. 22 (2006) 943.

[158] M. Shamsipur, M. Yousefi, M. Hosseini, M.R. Ganjali, Anal. Lett. 34 (2001) 2249.

[159] M. Shamsipur, M. Yousefi, M.R. Ganjali, Anal. Chem. 72 (2000) 2391.

[160] H. Karami, M.F. Mousavi, M. Shamsipur, I. Yavari, A.A. Alizadeh, Anal. Lett. 36 (2003) 1065.

[161] M. Akhond, M.B. Najafi, J. Tashkhourian, Sens. Actuators B 99 (2004) 410.

[162] H.A. Zamani, M.R. Ganjali, M. Adib, Sens. Actuators B 120 (2006) 410.

[163] M.R. Ganjali, F. Mirnaghi, P. Norouzi, M. Adib, Sens. Actuators B 115 (2006) 374.

[164] M. Shamsipur, M. Hosseini, K. Alizadeh, M.F. Mousavi, A. Garau, V. Lippolis, A. Yari, Anal. Chem. 77 (2005) 276.

[165] P. Norouzi, M.R. Ganjali, A. Ahmadalinezhad, M. Adib, J. Brazil. Chem. Soc. 17 (2006) 1309.

[166] [166] M.R. Ganjali, A. Ahmadalinezhad, P. Norouzi, M. Adib, J. Appl. Electrochem. 36 (2006) 931.

[167] [167] M. Shamsipur, M. Hosseini, K. Alizadeh, Z. Talebpour, M.F. Mousavi, M.R. Ganjali, M. Arca, V. Lippolis, Anal. Chem. 75 (2003) 5680.

[168] M. Shamsipur, M. Hosseini, K. Alizadeh, M.M. Eskandari, H. Sharghi, M.F. Mousavi, M.R. Ganjali, Anal. Chim. Acta 486 (2003) 93.

[169] M.R. Ganjali, M.R. Pourjavid, M. Rezapour, S. Haghgoo, Sens. Actuators B 89 (2003) 21.

[170] M.R. Ganjali, M. Rezapour, M.R. Pourjavid, S. Haghgoo, Anal. Sci. 20 (2004) 1007.

[171] M.R. Ganjali, M. Rahimi, B. Maddah, A. Moghimi, S. Borhany, Anal. Sci. 20 (2004) 1427.

[172] M.R. Ganjali, P. Norouzi, A. Daftari, F. Faridbod, M. Salavati-Niasari, Sens. Actuators B 120 (2006) 498.

[173] M.R. Ganjali, M. Emami, M. Rezapour, M. Shamsipur, B. Maddah, M. Salavati-Niasari, M. Hosseini, Z. Talebpoui, Anal. Chim. Acta 495 (2003) 51.

[174] M.R. Ganjali, M. Tahami, M. Shamsipur, T. Poursaberi, S. Haghgoo, M. Hosseini, Electroanalysis 15 (2003) 1038.

[175] M.R. Ganjali, M. Rezapour, P. Norouzi, M. Salavati-Niasari, Electroanalysis 17 (2005) 2032.

[176] M.R. Ganjali, P. Norouzi, T. Alizadeh, A. Tajarodi, Y. Hanifehpour, Sens. Actuators B 120 (2006) 428.

[177] M.R. Ganjali, A. Ghesmi, M. Hosseini, M.R. Pourjavid, M. Rezapour, M. Shamsipur, M. Salavati-Niasari, Sens. Actuators B 105 (2005) 334.

[178] H.A. Zamani, Gh. Rajabzadeh, M.R. Ganjali, J. Braz. Chem. Soc. 17 (2006) 1297.

[179] M.R. Ganjali, J. Ravanshad, M. Hosseini, M. Salavati-Niasari, M.R. Pourjavid, M.R. Baezzat, Electroanalysis 16 (2004) 1771.

[180] M.R. Ganjali, M. Dodangeh, H. Ghorbani, P. Norouzi, M. Adib, Anal. Lett. 39 (2006) 495.

[181] M.R. Ganjali, S. Rasoolipour, M. Rezapour, P. Norouzi, M. Amirnasr, S. Meghdadi, J. Brazil. Chem. Soc. 17 (2006) 1211.

[182] M.R. Ganjali, P. Norouzi, M. Adib, A. Ahmadalinezhad, Anal. Lett. 39 (2006) 1075.

[183] M.R. Ganjali, F. Faridbod, P. Norouzi, M. Adib, Sens. Actuators B 120(2006) 119.

[184] M.R. Ganjali, S. Rasoolipour, M. Rezapour, P. Norouzi, M. Adib, Electrochem. Commun. 7 (2005) 989.

[185] M.R. Ganjali, P. Norouzi, A. Tamaddon, S. Waqif Husain, Bull. Korean Chem. Soc. 27 (2006) 1418.

[186] M.R. Ganjali, L. Naji, T. Poursaberi, M. Shamsipur, S. Haghgoo, Anal. Chim. Acta 475 (2003) 59.

[187] M.R. Ganjali, S. Rasoolipour, M. Rezapour, P. Norouzi, A. Tadjarodi, Y. Hanifehpour, Electroanalysis 17 (2005) 1534.

[188] M.R. Ganjali, P. Norouzi, A. Tamaddon, M. Adib, Sens. Actuators B 114 (2006) 855.

[189] M.R. Ganjali, A. Tamaddon, P. Norouzi, M. Adib, Sens. Actuators B 120 (2006) 194.

[190] M. Shamsipur, A. Soleymanpour, M. Akhond, H. Sharghi, A.R. Massah, Talanta 58 (2002) 237.

[191] M. Shamsipur, M. Saeidi, A. Yari, A. Yaganeh-Faal, M.H. Mashhadizadeh, G. Azimi, H. Naeimi, H. Sharghi, Bull. Korean Chem. Soc. 25 (2004) 629.

[192] A. Asghari, M.K. Amini, H.R. Mansour, M. Salavati-Niasari, M. Rajabi, Anal. Sci. 19 (2003) 1121.

[193] M.M. Ardakani, M. Salavati-Niasari, M. Jamshidpoor,

Sens. Actuators B 101 (2004) 302.
[194] M.M. Ardakani, A. Dastanpour, M. Salavati-Niasari, J. Electroanal. Chem. 568 (2004) 1.
[195] M. Shamsipur, M. Javanbakht, A.R. Hassaninejad, H. Sharghi, M.R. Ganjali, M.F. Mousavi, Electroanalysis 15 (2003) 1251.
[196] M.R. Ganjali, M. Rezapour, M.R. Pourjavid, M. Salavati-Niasari, Anal. Sci. 19 (2003) 1127.
[197] M.R. Ganjali, S. Shirvani-Arani, P. Norouzi, M. Rezapour, M. Salavati-Niasari, Microchim. Acta 146 (2004) 35.
[198] M.R. Ganjali, F. Mizani, M. Salavati-Niasari, Anal. Chim. Acta 481 (2003) 85.
[199] M.R. Ganjali, F. Mizani, M. Emami, M. Salavati-Niasari, M. Shamsipur, M. Yousefi, M. Javanbakht, Electroanalysis 15 (2003) 139.
[200] M.R. Ganjali, P. Norouzi, M. Ghomi, M. Salavati-Niasari, Anal. Chim. Acta 567 (2006) 196.
[201] M.R. Ganjali, P. Norouzi, N. Hatambeygi, M. Salavati-Niasari, J. Braz. Chem. Soc. 17 (2006) 859.
[202] M. Shamsipur, G. Khayatian, S. Tangestaninejad, Electroanalysis 11 (1999) 1340.
[203] M.K. Amini, S. Shahrokhian, S. Tangestaninejad, Anal. Chim. Acta 402 (1999) 137.
[204] M.K. Amini, S. Shahrokhian, S. Tangestaninejad, Anal. Lett. 32 (1999) 2737.
[205] T. Poursaberi, M. Salavati-Niasari, S. Khodabakhsh, L. Hajiagha-Babaei, M. Shamsipur, M. Yousefi, S. Rouhani, M.R. Ganjali, Anal. Lett. 34 (2001) 2621.
[206] J.H. Khorasani, M.K. Amini, H. Motaghi, S. Tangestaninejad, M. Moghadam, Sens. Actuators B 87 (2002) 448.
[207] M.R. Ganjali, T. Poursaberi, F. Basiripour, M. Salavati-Niassari, M. Yousefi, M. Shamsipur, Fresenius J. Anal. Chem. 370 (2001) 1091.
[208] M.R. Ganjali, M. Yousefi, M. Javanbakht, T. Poursaberi, M. Salavati-Niasari, L. Hajiagha-Babaei, E. Latifi, M. Shamsipur, Anal. Sci. 18 (2002) 887.
[209] A. Abbaspour, M.A. Kamyabi, A.R. Esmaeilbeig, R. Kia, Talanta 57 (2002) 859.
[210] M.M. Ardakani, A.A. Ensafi, M. Salavati-Niasari, S.M. Chahooki, Anal. Chim. Acta 462 (2002) 25.
[211] M.K. Amini, A. Rafi, M. Ghaedi, M.H. Habibi, M.M. Zohory, Microchem. J. 75 (2003) 143.
[212] M. Shamsipur, T. Poursaberi, M. Rezapour, M.R. Ganjali, M.F. Mousavi, V. Lippolis, D.R. Montesu, Electroanalysis 16 (2004) 1336.
[213] M.M. Ardakani, M. Salvati-Niassari, A. Sadeghi, New J. Chem. 28 (2004) 595.
[214] M.M. Ardakani, A. Sadeghi, M. Salavati-Niasari, Talanta 66 (2005) 837.
[215] M. Shamsipur, S. Ershad, N. Samadi, A.R. Rezvani, H. Haddadzadeh, Talanta 65 (2005) 991.
[216] S. Shahrokhian, M.J. Jannatrezvani, H. Khajehsharifi, Anal. Lett. 38 (2005) 1221.
[217] H.A. Zamani, F. Malekzadegan, M.R. Ganjali, Anal. Chim. Acta 555 (2006) 336.
[218] M. Shamsipur, M. Yousefi, M. Hosseini, M.R. Ganjali, H. Sharghi, H. Naeimi, Anal. Chem. 73 (2001) 2869.
[219] M.R. Ganjali, F. Mizani, H. Pirelahi, M. Taghizadeh, J. Amani, Canadian J. Anal. Sci. Spect. 47 (2002) 157.
[220] M.R. Ganjali, L. Naji, T. Poursaberi, M. Taghizadeh, H. Pirelahi, M. Yousefi, A. Yeganeh-Faal, M. Shamsipur, Talanta 58 (2002) 359.
[221] M. Shamsipur, M. Yousefi, M.R. Ganjali, T. Poursaberi, M. Faal-Rastgar, Sens. Actuators B 82 (2002) 105.
[222] M.R. Ganjali, P. Norouzi, M. Golmohammadi, F. Mizani, T. Poursaberi, M. Salavati-Niasari, M. Shamsipur, M. Hosseini, M. Javanbakht, Annali Di Chim. 93 (2003) 679.
[223] M.R. Ganjali, M.R. Poujavid, M. Shamsipur, T. Poursaeri, M. Rezapour, M. Javanbakht, H. Sharghi, Anal. Sci. 19 (2003) 995.
[224] M.R. Ganjali, M. Rezapour, M.R. Pourjavid, M. Salavati-Niasari and T. Poursaberi, Anal. Lett. 36 (2003) 881-894.
[225] M.R. Ganjali, S. Shirvani-Arani, P. Nourozi, D. Salimzadeh, M. Faal-Rastegar, A. Moghimi, Electroanalysis 16 (2004) 1009.
[226] M.R. Ganjali, V. Akbar, A. Daftari, P. Norouzi, H. Pirelahi, A. Mouradzadegun, J. Chin. Chem. Soc. 51 (2004) 309.
[227] M.R. Ganjali, M. Ghorbani, A. Daftari, P. Norouzi, H. Pirelahi, H.D. Dargahani, Bull. Korean Chem. Soc. 25 (2004) 172.

[228] M.R. Ganjali, A. Sepehri, A. Daftari, P. Norouzi, H. Pirelahi, A. Moradzadegan, Microchim. Acta 149 (2005) 245.

[229] M.M. Ardakani, Z. Akrami, M. Mansournia, H.R. Zare, Anal. Sci. 22 (2006) 673.

[230] M.R. Ganjali, M. Yousefi, T. Poursaberi, L. Naji, M. Salavati-Niasari, M. Shamsipur, Electroanalysis 15 (2003) 1476.

[231] M. Shamsipur, A. Soleymanpour, M. Akhond, H. Sharghi, A.R. Hasaninejad, Sens. Actuators B 89 (2003) 9.

[232] M.A. Zanjanchi, M. Arvand, M. Akbari, K. Tabatabaeian, G. Zaraei, Sens. Actuators B 113 (2006) 304.

[233] M.R. Ganjali, P. Norouzi, M.Yousefi, L. Naji, M. Salavati-Niasari, Sens. Actuators B 120 (2006) 422.

[234] M.M. Ardakani, M. Jalayer, H. Naeimi, H.R. Zare, L. Moradi, Anal. Bioanal. Chem. 381 (2005) 1186.

[235] M.R. Ganjali, M.R. Pourjavid, M. Rezapour, T. Poursaberi, A. Daftari, M. Salavati-Niasari, Electroanalysis 16 (2004) 922.

[236] M. Shamsipur, S. Rouhani, A. Mohajeri, M.R. Ganjali, P. Rashidi-Ranjbar, Anal. Chim. Acta 418 (2000) 197.

[237] M.R. Ganjali, M. Tahami, T. Poursaberi, A.R. Pazoukian, M. Javanbakht, M. Shamsipur, M.R. Baezat, Anal. Lett. 36 (2003) 347.

[238] M.R. Ganjali, G. Norouzi, M. Golmohammadi, M. Rezapour, M. Salavati-Niasari, Electroanalysis 16 (2004) 910.

[239] M. Shamsipur, S. Sadeghi, H. Naeimi, H. Sharghi, Polish J. Chem. 74 (2000) 231.

[240] M. Shamsipur, A. Soleymanpour, M. Akhond, H. Sharghi, M.A. Naseri, Anal. Chim. Acta 450 (2001) 37.

[241] S. Shahrokhian, A. Taghani, F. Moattar, Electroanalysis 14 (2002) 1621.

[242] T. Poursaberi, M. Hosseini, M. Taghizadeh, H. Pirelahi, M. Shamsipur, M.R. Ganjali, Microchem. J. 72 (2002) 77.

[243] M.R. Ganjali, T. Poursaberi, M. Hosseini, M. Salavati-Niasari, M. Yousefi, M. Shamsipur, Anal. Sci. 18 (2002) 289.

[244] M.K. Amini, M. Ghaedi, A. Rafi, M.H. Habibi, M.M. Zohory, Sensors 3 (2003) 509.

[245] M.R. Ganjali, A. Daftari, F. Mizani, M. Salavati-Niasari, Bull. Korean Chem. Soc. 24 (2003) 23.

[246] K. Farhadi, R. Maleki, R.H. Yamchi, H. Sharghi, M. Shamsipur, Anal. Sci. 20 (2004) 805.

[247] M. Ghaedi, A.F. Shojaie, M. Montazerozohori, B. Karami, S. Gharaghani, Electroanalysis 17 (2005) 1746.

[248] H.R. Zare, F. Memarzadeh, A. Gorji, M.M. Ardakani, J. Brazil. Chem. Soc. 16 (2005) 571.

[249] A. Rouhollahi, M. Shamsipur, Anal. Chem. 71 (1999) 1350.

[250] K. Farhadi, H. Shaikhlouei, R. Maleki, H. Sharghi, M. Shamsipur, Bull. Korean Chem. Soc. 23 (2002) 1635.

[251] K. Farhadi, R. Maleki, M. Shamsipur, Electroanalysis 14 (2002) 760.

[252] S. Sadeghi, G.R. Dashti, Anal. Chem. 74 (2002) 2591.

[253] S. Sadeghi, A. Gafarzadeh, M.A. Naseri, H. Sharghi, Sens. Actuators B 98 (2004) 174.

[254] M.R. Ganjali, P. Norouzi, S. Shirvani-Arani, M. Salavati-Niasari, Bull. Korean Chem. Soc. 26 (2005) 1738.

[255] G. Khayatian, H. Rezatabar, A. Salimi, Anal. Sci. 21 (2005) 297.

[256] M.R. Ganjali, M. Emami, M. Javanbakht, M. Salavati-Niasari, M. Shamsipur, M. Yousefi, Sens. Actuators B 105 (2005) 127.

[257] S. Sadeghi, A. Gafarzadeh, H. Naeimi, J. Anal. Chem. 61 (2006) 677.

[258] M.R. Ganjali, S. Shirvani-Arani, G.N. Bidhendi, P. Norouzi, M. Salavati-Niasari, J. Chin. Chem. Soc. 53 (2006) 275.

[259] M.R. Ganjali, M.R. Moghaddamb, P. Norouzi, S. Shirvani-Arani, P. Daneshgar, M. Adib, H.R. Sobhi, Anal. Lett. 39 (2006) 683.

[260] S. Sadeghi, F. Fathi, A. Ali Esmaeili, H. Naeimi, Sens. Actuators B 114 (2006) 928.

[261] M.R. Ganjali, P. Norouzi, M. Qomi, M. Salavati-Niasari, Canadian J. Anal. Sci. Spec. 51(2006) 108.

[262] M.M. Ardakani, M. Salavati-Niasari, A. Dastanpour, Bull. Electrochem. 20 (2004) 193.

[263] M.M. Ardakani, A. Dastanpour, M. Salavati-Niasari, Microchim. Acta 150 (2005) 67.

[264] H. Khodakarami, H.O. Ghourchian, Iranian J. Chem. Chem. Eng. 19 (2000) 51.

[265] M.K. Amini, S. Shahrokhian, S. Tangestaninejad, Analyst 124 (1999) 1319.

[266] M.K. Amini, S. Shahrokhian, S. Tangestaninejad, Anal. Chem. 71 (1999) 2502.

[267] M.R. Ganjali, M. Abdi, H. Pirelahi, A. Mouradzadegun, M.R. Sohrabi, Anal. Sci. 19 (2003) 1387.

[268] M.R. Ganjali, M. Abdi, H. Pirelahi, A. Mouradzadegun, M.R. Sohrabi, Anal. Lett. 37 (2004) 179.

[269] N. Alizadeh, R. Mehdipour, J. Pharm. Biomed. Anal. 30 (2002) 725.

[270] M.K. Amini, S. Shahrokhian, S. Tangestaninejad, V. Mirkhani, Anal. Biochem. 90 (2001) 277.

[271] M.M. Ardakani, M. Jalayer, H. Naeimi, A. Heidarnezhad, H.R. Zare, Biosens. Bioelectron. 21 (2006) 1156.

[272] M. Arvand, M.F. Mousavi, M.A. Zanjanchi, M. Shamsipur, J. Pharm. Biomed. Anal. 33 (2003) 975.

[273] S.M. Ghoreishi, M. Behpour, M. Nabi, Sens. Actuators B 113 (2006) 963.

[274] S. Sabah, M. Aghamohammadi, N. Alizadeh, Sens. Actuators B 114 (2006) 489.

[275] S. Shahrokhian, Anal. Chem. 73 (2001) 5972.

[276] S. Riahi, M.F. Mousavi, S.Z. Bathaie, M. Shamsipur, Anal. Chim. Acta 548 (2005) 192.

[277] S. Shahrokhian, A. Taghani, A. Hamzehloei, S.R. Mousavi, Talanta 63 (2004) 371.

[278] S. Shahrokhian, A. Souri, Anal. Chim. Acta 518 (2004) 101.

[279] M.R. Ganjali, R. Kiani-Anbouhi, M.R. Pourjavid, M. Salavati-Niasari, Talanta 61 (2003) 277.

[280] M.R. Ganjali, P. Norouzi, M. Ghorbani, A. Ahmadi, Canadian J. Anal. Sci. & Spec. 51 (2006) 244.

[281] M. Shamsipur, F. Jalali, Anal. Sci. 16 (2000) 549.

[282] M. Shamsipur, F. Jalali, Anal. Lett. 35 (2002) 53.

[283] M. Shamsipur, F. Jalali, S. Haghgoo, J. Pharm. Biomed. Anal. 27 (2002) 867.

[284] M. Shamsipur, F. Jalali, S. Ershad, J. Pharm. Biomed. Anal. 37 (2005) 943.

[285] M. Shamsipur, F. Jalali, S. Haghgoo, Anal. Lett. 38 (2005) 401.

[286] M. Moghimi, M. Arvand, R. Javandel, M.A. Zanjanchi, Sens. Actuators B 107 (2005) 296

[287] N. Alizadeh, H. Khodaei-Tazekendi, Sens. Actuators B 75 (2001) 5.

[288] L. Shafiee-Dastjerdi, N. Alizadeh, Anal. Chim. Acta 505 (2004) 195.

[289] M.F. Mousavi, M. Shamsipur, S. Riahi, M.S. Rahmanifar, Anal. Sci. 18 (2002) 137.

[290] N. Alizadeh, M. Mahmodian, Electroanalysis 12 (2000) 509.

[291] M. Arvand-Barmchia, M.E. Mousavi, M.A. Zanjanchi, M. Shamsipur, Microchem. J. 74 (2003) 149.

[292] H. Karami, M.F. Mousavi, Talanta 63 (2004) 743.