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Effect of temperature on the parameters of ion-selective electrodes obtained using different types of nanostructured materials – a comparative study.

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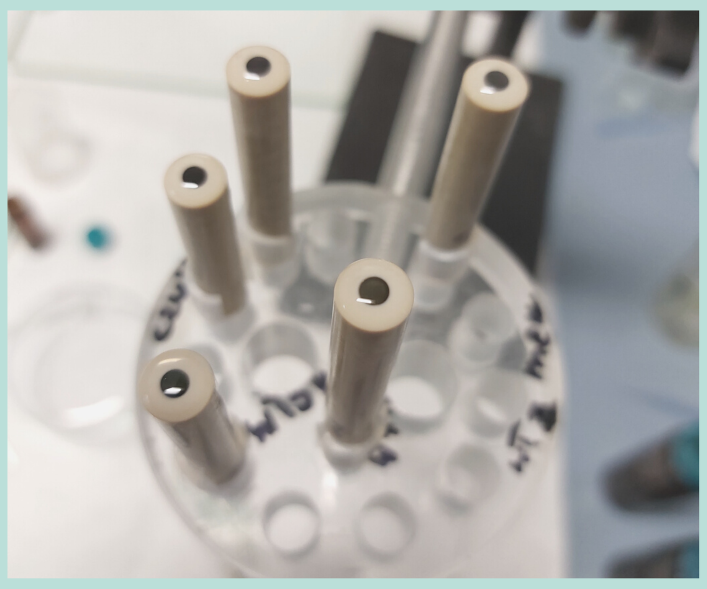
1. *Introduction*

Solid contact ion-selective electrodes (SCISEs) are useful, simple and often chosen measuring devices in potentiometry. Due to this, it is important to improve their construction to make the obtained results more accurate, precise and reproducible. One of the more frequently modified element of these electrodes is a solid contact (SC), which ensures the reversibility and stability of the potential [1]. In addition, it provides good ion-electron conductivity,excellent stability and reproducibility of the potenital and moreover faster charge transfer, which in turn improves other analytical parameters of electrodes, i.e. the membrane resistance and electrical capacitance of the double layer [2].



2. *Methods*

The aim of the study was to investigate the effect of temperature on the performance of potassium ion-selective electrodes, in which different nanostructured materials, i.e. perinone polymer (ISE 1), poly(3-octylthiophene) (POT) (ISE 2) and multiwalled carbon nanotubes (MWCNTs) (ISE 3) were used as the solid contact. SCISEs were prepared by covering glassy carbon disc electrode (GCE) with a layer of solid contact material and then depositing a membrane cocktail by the drop casting method. The control electrode was an unmodified membrane coated disc electrode (ISE 0). For all prepared electrodes, the effect of temperature on parameters such as the slope of characteristic, range of linearity, limit of detection, stability and reversibility of the potential and selectivity towards Mg2+, Na+, Ca2+ ions was studied.

3. *Results*

The detection limit, slope of the characteristic and range of linearity

Tab.1 The slopes of characteristic [mV/decade].

Temperature	ISE 0	ISE 1	ISE 2	ISE 3
10°C	53.19	48.02	51.11	48.07
23°C	56.10	48.81	53.45	48.77
35°C	58.69	52.00	55.48	53.48

Tab.2 The limit of detection [M].

Temperature	ISE 0	ISE 1	ISE 2	ISE 3
10°C	4.85x10^{-5}	5.84x10^{-5}	4.85x10^{-5}	4.78x10^{-5}
23°C	4.66x10^{-5}	4.28x10^{-5}	4.61x10^{-5}	4.42x10^{-5}
35°C	9.85x10^{-5}	4.40x10^{-5}	4.73x10^{-5}	4.65x10^{-5}

Tab.3 The range of linearity [M].

Temperature	ISE 0	ISE 1	ISE 2	ISE 3
10°C	5x10^{-5}-1x10^{-1}	1x10^{-4}-1x10^{-1}	5x10^{-5}-1x10^{-1}	5x10^{-5}-1x10^{-1}
23°C	5x10^{-5}-1x10^{-1}	1x10^{-4}-1x10^{-1}	5x10^{-5}-1x10^{-1}	5x10^{-5}-1x10^{-1}
35°C	5x10^{-5}-1x10^{-1}	5x10^{-5}-1x10^{-1}	5x10^{-5}-1x10^{-1}	5x10^{-5}-1x10^{-1}

Short-term stability of the potential

Tab.4 The drift of the potential [mV/s]

Temperature	ISE 0	ISE 1	ISE 2	ISE 3
10°C	0.00123	0.00143	0.00095	0.00007
23°C	0.00615	0.00050	0.00500	0.00076
35°C	0.00689	0.00038	0.00798	0.00131

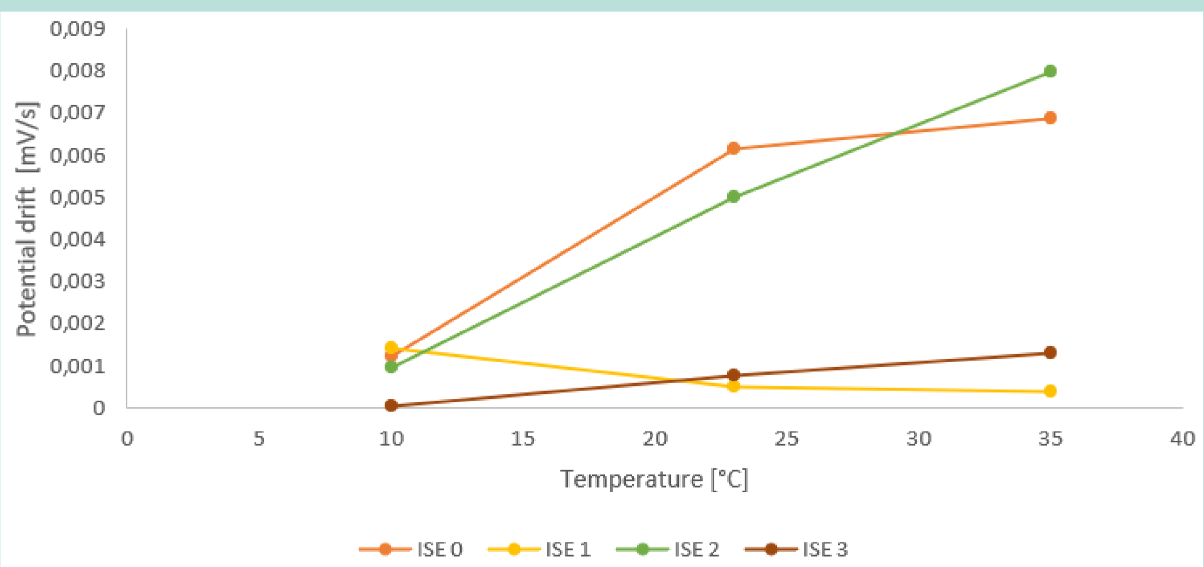


Fig. 1 Temperature dependence of potential drift for all ISEs.

Reversibility of the potential

Tab.5 Mean potential value with standard deviation obtained from four measurements at 10° C.

Solution [M]	ISE 0	ISE 1	ISE 2	ISE 3
1x10^{-3}	342.57 ± 4.35	274.86 ± 1.61	419.5 ± 3.81	403.08 ± 1.92
1x10^{-4}	286.32 ± 6.43	226.81 ± 1.70	390.59 ± 4.26	358.4 ± 2.41

Tab.6 Mean potential value with standard deviation obtained from four measurements at 23° C.

Solution [M]	ISE 0	ISE 1	ISE 2	ISE 3
1x10^{-3}	294.30 ± 5.98	257.78 ± 1.01	397.49 ± 8.06	388.42 ± 0.87
1x10^{-4}	271.28 ± 13.4	205.68 ± 1.20	343.33 ± 10.3	336.06 ± 1.39

Tab.7 Mean potential value with standard deviation obtained from four measurements at 35° C.

Solution [M]	ISE 0	ISE 1	ISE 2	ISE 3
1x10^{-3}	290.77 ± 3.39	247.07 ± 0.74	408.25 ± 7.14	387.68 ± 1.30
1x10^{-4}	266.69 ± 2.95	196.60 ± 1.12	354.21 ± 7.95	337.33 ± 1.31

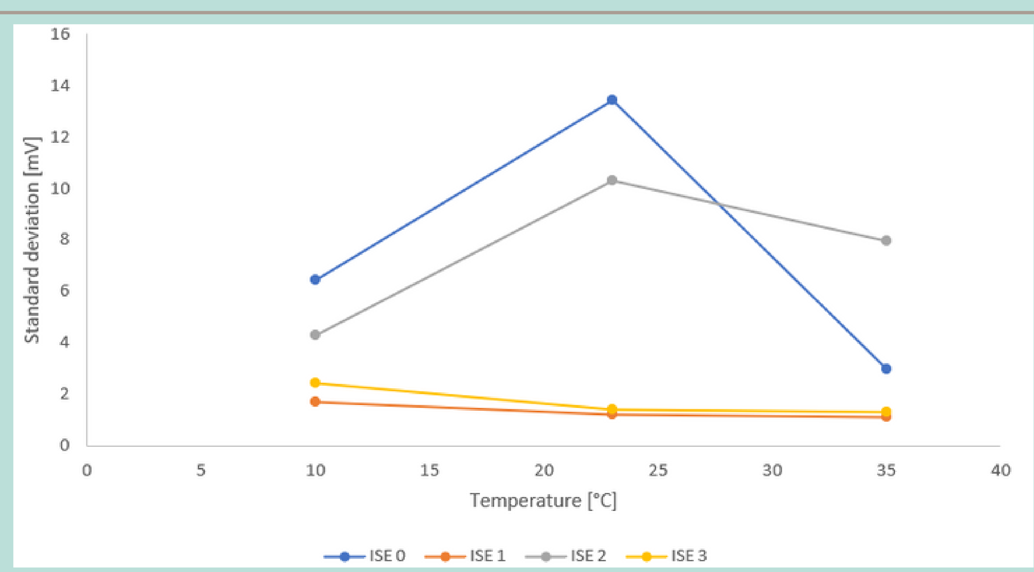


Fig.2 Temperature dependence of the deviation value.

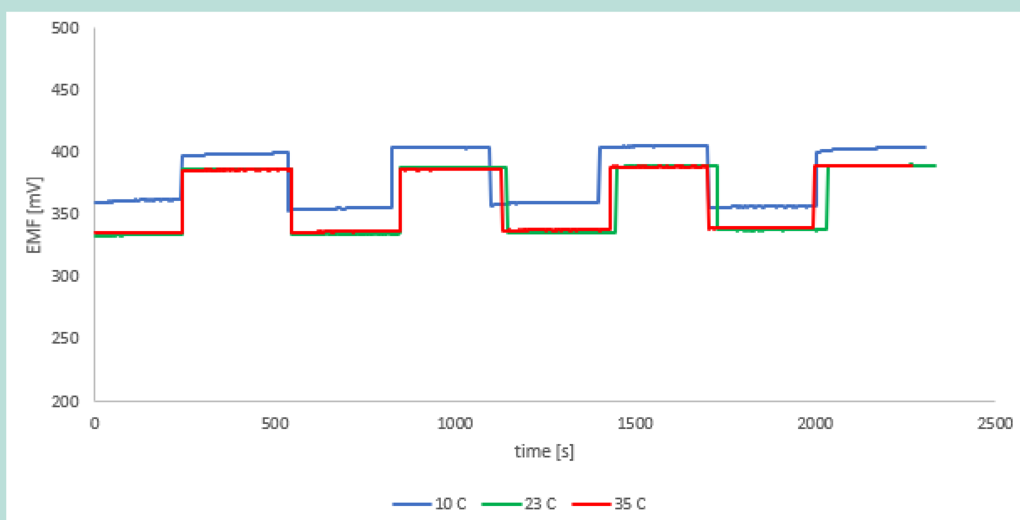


Fig. 3 Reversibility of the potential for ISE 3.

Selectivity

Tab.8 Values of logarithmic selectivity coefficients of potassium ion-selective electrodes obtained at 10° C.

Interfering ion	ISE 0	ISE 1	ISE 2	ISE 3
Na^{+}	-6.08	-6.56	-6.449	-5.71
Ca^{2+}	-5.28	-5.91	-5.90	-5.19
Mg^{2+}	-5.04	-5.71	-5.80	-5.06

Tab.9 Values of logarithmic selectivity coefficients of potassium ion-selective electrodes obtained at 23° C.

Interfering ion	ISE 0	ISE 1	ISE 2	ISE 3
Na^{+}	-4.37	-4.40	-3.25	-4.55
Ca^{2+}	-3.83	-4.07	-3.50	-4.20
Mg^{2+}	-3.97	-4.08	-3.82	-4.28

Tab.10 Values of logarithmic selectivity coefficients of potassium ion-selective electrodes obtained at 35° C.

Interfering ion	ISE 0	ISE 1	ISE 2	ISE 3
Na^{+}	-4.85	-4,05	-5.30	-4.13
Ca^{2+}	-4.74	-3.93	-5.16	-4.48
Mg^{2+}	-4.73	-3.92	-5.08	-4.04

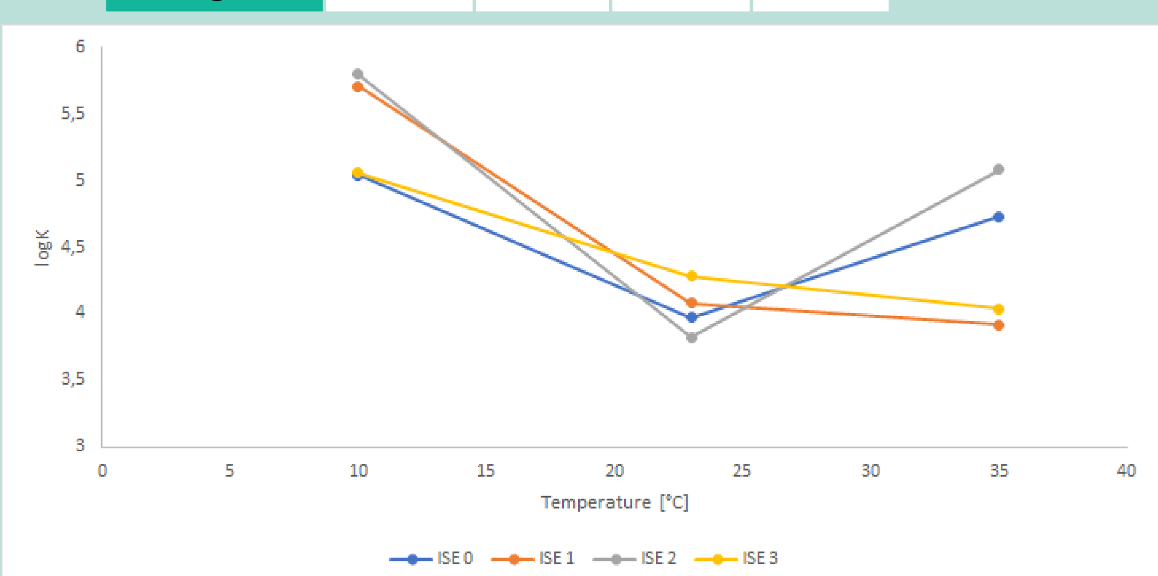


Fig. 4 Temperature dependence of the logarithmic selectivity coefficients of potassium ion-selective electrodes obtained for Na^{+} ions.

4. *Conclusions*

Depending on the type of intermediate layer (solid contact), temperature will show different effects on the parameters of the given ISEs.

Temperature has the greatest influence on the stability and reversibility of the potential, as well as on the slope of the characteristic, which is consistent with the Nernst equation - as temperature increases, the slope increases. The rest of the parameters, i.e. the calibration curve or selectivity, are not much influenced by temperature.

The best results were obtained for electrodes modified with MWCNTs and perinone polymer.

5. *Bibliography*

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[2] Pietrzak K., Morawska K., Malinowski S., Wardak C. Chloride Ion-Selective Electrode with Solid-Contact Based on Polyaniline Nanofibers and Multiwalled Carbon Nanotubes Nanocomposite // Membranes.-2022.-12, N 11.-P1150.