ELECTRICAL CAPACITY AS SIGNIFICANT PARAMETER DETERMINIG THE PERFORMANCE OF SOLID-CONTACT ION-SELECTIVE ELECTRODES

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ISEs

Introduction

What is Ion Selective Electrode?

ISEs are defined as **electrochemical sensors** that transform the effect of the electro-chemical interaction ion - membrane into a signal.

Examined material for mediation layer:
hydrous ruthenium dioxide RuO_2xH_2O

Types of ISEs

1. conventional

internal reference electrode | internal reference solution | ion-selective membrane

2. all-solid-state

solid - contact

GC electrode | mediation layer | ion-selective membrane

coated - disc

GC electrode | ion-selective membrane

Conditions that should be fulfilled by materials for mediation layer:

I. **high electrical capacity**
II. low hydrophilicity
III. ion-to-electron transduction

the properties of layers strongly determine the properties of designed electrodes

Methods: The electrical capacitance of material can be evaluated using various electrochemical techniques such as chronopotentiometry, cyclic voltammetry and electrochemical impedance spectroscopy.

Electrochemical Impedance Spectroscopy

EIS measurements are run with the set frequency range (exemplary from 20 kHz to 10 mHz), with an AC amplitude of 0.01 V versus the open circuit potential. After the measurement, the equivalent circuit is fitted to the EIS data using the NOVA 2.1 software and **the capacitance value is obtained based on the parameters of circuit elements**.

Chronopotentiometry

For the chronopotentiometry method the constant current (I) of +1nA is forced to flow through the cell, followed by the current flow of −1nA. Both steps last for 60s. During those steps, the potential response (E_{dc}) is recorded over the time (t). **The capacitance value is calculated using the $I = C(dE_{dc}/dt)$ equation**.

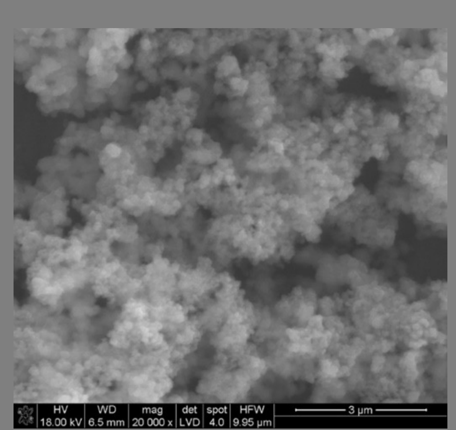
Cyclic Voltammetry

The CV measurements are conducted starting and ending with 0V potential in the set potential range (exemplary from −0.5 to 0.5 V) at the scan rate of 0.1 V/s. **The average current read for the horizontal part of the curve is divided by the scan rate and the capacitance value is obtained**.

size of particles

the smaller the particles, the larger the surface area of material

SEM scan:



nanometric particles of RuO_2xH_2O

the larger the surface area, the greater the electrical capacity of material and, in consequence, of electrodes

electrical capacity of material for mediation layer

RuO_2xH_2O layer
C ~ 2.6 mF

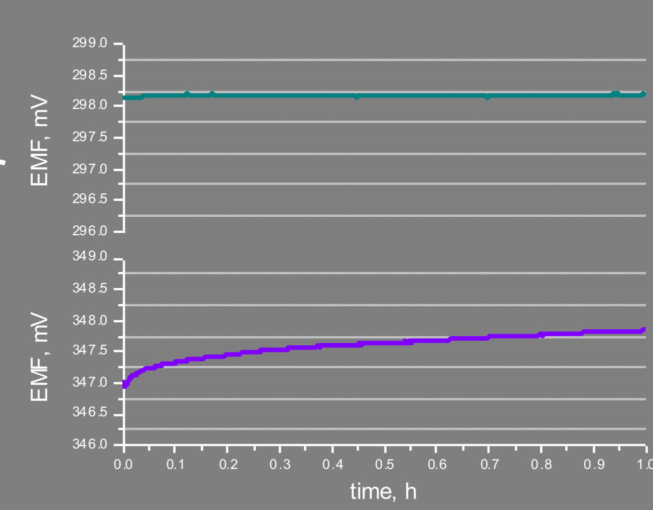
electrical capacity of ion-selective electrodes

RuO_2xH_2O electrode
C ~ 1.2 mF

stability of potentiometric response

potential drift

with RuO_2xH_2O layer — 1.5 μV/s



without layer — 42 μV/s

high electrical capacity determines the stability of potentiometric response

scheme: from layer's properties to electrode's performance

Conclusion

Electrical capacitance of ruthenium dioxide layer and subsequently ready-to-use ion-selective electrodes with ruthenium dioxide layer was tested using three electrochemical techniques including: chronopotentiometry, cyclic voltammetry and electrochemical impedance spectroscopy.

Small size of ruthenium dioxide particles ensured high surface area, therefore **hydrous ruthenium dioxide turned out to be favorable material in the context of designing ion-selective electrodes**.