MONITORING NITROGEN LEVELS IN SOIL – A WAY TO REDUCE FOOD WASTE

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INTRODUCTION

One way to prevent food waste is to grow food properly, including using the right fertilisers. One of the most important components of mineral fertilisers is nitrogen, which occurs in two forms: ammonium and nitrate which are best absorbed by plants. The right amount of nitrogen in the soil enables proper root system development and stimulates the uptake of other nutrients, such as phosphorus and potassium. However, excess nitrogen in the soil is not recommended, as it can adversely affect plants, causing excessive growth and weakening their resistance to disease. This leads to poor-quality crops and faster food spoilage. Testing the soil for mineral nitrogen content provides information about its fertility and allows for optimising fertilisation. This paper presents new solid contact potentiometric sensors for the determination of ammonium and nitrate(V) ions. An innovative electrode substrate in the form of a gold microelectrode array consisting of several hundred individual microelectrodes was used in the construction of the sensors. This solution allows for shorter and simpler sensor preparation while maintaining good performance and stability of readings. The developed sensors have been successfully used to determine the mineral nitrogen content in soils and groundwater.

EXPERIMENTAL SECTION

I. Electrode construction

GMA/ISM-K$^+$ GMA/ISM-Cl$^-$/NO$_3^-$
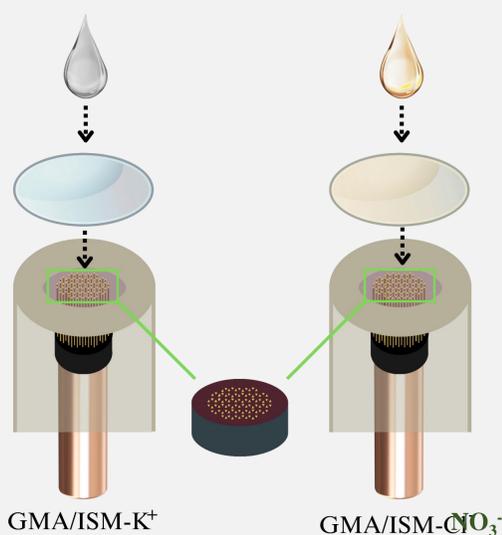
II. SEM images of the gold microelectrode array substrate

500 µm   50 µm
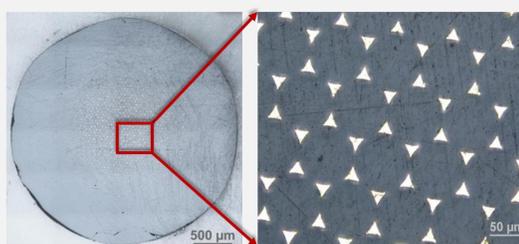
III. Membrane composition

NH$_4^+$-membrane

3% nonactin
1% potassium tetrakis(p-chlorophenyl) borate   KTpClPB
32% polyvinyl chloride (PVC)
64% bisbutylpentyl adipate (BBPA)

NO$_3^-$ -membrane

6 % tridodecyldimethylammonium nitrate   TDMANO$_3$
32% polyvinyl chloride (PVC)
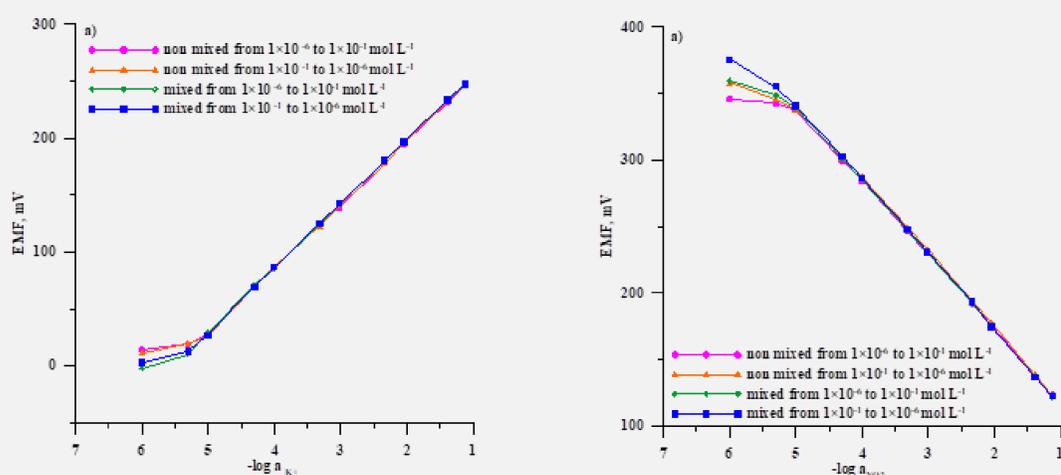62% o-nitrophenyl octyl ether (NPOE)

IV. Potentiometric response

Fig. 1. Calibration curves for ammonium (a) and nitrate (b) determined in the direction of increasing and then decreasing concentrations of the main ion for unmixed and mixed solutions, respectively.

Table 1. Analytical parameters of electrodes determined from calibration by measuring potential

Electrode	Slope [mV/dec]	Detecion limit [M]	Linearity range [M]
NH$_4^+$-GME	56.44	3.9x10^{-6}	1x10^{-1}-1x10^{-5}
NO$_3^-$ -GME	57.42	4.4x10^{-5}	1x10^{-1}-1x10^{-4}

V. Analytical application
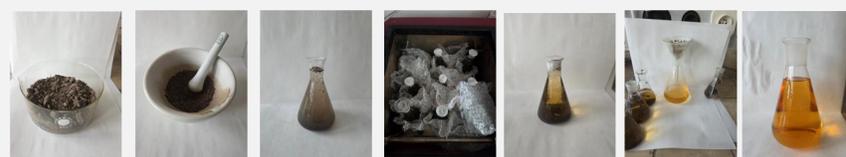
Soil sample preparation

Table 2. Results od amonium and nitrate determination in ground water and soli samples.

Sample	Amonium content µg/ L	Recovery, %	Nitrate content , mg/ L	Recovery, %
Ground water	203.2±7.9		38,6±1.8	
Ground water + 270 µg/L NH$_4^+$	465.2±18.4	98.3		
Ground water + 62mg/L NO$_3^-$			102.1±3.8	101.5
Soil	37.6±2,2	-	196.6±8.7	
Soil+ 80 mg/kg NH$_4$NO$_3$	54.3±3,4	98.1	266.4±12.2	103.0
Soil+ 400 mg/kg NH$_4$NO$_3$	128.1±6,8	100.4	506.6±23.8	98.6

CONCLUSIONS

➢ New types of electrodes based on gold microelectrodes selective to NH$_4^+$ and NO$_3^-$ ions were developed.
➢ The electrodes exhibited high sensitivity, repeatability, reversibility and potential stability.
➢ The developed electrodes were succesfully used for ammonium and nitrate deteremination in soil and ground water.
➢ Proposed electrodes are simple and cheap analytical devices for nitrogen monitoring in soils and ground waters in order to prevent food loss.