

A microconductometric ethanol sensor prepared through encapsulation of alcohol dehydrogenase in chitosan

Application to the determination of alcoholic content in headspace above beverages

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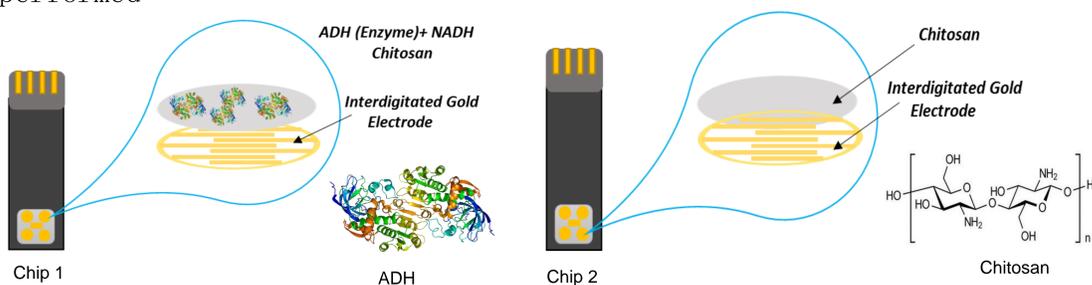
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INTRODUCTION

A conductometric transducer is proposed for the first time for the detection of ethanol vapor. This ethanol microsensor is prepared by encapsulation of alcohol dehydrogenase (ADH) in chitosan. The electrodeposition of chitosan allows the addressing of the chitosan film on the microconductometric devices and to encapsulate ADH and nicotinamide adenine nucleotide (NAD⁺), which was monitored by IRTF. The analytical performance of the ethanol microsensor was determined in gaseous methanol, ethanol and acetone samples, collected from the head space above aqueous solutions of known concentration. The response time (t_{90}) of the sensor varies from 9 s to 46 s from lower concentrations to higher concentrations. The detection limit is 0.12v/v % in the gas phase, corresponding to 0.22 M in the liquid phase. The relative standard deviation for the same sensor is from 12% for lower concentrations to 2% for higher concentrations. Ethanol sensor presents a 2.6 times lower sensitivity for methanol and 28.3 times lower sensitivity for acetone. A detection of ethanol in a red wine sample was performed

Functionalization of Interdigitated Chip



Conditions for conductometric measurements

- Small-amplitude sinusoidal voltage (10 mV peak-to-peak at 0 V).
- 10 kHz frequency generated by a low-frequency waveform generator.
- Differential output signal measurement used between the working and reference pairs of interdigitated electrodes.
- Stanford Research Systems Lock-in amplifier SR510 was used for the characterization of our developed biosensor.



Electrodeposition by Chronoamperometry

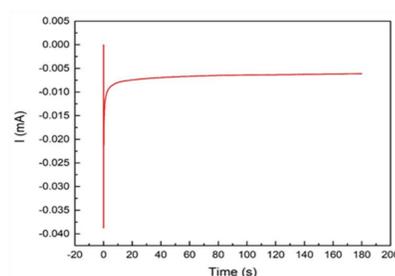


Figure 2. Monitoring of the chitosan/ADH+NAD⁺ film electrodeposition

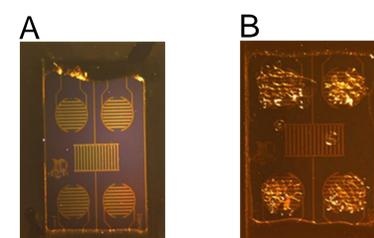


Figure 3. Bonded and encapsulated microconductometric chip (A). Microconductometric chips after chitosan film deposition (chip B)

FTIR characterization

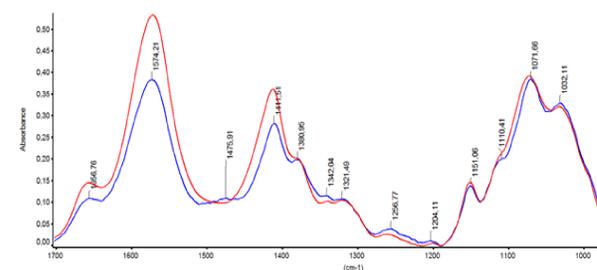


Figure 4. IRTF spectra of pure chitosan film (red curve) and of chitosan film including ADH and NAD⁺.

Electrochemical characterization by Conductimetry

VOC Detection (ethanol)

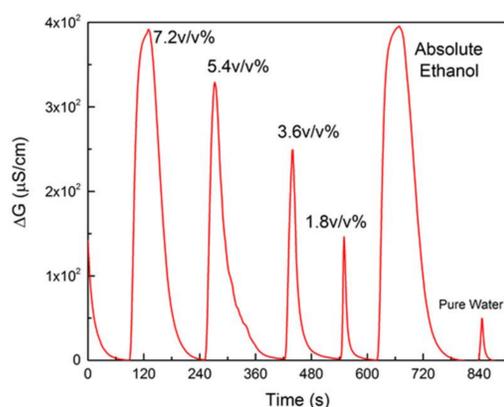


Figure 5. Detection of gas phase concentration for different ethanol/water solutions

Interference study

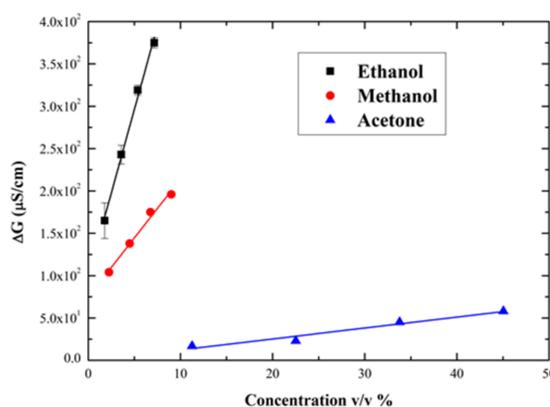


Figure 6. Calibration curves of ethanol, methanol and acetone in gas phase

Real application

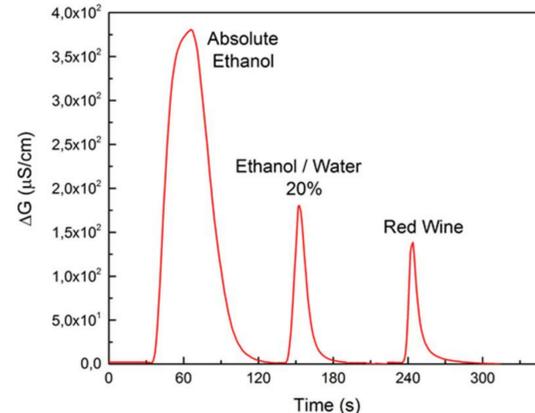


Figure 7. Detection of gas phase concentration for different ethanol/water solutions and for red wine

CONCLUSIONS

The analytical performance of the fabricated ethanol microconductometric sensor was determined in gaseous methanol, ethanol and acetone samples, collected from the head space above aqueous solutions of known concentration. The response time (t_{90}) of the sensor varies from 9 s to 46 s from lower concentrations to higher concentrations, which is very low compared to previously published amperometric ethanol sensors. The detection limit is 0.12v/v % in the gas phase, corresponding to 0.22 M in the liquid phase. The ethanol microsensor presents a 2.6 times lower sensitivity for methanol and 28.3 times lower sensitivity for acetone. A detection of ethanol in a red wine sample was performed. The detection limit of the ethanol microconductometric sensor is very high compared to previously published amperometric sensors. This detection limit could be improved by the pre-functionalization of the microconductometric devices with gold nanoparticles.

Acknowledgements

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