Differential microelectrodes as a chemical sensor for the detection of electrolyte concentrations

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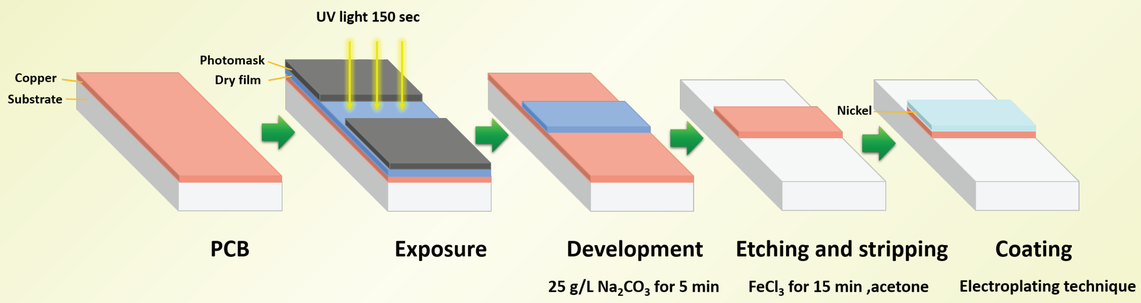
Abstract

Microelectrode impedance sensors play an important role in rapid chemical analysis for various applications, especially environmental monitoring. In this work, dual circular-shaped microelectrodes were fabricated using a low-cost printed circuit board. The electrodes were characterized; and results revealed that the impedance of both electrodes was well matched. The prototype was then implemented with a differential pick-off circuit based on AC Wheatstone Bridge. Various concentrations of KCl were used to evaluate the performance of the differential microelectrode sensor. Experimental results showed that the output signal was linearly proportional to the logarithm of electrolyte concentrations, ranging from $3.57x10^{-5}$ M to $3.57x10^{-3}$ M.

Introduction

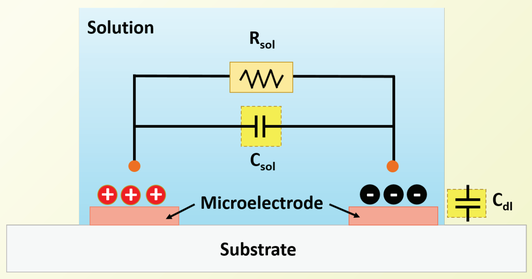
Concentration was generally measured by various techniques, such as titration , absorbance measurement by absorption spectrophotometer comparing with calibration curve. However, these techniques were complicated and slowly analysis. This study aimed to develop differential microelectrodes as a chemical sensor for the detection of electrolyte concentrations, that was rapid chemical analysis and easily fabricated using a low-cost printed circuit board.

Microelectrode fabrication

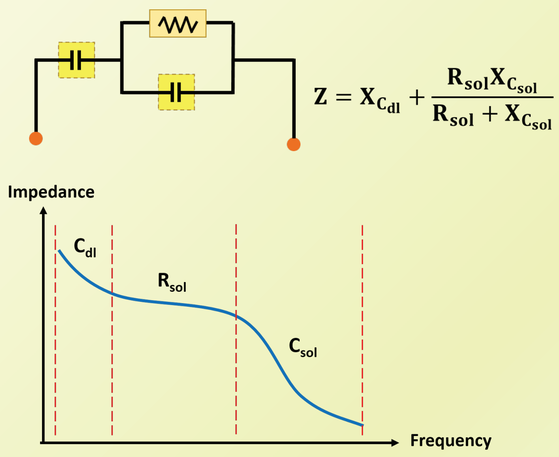


Schematic illustration of fabrication steps leading to microelectrode sensor

Theory



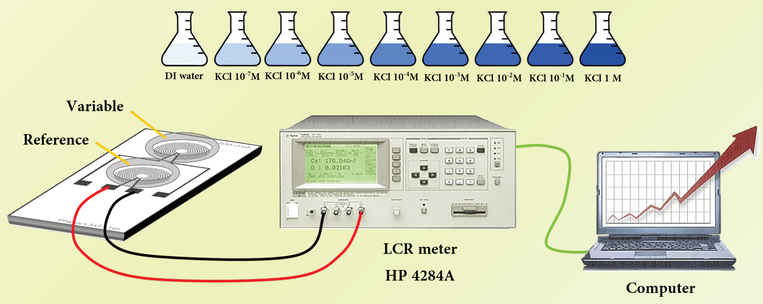
Schematic illustration of electrical model



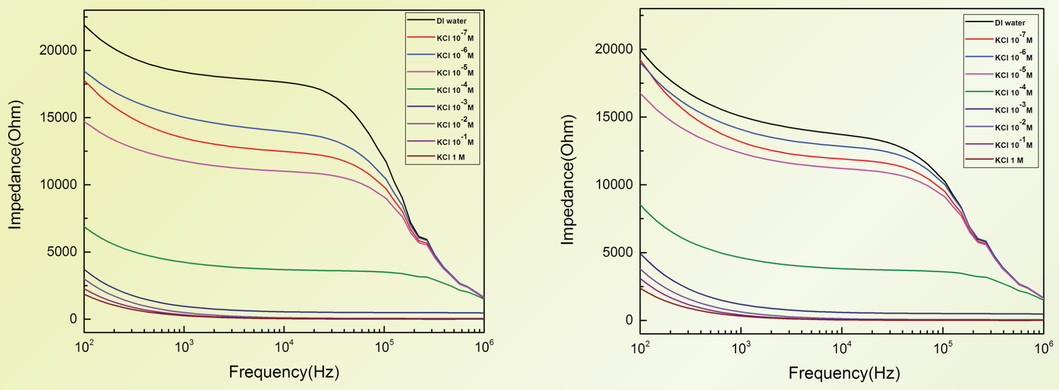
Relation between impedance and frequency of electrical model

Experiment & Result

Microelectrode characterization



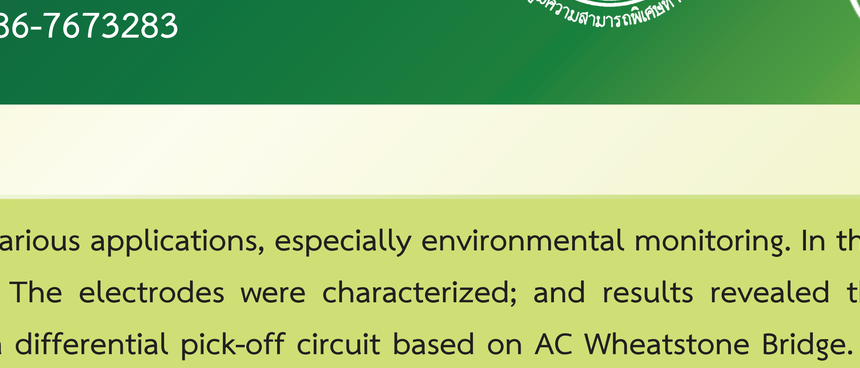
Schematic illustration of microelectrodes characterization with various concentration KCl



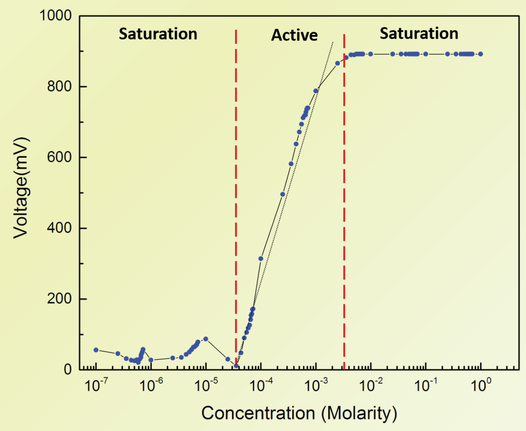
Impedance measurement of variable and reference microelectrode sensor at various concentration KCl

Microelectrode characteriazation result showed that the impedance of both electrodes was well matched. When we selected frequency at 10 kHz that the impedance mainly depended on solution resistance. We could perform a differential pick-off circit which composed of AC Wheatstone Bridge , voltage follower and differential amplifier.

Developed system characterization



Schematic illustration of a differential pick-off circuit based on AC Wheatstone Bridge



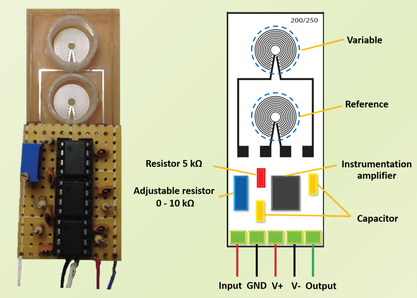
Relation between output voltage and logaritm of concentrations showed saturaton area and active area, the output signal was linearly proportional to logarithm of concentrations, ranging from $3.57x10^{-5}$ M - $3.57x10^{-3}$ M. Transfer function was following.

$$V_{out}(mV) = 247.88 \ln(conc) + 2542.7$$

Relation between output voltage and logarithm of concentrations

Conclusion

- Dual circular-shaped microelectrodes well fabricated with using a low-cost printed circuit board.
- Fabricated differential microelectrodes sensor could well measure electrolyte concentrations, ranging from $3.57x10^{-5}$ M - $3.57x10^{-3}$ M .
- We can reduced sensor dimensions by using instrument amplifier and future work could study at junction capacitance range, which impedance mainly depended on junction capacitance, with capacitor circuit.



Prototype of differential microelectrode sensor

Acknowlengement

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Reference

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- Kabilar Gunalana et al., “An automated system for measuring tip impedance and among-electrode shunting in high-electrode count microelectrode arrays”, Journal of Neuroscience Methods, 2009.