Conductometric Mercury sensor based on Polyaniline as transducer

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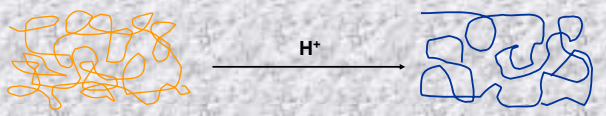
Mercury is one of the most common pollutants in natural water. Several chelating agents have been used to treat mercury poisoning. Among these agents British-anti-Lewisite (dimercaprol, 2,3-dimercapto-1-propanol, BAL) is a particularly successful antidote to inorganic mercury poisoning. In the present study a conductometric electrochemical sensor for Hg^{2+} ion was developed using polyaniline as the transducer as well as the immobilisation matrix and BAL as the receptor for the heavy metal ion determination. There is a release of H^+ ions in solution when Hg-BAL complex is formed causing an increase in the conductance of the polyaniline film. The study was performed using Hg^{2+} solutions of varying concentrations prepared in 10^{-2} M HCl solution as the supporting electrolyte. The polyaniline conductance was measured in the presence of different concentrations of Hg^{2+} ions. The study showed an increase in the conductance of the polyaniline film in the presence of increasing concentrations of Hg^{2+} ions at -0.2 V gate potential vs SCE. This conductometric sensor showed a good sensitivity in concentrations as low as 10^{-12} M of Hg^{2+} ions.

Organic conducting polymers are promising materials for the development of compact and portable sensors. Among conducting polymers, polyaniline has a unique position due to its easy synthesis, environmental stability and reversible acid-base chemistry in aqueous solution. Polyaniline has been used both as an immobilization matrix and as a physicochemical transducer to convert a chemical signal into an electrical signal. This property of Polyaniline has been explored in the fabrication of conductometric sensors for the determination of various biomolecules/ions in our laboratory.

Sensor Concept



SH

$HS - CH_2 - CH - CH_2 - OH$

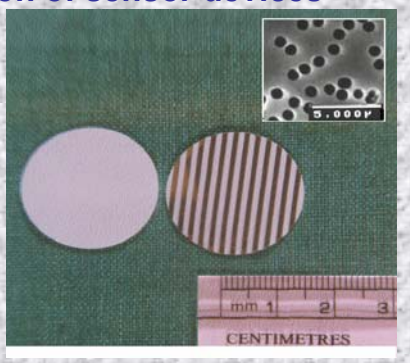
2,3-dimercapto-1-propanol (BAL)

There is an increase in the $[H^+]$ ions in the microenvironment of the polyaniline film when Hg^{2+}-BAL complex is formed according to the reaction:

$$HgCl_2 + BALH_3 \longrightarrow HgBALH + 2HCl$$

This increase in $[H^+]$ causes increase in the conductance of the PANI film and this can be used for detection of Hg^{2+} ion quantitatively.

Fabrication of sensor devices



Commercially available isoporous polycarbonate membranes were used to fabricate sensor in laboratory. They have pore diameter of 1.2 μm and thickness 10.0 μm. Superimposed gold lines (800 – 1000Å) were deposited on both sides of the membrane. Each line was used as an electrode.

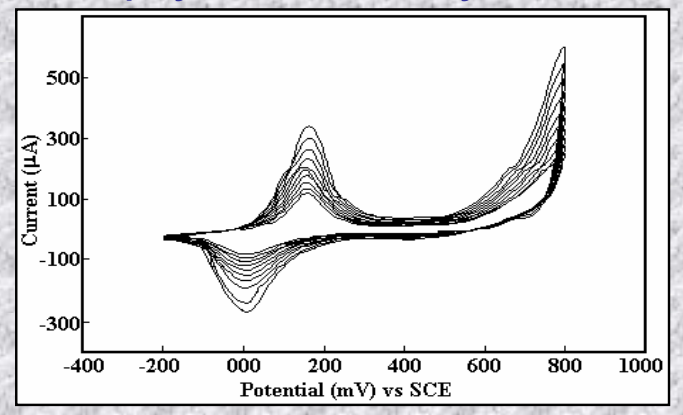
Electrochemical control of receptor immobilization

Reduced polymer, -0.2 V
neutral, compact

Oxidized polymer, +0.5 V
charged, hydrated & swollen

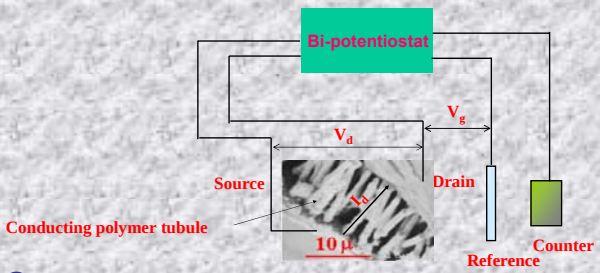
Partially reduced polymer, +0.2 V

Electropolymerisation of Polyaniline



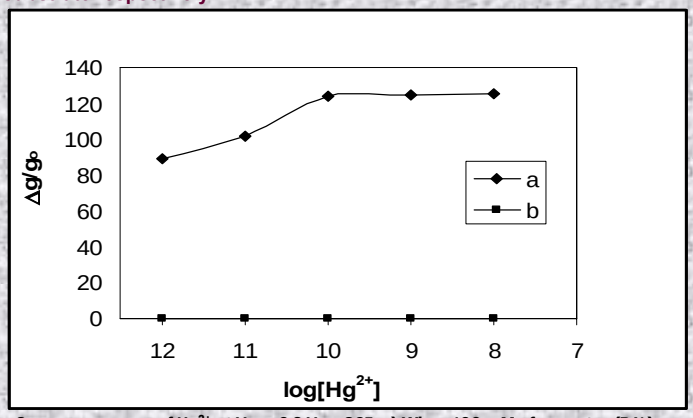
CV of growth of polyaniline from 0.1 M aniline in 0.5 M H_2SO_4

Conductivity measurements



Sensor response

The sensor response was determined by measuring the conductance of the polymer tubules in the transistor mode using bipotentiostat. Device conductance = I_D/V_D. Sensor response is $\Delta g/g_o$, where $\Delta g = g - g_o$ g and g_o are the conductances of the device in presence and absence of the substrate respectively.



Sensor response of Hg^{2+} at V_g = -0.2 V vs SCE; a) When 100 mM of receptor (BAL) was immobilized in the polymer, b) Blank (without any receptor).

Conclusion:

In this report, it has been shown that a conductometric Hg^{2+} sensor can be fabricated using 2,3-dimercapto-1-propanol as receptor and polyaniline as transducer as well as immobilization matrix. Using this approach, concentrations of Hg^{2+} ion as low as 10^{-12} M could be detected.