Electrochemical Production of an Antimony Electrode for a pH Sensor

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Introduction

Sierra Medical Technology is a medical device company that has created a product called Dx-pH Measurement System, which is a sensor able to measure gastric reflux in the airway occurring at the back of the throat.

The pH probe is constructed by miniaturizing a standard pair of antimony and silver/silver chloride electrodes. The entire probe is contained within a small tip that is inserted through the nostrils and hangs in the throat where mist from a patient's respiration is analysed.

The current method used by Sierra Medical Technology to produce antimony electrodes by is based on somewhat crude metallurgical methods. Failure of the antimony electrode is the single most common problem with the performance of the device.

Purpose

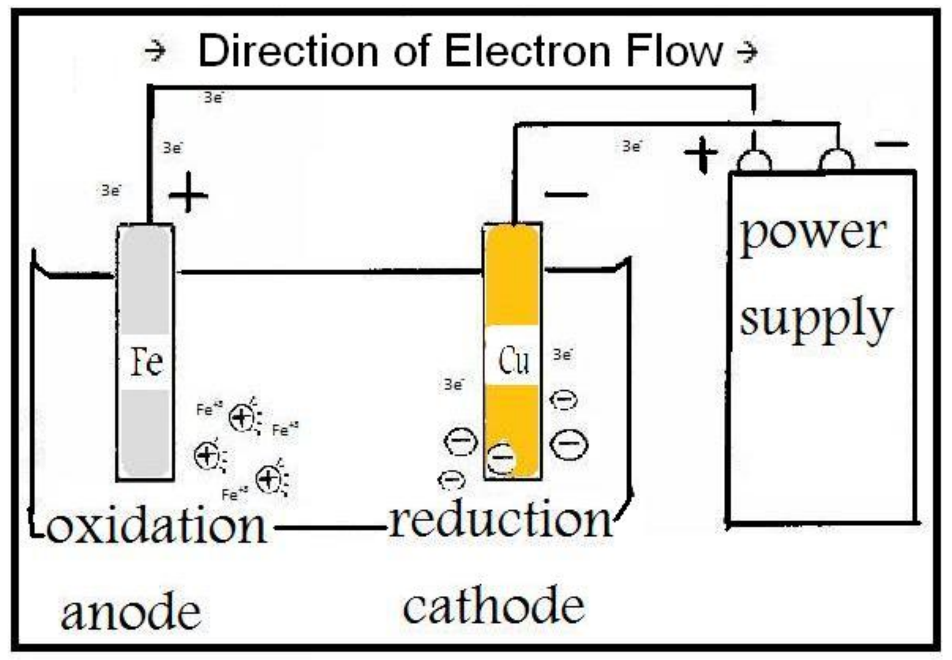
The purpose of this project is to improve the construction of the antimony electrode of the pH probe by developing a method that is cost, time, and labor efficient. The ultimate goal is the design and creation of a durable and accurate antimony electrode for use in the device produced by Sierra Medical Technology.

Method

The electrochemical procedure is based on a patent that outline a process whereby a layer of antimony metal can be deposited on a layer of iron previously deposited on a copper wire.

The process starts with a piece of copper wire that will subsequently be plated with iron and antimony. The wire has a nylon insulation that needs to be removed before plating the surface of the wire.

The organic solvent, p-bromophenol, softens the insulation after the wire is immersed for a period of 24 hours. The insulation can then be easily removed with a tissue, leaving the copper wire ready for electroplating. Conditions for plating with the iron solution include maintaining the temperature from 49 C to 71 C and a current density from 30 to 40 A/ft^2 to produce a uniform layer of iron on the copper wire.



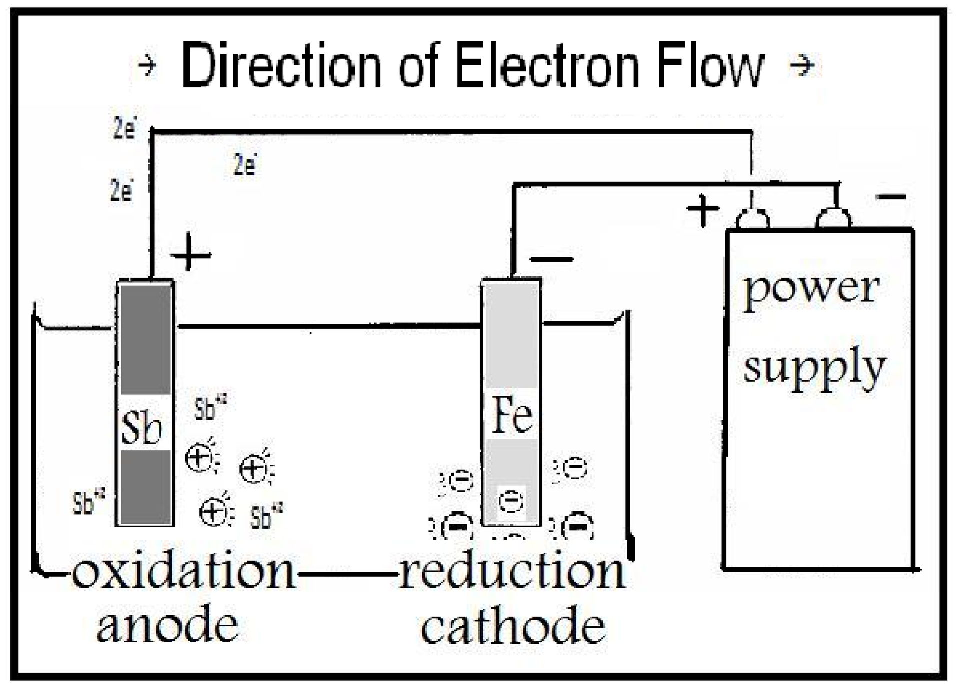
$Fe (s) \rightarrow Fe^{3+} (aq) + 3e^-$

(anode) oxidation half-reaction at the iron wire

$Fe^{3+} (aq) + 3e^- \rightarrow Fe (s)$

(cathode) reduction half-reaction at the copper wire

The reaction occurs from anode to cathode, the iron is being oxidized and electrons are being reduced on the cathode (copper wire)



$Sb (s) \rightarrow Sb^{2+} (aq) + 2e^-$

(anode) oxidation half-reduction at the antimony

$Sb^{2+} + 2e^- \rightarrow Sb (s)$

(cathode) reduction half-reduction at the iron plated on copper

The reaction occurs from anode to cathode, the antimony is oxidized and electrons are being reduced on the cathode (iron plated on copper)

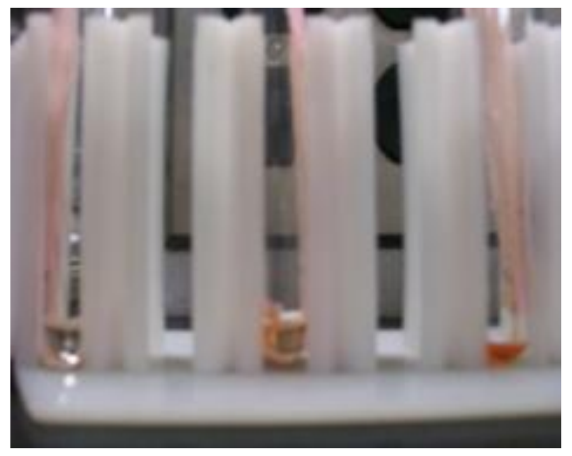
Once the copper wire has been plated with iron, an antimony solution at a temperature of 49 C and a current density of 30 A/ft^2, will deposit on the iron-plated wire.

There is an intermediate phase in the procedure that consists of an acid and water rinse to remove excess ions from the iron solution.

Properties and processes such as these have an impact on the results:

- Surface area of the wire
- Temperature, time of deposition, current and voltage applied from power supply
- pH of plating solutions
- Degradation of plating solutions

Keeping a record of different trials under different conditions helps us maintain a standard on the improvement of the product.



Testing with 1,10-phenanthroline for iron presence after antimony coating. A red color indicates the reaction with iron ions in aqueous solution.

Results are evaluated on:

- •Durability
- •Longevity
- •Environmental conditions (corrosion, oxidation)
- •Overall quality

Results

A nice layer of iron on a .5" diameter copper wire was obtained after a 4 minute period of deposition in the iron solution at approximately 50 °C, starting to electroplate as soon as the power supply is turned on and the current is regulated at 1.9 mA. After, the antimony solution was kept also at 50 °C and 5 minutes was the time of deposition on the antimony solution and ta regulated current of 1.6 mA.

Sample of copper wire plated with iron and antimony at the conditions described above.

Figure 1.

Electrolytic cell consisting of an Iron plating solution followed by an antimony solution.

Discussion

In an attempt to improve the electroplating of antimony and iron, experiments that varied conditions outside those recommended by the patent were performed. Flaws such as crystals, filaments, oxidation and uneven or uncovered areas were observed after being plated at various times and magnitude of applied current. Based on the observations made with the microscope, modifications to improve the procedure are made possible.

Conclusion

Much progress has been made toward determining the optimal conditions for constructing an antimony electrode by electrochemical means. Future work includes the understanding of surface preparation and more detailed analysis of the antimony electrodes produced by this method .

This project not only permits making a contribution to the enhancement of a unique medical device, but it also provides opportunities for undergraduate students at a community college to apply scientific principles and gain valuable experience.

Reference

Schaer, Glenn R., "Antimony Plating Process." United States Patent Office, Patent Number 2,918,415 (1959).

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