Imperial College London

The Development of a Photoelectrochemical Sensor for the Determination of Cyanide in the Blood of Burns Victims

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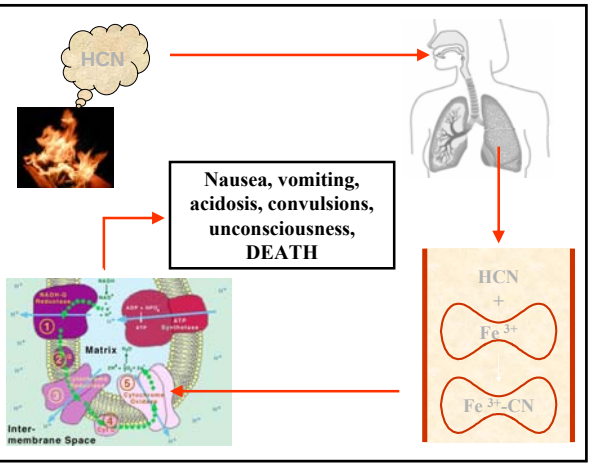
Introduction

The Problem:

- Cyanide gas (HCN) is often given off during fires
- Fire victims can get cyanide poisoning
- Current antidotes are highly toxic
- Analytical procedures are time-consuming and inaccurate



Cyanide Concentrations in Blood

- 'Normal' subject have < 1 μmol dm^{-3}
- 'Fatal dose' often quoted as 40 μmol dm^{-3}
- But survivors can be > 200 μmol dm^{-3}
- Values measured in fatalities can be > 400 μmol dm^{-3}

Detection

- Colorimetry
- Chromatography
- Electrochemical Detection
- Indirect Measurement - COHb

Photolysis

- The Fe-CN bonds can be broken with UV/visible light
- Get complete recovery
- We can use this to separate the cyanide from MetHb

Cyanide Electrochemistry

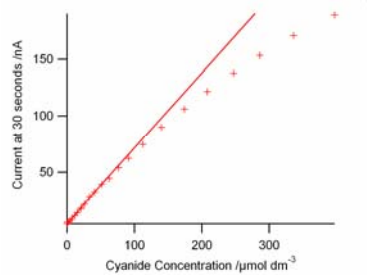
- Electrooxidation of cyanide

$$CN^- + 2OH^- \rightarrow CNO^- + H_2O + 2e^-$$

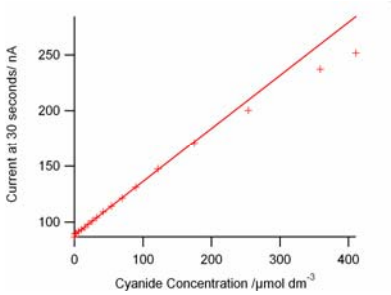
- Many electrode materials include gold, platinum, nickel and metal oxides

Biocompatability

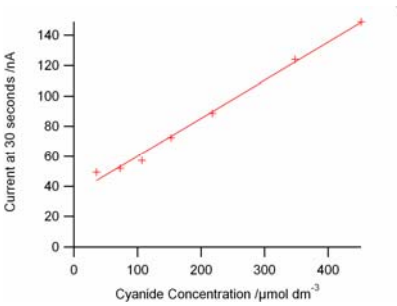
- Electrodes prone to fouling
- Poor selectivity
- Nafion



Current 30 seconds after 0.4 V vs Ag/AgCl applied. 2mm diameter Au electrode coated with nafion. PBS pH 7.4. Linear response ≤ 50 μmol dm^{-3}. Limit of detection 2.3 μmol dm^{-3}.



2 mm Au with Nafion in 40 g/dm^{-3} albumin, 50 μmol dm^{-3} pyruvate, 0.3 mmol dm^{-3}, uric acid, 1.4 mmol dm^{-3} lactic acid in PBS pH 7.4. 0.4 V vs Ag/AgCl applied. Limit of detection 3.8 μmol dm^{-3}. Linear ≤ 90 μmol dm^{-3}.

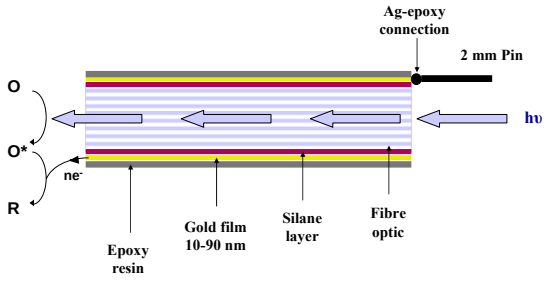


Applied potential of 0.4 V Vs Ag|AgCl using a 2 mm diameter Au electrode coated with Nafion with standard additions of CN^- to bovine plasma. Limit of Detection 41 μmol dm^{-3} (3 S.D.).

Optical Electrodes

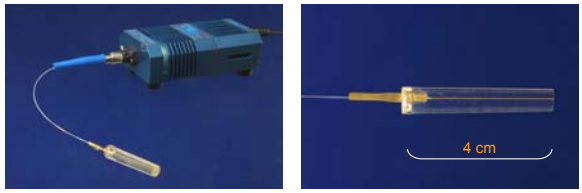
- Can shine light through solution
- Can shine light through electrode
- Or can use a ring electrode round a fibre optic

The Micro-Optical Ring Electrode

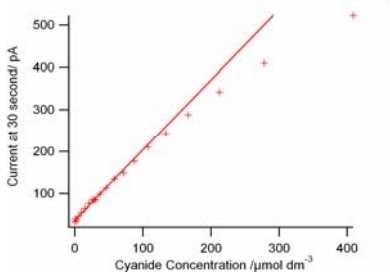


Ring electrodes - enhanced current density.
Thin ring = r1/r2 > 0.91

MORE and Light Source



MORE with standard additions



Additions of sodium cyanide solution to 40 g/dm^{-3} albumin in PBS pH 7.4 using 200 μm fibre diameter MORE with ca. 80 nm Au. Linear ≤ 58 μmol dm^{-3}. Limit of detection 5.5 μmol dm^{-3} (3 s.d.)

Conclusions

- Linear current response with cyanide concentration on gold up to 50 μmol dm^{-3} at both alkaline and physiological pH.
- Nafion successfully inhibits biomolecular interaction with the sensor in albumin.
- Linear response to cyanide concentration with the addition of more interferents and plasma.
- Linear response using the MORE

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