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3. Fuel Cell Sensors (The Formaldemeter)

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Abstract

Fuel cell sensors are electrochemical cells in which a substance is catalytically oxidised giving rise to an electric potential which results in a flow of current in an external circuit. Fuels are commonly readily oxidisable organic substances, formaldehyde being one example and catalysts are usually highly surface active platinum based types. The detailed mechanism is complex and is not completely understood, but the overall system may be represented simply (in the case of formaldehyde) as

$$[O_2 H_2O]$$
$$2HCHO \rightarrow 2HCOOH + 2H^+ + 2e-$$
$$HCHO \rightarrow CO_2 + 2H^+ + 2e-$$
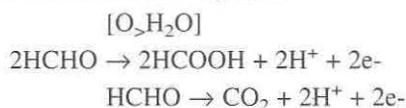
Fuel cells are extensively used in ethanol (drink driving) monitoring equipment, but can, in theory, be used for any oxidisable species, including inorganic species such as sulphur diozide and carbon monoxide. Most of the current research into fuel cells is not directed towards sensors, but towards their use as power sources, especially in the automotive industry.

Personal details — Dr. W. J. Criddle

Dr. Criddle has until recently been Senior Lecturer in Analytical Chemistry in the Department of Chemistry, University of Wales, Cardiff. During this time, he has published about 70 papers in the general area of analytical chemistry, and particularly in the area of fuel cell sensors. He is presently Consultant in Analytical Chemistry to the School of Pure and Applied Biology, University of Wales, Cardiff, and to several companies associated with analytical chemistry, including PPM Ltd., manufacturers of a range of formaldehyde monitoring equipment. PhD in Chemistry University of Wales, Cardiff 1960.
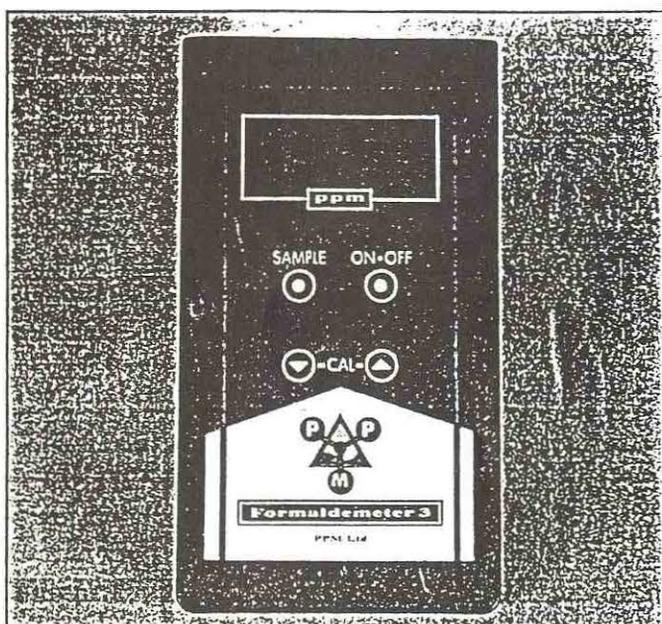
FORMALDEMETER™ 3

The NEW easy-to-use Formaldemeter™ 3 from PPM Ltd. gives a rapid indication of whether the formaldehyde level is below the Maximum Exposure Limit.

- Uses the well proven Lion electrochemical fuel cell sensor
- Has improved selectivity
- Stores time to peak readings
- Stores the peak readings

Research has shown that with the Lion fuel cell, the measured 'time to peak' reading is a function of the gases being analysed. Alcohols, which may be present in the environment where aldehyde is measured, have approximately double the 'time to peak" of formaldehyde 'window' will indicate that an interfering substance is present. This qualitative test will therefore serve to indicate whether a more sophisticated analysis is required. With the use of a microprocessor, calibration and zero pots have been eliminated. The maximum peak reading is retained on the display until the unit is switched off.

Applications

Formaldehyde is one of the most commonly used substances in industry, and occurs in many processes and products such as:

- Medical
- Pharmaceutical
- Particle boards
- Laminated boards
- Synthetic resins
- Paint manufacture
- Paper manufacture
- Dye stuffs
- Textile treatments
- Horticulture
- Deodorants

COSHH

The COSHH regulations based on Maximum Exposure Limits make the Formaldemeter 3 an ideal instrument for obtaining a rapid reading, thus eliminating expensive complex and time-consuming laboratory methods.

Principle of operation

The formaldehyde vapour when drawn across the fuel cell sensor undergoes catalytic oxidation on the platinum surface. This produces an electrical output directly proportional to the formaldehyde level in the atmosphere.

How to use

1. Hold the instrument in the atmoshere to be analysed and switch ON.
2. Depress the sample buttom.
3. The formaldehyde level is displayed in approximately 8 seconds.

Calibration

The Formaldemeter will normally hold accurate calibration for several months. An easy-to-use formaldehyde standard is included for periodic checking and recalibration.

Selectivity

A high degree of selectivity has been incorporated into the fuel cell sensor. However, some substances such as ethanol, propanol and butanol can interfere. By comparing the time to peak with that of the standard it is possible to determine if interfering substances are present and whether more sophisticated analysis is required.

Phenol filters

Complete removal of contaminants such as phenol and resorcinol can be achieved by attaching the filters provided to the instruments sampling port. The data shown in Table 2 demonstrates this for the Formaldemeter MK II.

Table 1. Accuracy

FORMALDEMETER MK II (F) versus
The Modified NIOSH (N) Method
(Formaldehyde Concentration (ppm))

	N	F	N	F	N	F
	0.37	0.4	1.84	1.9	5.07	4.9
	0.37	0.4	1.96	1.9	4.94	5.0
	0.31	0.3	1.93	1.7	5.07	5.1
	0.34	0.3	1.93	1.7	5.15	5.1
mean	0.35	0.35	1.91	1.80	5.05	5.03
std dev	0.03	0.05	0.05	0.10	0.10	0.09

Reference: Am. Ind. Hyg. Assoc. J. 46(10): 578-584(1985)

Table 2. Phenol filters

Results at 21.3°C from 0.5g formaldehyde 1^{-1} and 80g
PHENOL 1^{-1} STANDARD
(Formaldehyde Concentration 2.7 ppm)
Response (ppm)

Instr. no.	67	74	97	132
without filter	53.5	42.1	43.1	37.1
with filter	2.7	2.8	2.6	2.6

Reference: BTTG Shirley Technology Centre

TECHNICAL SPECIFICATIONS

Sensor:
Electrochemical Fuel Cell

Calibration:
In Field Formaldehyde impregnated silica gel standard

Display:
3 digit LCD

Sampling rate:
0-2 mins depending on previous reading

Sample volume:
10 cm³ approx.

Detection range:
0.05-50 ppm

Precision:
10% at 2.0 ppm level

Response time:
Approximately 8 seconds from sampling formaldehyde

Battery life:
300 field tests approx. (PP3 size alkaline battery)

Weight:
Instrument: 270 g
Complete Kit: 750 g

Dimensions:
Instrument: 150 × 80 × 34 mm
Carrying Case: 266 × 230 × 50 mm

Kit contents:
1 instrument incl. battery
1 calibration standard
10 phenol filters
1 handbook

Accessories:
Calibration Standard
Phenol filters (100 pack)