PROJECT AuTEK

AuroPureH$_2$

Efficient Gold Catalyst System for Hydrogen Purification

ANGLOGOLD ASHANTI

GOLD FIELDS

HARMONY™ MINTEK

Stimulus for this New Technology

Inexpensive impure H_2-rich gas, e.g. H_2 that would be stored in a fuel tank/cylinder but that would have some CO contamination and would essentially be dry, could be cleaned from carbon monoxide using this new AuroPureH_2 system to a very high purity level suitable for running a fuel cell for long periods without impairing its performance.

Description of Technological Achievement

Project AuTEK's AuroPureH_2 system removes carbon monoxide at room temperature to below 1 ppm (from 10 – 2000 ppm CO in H_2 with 1 – 2% air bleed). The AuroPureH_2 system out-performs the PtRu and PtMo CO tolerant anode technologies.

The system design is simple (*see Figure 1*) and low cost and we are looking for *commercial partners* to help develop this innovative technology into a *commercial product.*

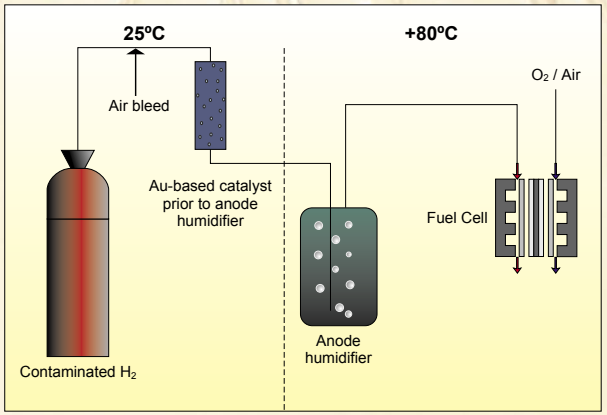
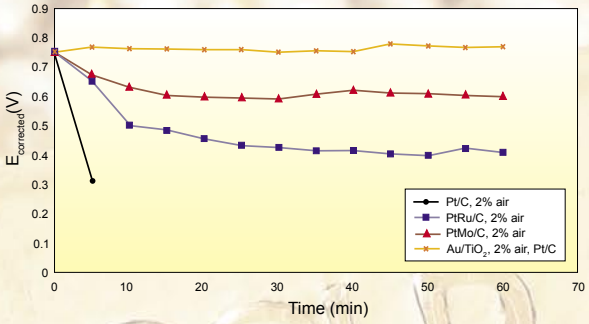


Figure 1: Schematic illustration of the Au-based H_2 purification system – AuroPureH_2

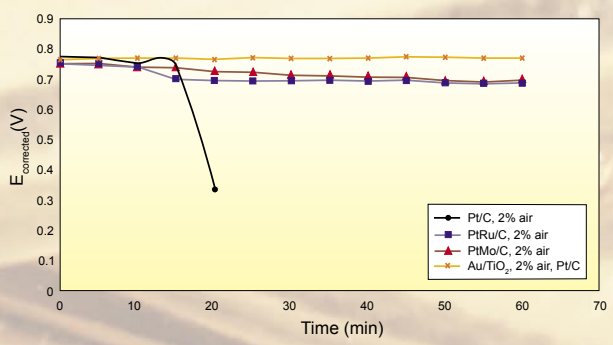
The results of the use of this new technology on the performance of a PEM Fuel Cell are given in graphical and tabular form in Figure 2 for hydrogen feeds containing 1000 ppm CO.



System	Performance loss (mV)	Performance loss (%)
Pt/C	Tripped below minimum V of 0.25 V	100
PtRu/C	399	45
PtMo/C	147	20
Pt/C + Au/TiO_2	0	0

Figure 2: Summary of CO tolerance results (1000 ppm CO, 0.5 A.cm^{-2}, 1.5x stoichiometric H_2 flow rate, SV over 3 wt% Au/TiO_2 catalyst = 250 000 ml.g$_{cat}^{-1}$.h^{-1}, Au-based catalyst chamber at 25°C, fuel cell at 80°C, 30 psi)

A similar plot and Table for results obtained with a hydrogen feed containing 100 ppm CO are given in Figure 3:



System	Performance loss (mV)	Performance loss (%)
Pt/C	Tripped below minimum V of 0.25 V	100
PtRu/C	54	7.2
PtMo/C	69	9.1
Pt/C + Au/TiO_2	0	0

Figure 3: Summary of CO tolerance results (100 ppm CO, 0.5 A.cm^{-2}, 1.5x stoichiometric H_2 flow rate, SV over 3 wt% Au/TiO_2 catalyst = 330 000 ml.g$_{cat}^{-1}$.h^{-1}, Au-based catalyst chamber at 25°C, fuel cell at 80°C, 30 psi)

The oxygen concentration is limited by an air bleed and has only a very small effect on fuel efficiency, as demonstrated by the performance loss graph given in Figure 4.

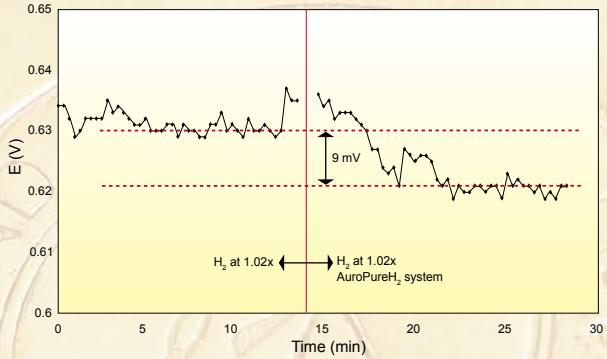


Figure 4: The comparative performance of a fuel cell operating at 0.7 A.cm^{-2} and H_2 stoichiometry of 1.02 (290 000 ml.g$_{cat}^{-1}$.h^{-1}) in the absence and presence of the 3 wt% Au/TiO_2 catalyst system (anode: 0.39 mg Pt.cm^{-2}, cathode: 0.84 mg Pt.cm^{-2}, fuel cell at 80°C, Au/TiO_2 catalyst chamber at room temperature, 30 psi)

Present Position

It has been demonstrated that the AuroPureH_2 system achieves complete removal of up to 2000 ppm carbon monoxide in hydrogen streams over a 3 wt% Au/TiO_2 catalyst at a space velocity of 850 000 ml.g$_{cat}^{-1}$.h^{-1} with a 2% air bleed and at a gold cost of less than 1% of the US DoE stipulated cost target of $45/kW.

The AuroPureH_2 system is superior to other state of the art CO tolerance technologies based on PtRu/C and PtMo/C catalysts.

The advantages of the AuroPureH_2 system are:

- Use of on-board storage of less pure, cheaper hydrogen
- Provision of less expensive hydrogen to the end user
- Dry hydrogen is taken directly from cylinder supply
- Protection of Pt fuel cell catalyst against CO poisoning: effective on a large range of CO concentrations in feed gas (up to 2000 ppm): CO removed down to sub ppm levels
- Low operating temperature gives higher selectivity for CO oxidation, and means that no additional energy is needed to heat the reactor
- The low oxygen concentration required (2% air or 0.42% oxygen) gives high selectivity
- Fuel efficiency essentially maintained
- Low cost system (cost of gold less than 1% of $45/kW target)
- Allows lower Pt loadings at anode of fuel cell and avoids use of PtRu or PtMo anodes, thereby cutting down overall cost of system
- The system is simple and practical and does not add significantly to the weight and volume of the fuel cell system.

Principal Considerations

The purity of hydrogen and its production and distribution costs have still to be optimised before PEM fuel cells will be an attractive commercial proposition for use with automotive and stationary power supply systems. There is an important 'trade off' between hydrogen purity and cost. For automotive applications, the US Department of Energy strongly supports on board storage of hydrogen. Currently even high purity hydrogen contains trace amounts of CO (e.g. JIS K 0512 Grade 3, 99.99% hydrogen still contains 10 ppm CO, enough to cause poisoning of the Pt electrocatalyst and deterioration in fuel cell performance).

CO tolerant technologies devised to date, based on PtRu and PtMo catalysed anodes show significant loss in performance in hydrogen feeds containing 100 ppm CO. Ralph et al. (Platinum Metals Review, 2002, 46, 117) reported a 6% loss in performance at 500 mA/cm^2 for PtRu in hydrogen with 10 ppm CO. The commercial requirement to reduce Pt loadings and maximise the efficiency of fuel cells means that CO has to be removed from the hydrogen fuel down to sub-ppm levels.

Cost of gold in a 60 kW system is estimated at less than $30, i.e. less than 1.0% of the US DoE target $45/kW target for vehicular fuel cells

Collaborations with fuel cell producing, automotive and gas-producing companies will assist in commercialising this valuable AuroPureH_2 technology (Provisional South African Patent No. 2006/01120)

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