

Expanded graphite as an electrode material for an alcohol fuel cell

Arup Bhattacharya, Ashoke Hazra, Someswar Chatterjee, Pratik Sen,
Soumi Laha, I. Basumallick*

Electrochemical Laboratory, Department of Chemistry, Visva-Bharati University, Santiniketan 731235, India
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Abstract

An efficient graphite electrode has been developed using expanded graphite as the starting material. A graphite plate has been expanded by doping with potassium vapour using a vapour incorporation technique developed at our laboratory. The extent of expansion of the electrode plate is about 20% of its initial thickness. These expanded graphite electrodes have been platinized by an electrodeposition method. The electrocatalytic activity of platinized expanded graphite has been examined, and the discharge profile of a conventional laboratory model fuel cell comprising a platinized Pt air cathode, expanded platinized graphite anode and sulphuric acid (2 M) as electrolyte has been measured. Analysis of the electrochemical parameters of the laboratory model cell clearly indicates that the expanded Pt graphite electrode shows better electrochemical behaviour towards methanol (1 M), ethanol (1 M) and propanol (1 M) oxidation than that of unexpanded graphite electrodes. The results are explained in terms of efficient electrocatalytic activity of the nano channel formed after the expansion. These electrodes are expected to have promising applications in fuel cells.

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1. Introduction

Interest in fuel cell research was significantly enhanced after its identification as a possible alternate power source for automobiles [1–4]. In alcohol fuel cells additional advantages are that alcohols are liquid fuels and they can be obtained from renewable biomass sources [4]. Among alcohols, the methanol fuel cell has been widely investigated [4] but relatively few studies are reported on ethanol and 2-propanol fuel cells. The reaction that occurs at the anode is the oxidation of fuel by a suitable electro-catalyst. However, the major problems of fuel cells are poisoning of the electro-catalyst [5] even with Pt as the catalyst and its cross over from anode to cathode compartment [6]. Besides electro-catalyst, the carbon material used as catalytic support also plays an important role in dictating fuel cell efficiency. In conventional fuel cells, sheet type graphite electrodes are used, as they are convenient to be stacked in the batteries. To our knowledge this is the first time that expanded graphite has been used in fuel cell development. Earlier [7] we have used expanded graphite as an electrode for Li-ion batteries.

In the present research we report behaviour of laboratory model alcohol fuel cell with platinized expanded graphite as

anode material and methanol, ethanol and 2-propanol as fuel. It may be mentioned that the use of such expanded graphite [7] as electrode material for Li-ion cells has improved the lithium intercalation ability many fold.

2. Experimental

2.1. Electrodes

The anode was a 10 mm² graphite plate of thickness 3.8 mm obtained from the R&D of BHEL, India. Graphite electrodes were expanded using a technique developed at our laboratory (Fig. 1) [7]. The graphite plate was

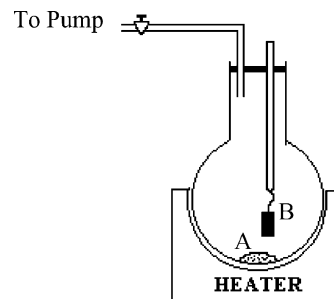


Fig. 1. Expansion of graphite plate using K-vapour: (A) solid block of potassium; (B) graphite electrode.

* Corresponding author.

E-mail address: ibasumallick@yahoo.co.uk (I. Basumallick).

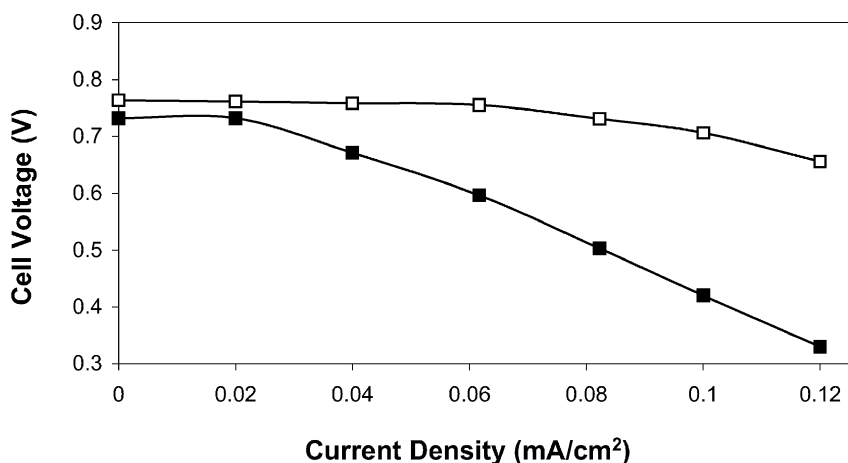


Fig. 2. V - I curves for 2-propanol using normal (■) and expanded graphite (□) as anode.

expanded to the extent of 20% by potassium vapour. The expanded material was loaded with Pt by electrodeposition [3]. The air cathode was fabricated by loading a 10 mm² graphite plate with Pt from a chloroplatinic acid bath using conventional techniques [8]. For the sake of comparison a Pt loaded anode without expansion was used as control.

2.2. Materials

Methanol (Merck), ethanol (Bengal Chemical) and 2-propanol (Merck) were purified as described earlier [9]. Sulphuric acid was used as-purchased and diluted with double distilled water to the appropriate concentration.

2.3. Laboratory model fuel cell

Laboratory model fuel cells were housed in two glass rectangular chambers (50 ml capacity) connected by an inverted U-shaped bridge. Cathode and anode, as fabricated above, were inserted into the respective chambers through the openings of the lid. H₂SO₄ (2 M) were poured into cathode and anode chambers, respectively. Alcohols were added to the anode chamber to obtain the desired concentration. The U tube was plugged with foam, that had been soaked in the acid to avoid crossover of alcohol. Air was bubbled slowly through cathode chamber using an air pump.

Steady open-circuit potentials (OCP) were reached within 30 min. The short circuit current (SCC) values were measured after attainment of a steady OCP value.

3. Results and discussion

Table 1 displays OCP and SCC values of the laboratory model fuel cell with different fuels in 2 M H₂SO₄ with an-

Table 1

Electrochemical parameters for alcohol (methanol, ethanol, 2-propanol) fuel cells in 2 M H₂SO₄ with normal and expanded graphite as anodes, at 25 °C (298.15 K)

Alcohol	Normal graphite (A)		Expanded graphite (B)	
	OCP (V)	SCC (mA)	OCP (V)	SCC (mA)
Methanol (1 M)	0.672	0.23	0.696	0.31
Ethanol (1 M)	0.721	0.25	0.736	0.36
2-Propanol (1 M)	0.732	0.37	0.763	0.47

A and B: platinized, loading time 10 min, geometric area = 10 mm².

odes (normal and expanded graphite) having the same catalyst loading. It is interesting to note that as we pass from methanol to 2-propanol the OCP values increase. For expanded graphite, similar trends are observed but the magnitudes of these parameters are much higher than these with normal graphite electrodes.

It seems that, as in the case of methanol, oxidation of other alcohols takes place via an initial absorption onto the anode surface followed by deprotonation. For expanded graphite the nanographite channels act as better absorption sites and the electro-catalytic activity of Pt within these channels is also enhanced as is reflected in their SCC values (Table 1).

It is interesting to note (Fig. 2) that the drop in potential under different current drains is respectively smaller for expanded graphite. This indicated that the exchange current density of alcohol oxidation on to expanded graphite is much larger compare to those at the unexpanded graphite.

4. Conclusion

This research introduces the use of expanded graphite as an electrode material in fuel cells and it is expected that this will improve the energy efficiency of fuel cells.

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