

## Supporting Information

### Remarkable performance of the unique catalyst Pd-Fe<sub>2</sub>O<sub>3</sub> toward EOR and ORR: Non-Pt and non-carbon electrode material for low temperature fuel cell

Rajib Adhikary<sup>a</sup>, Dipankar Sarkar<sup>a,b</sup>, Manabendra Mukherjee<sup>c</sup>, Jayati Datta<sup>a\*</sup>

<sup>a</sup>Department of Chemistry, Renewable Energy Research Centre, Heritage Institute of Technology, Kolkata 700107, W.B, India.

<sup>b</sup>Department of Chemistry, Indian Institute of Engineering Science and Technology, Shibpur, Howrah 700103, W.B, India.

<sup>c</sup>Surface Physics Division, Saha Institute of Nuclear Physics, Bidhannagar, Kolkata 700064, W.B, India.

\*E-mail: jayati\_datta@rediffmail.com

#### Synthesis of the catalysts:

**i. Synthesis of Fe<sub>2</sub>O<sub>3</sub>:** Appropriate amount of Ferrus Sulphate (FeSO<sub>4</sub>, 6H<sub>2</sub>O) was taken and dissolved in 250 ml deionised water in a conical flask and the solution is stirred and sonicated periodically for 1 hour to obtain a well dispersed solution. The resulting solution is kept as such for 2-3 days at room temperature covering the mouth of the conical flask with a watch glass. The solution was then filtered and washed thoroughly by distilled water. Subsequently the residue obtained was dried in oven at 150<sup>o</sup> C for 8 hours.

**ii. Synthesis of Pt/C, Pd/C and Pd/Fe<sub>2</sub>O<sub>3</sub>:** Calculated amount of Vulcan XC-72 powder was dissolved in 100 ml of ethylene glycol in a 250 ml round bottom flask. The solution was kept under constant stirring and sonication alternatively for 1 hour to get a homogeneous solution. To it required amount of palladium chloride (PdCl<sub>2</sub>, 2H<sub>2</sub>O) and chloroplatinic acid (H<sub>2</sub>PtCl<sub>6</sub>, 6H<sub>2</sub>O) solutions in appropriate strength were used as precursors for preparing Pd/C and Pt/C respectively

to maintain 40:60 weight % catalyst-support ratio. Now the resulting solutions were stirred and sonicated continuously for 2 hours and then few drops of NaOH was added to maintain its P<sup>H</sup> above 10. Then the solution was kept in reflux condition for 4-5 hours at 160<sup>0</sup> C - 180<sup>0</sup> C. After that the black coloured solution obtained was cooled at room temperature. Then the solution was filtered and washed thoroughly with deionized water and the residue obtained was dried in oven at 80<sup>0</sup> C for 12 hours.

For synthesizing Pd/Fe<sub>2</sub>O<sub>3</sub>, the same procedure is followed expect that we have taken our synthesized Fe<sub>2</sub>O<sub>3</sub> as support material instead of carbon (Vulcan XC-72) and Pd NPs were decorated over the surface, using the same palladium chloride (PdCl<sub>2</sub>, 2H<sub>2</sub>O) precursor salt solution and in this case the weight % of catalyst-support was maintained at 25:75 ratio.

#### **Calculation of catalyst loading in ORR:**

2.6 mg of synthesized catalyst-support was added to 1000 µl water and iso-propanol (1:1) mixture to which 50 µl of 5 wt.% nafion was added. The resultant solution was sonicated to get a homogeneous ink. 5 µl of the prepared ink is now fabricated on the glassy carbon electrode (GC) working electrode with 0.2407 cm<sup>2</sup> area.

#### **For Pt/C and Pd/C**

5 µl ink contained  $(2600/1050) \times 5 = 12.38$  µg catalyst-support

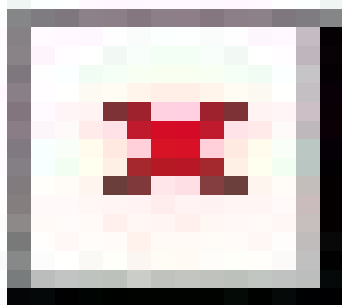
Loading on 0.2407 cm<sup>2</sup> GC electrode =  $12.38/0.2407 = 51.43$  µg/cm<sup>2</sup>

Since in general, we maintained the catalyst-support ratio 40:60 wt.%, the catalyst loading on the GC was calculated to be  $(51.43 \times 0.4) \approx 20.5$  µg/cm<sup>2</sup> (Pt/Pd).

### For Pd/Fe<sub>2</sub>O<sub>3</sub>

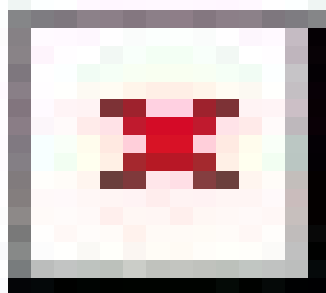
For the new catalyst the calculation was done under similar procedure except that the catalyst-support ratio is maintained at 25:75 wt.%; hence the catalyst loading on the GC =  $(51.43 \times 0.25) \approx 12.8 \mu\text{g}/\text{cm}^2$ .

### TAFEL Plot for all three catalysts



**Fig.S1** Mass transfer corrected Tafel plots for all three catalysts showing the linear part only (geometrical area normalized) at a rotation speed of 2400 rpm.

### L-K plot for bare Fe<sub>2</sub>O<sub>3</sub>



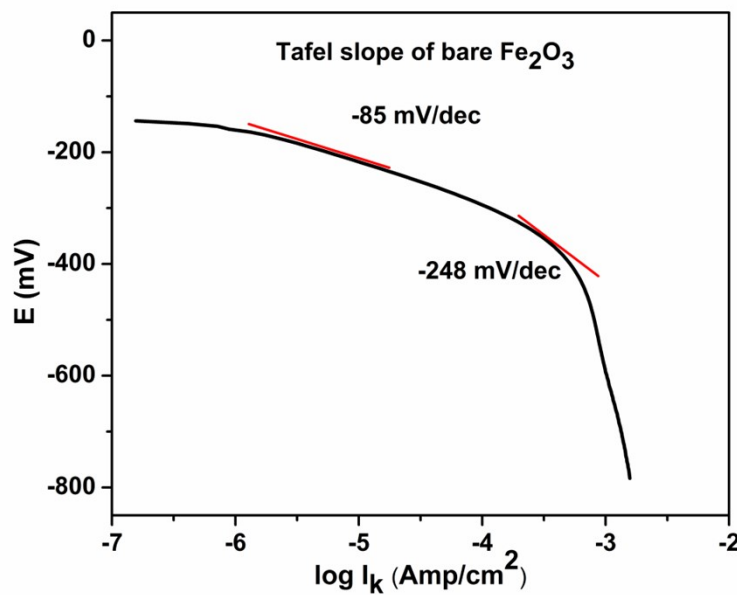
**Fig.S2** Levich- Koutecky plot for Fe<sub>2</sub>O<sub>3</sub>

### H<sub>2</sub>O<sub>2</sub> Estimation on bare Fe<sub>2</sub>O<sub>3</sub>



**Fig.S3(a)** H<sub>2</sub>O<sub>2</sub> estimation of bare Fe<sub>2</sub>O<sub>3</sub> by RRDE technique using 800 rpm. **(b)** % H<sub>2</sub>O<sub>2</sub> produced during ORR at 800 rpm.

### TAFEL slope of bare Fe<sub>2</sub>O<sub>3</sub>



**Fig.S4** Mass transfer corrected Tafel plot of Fe<sub>2</sub>O<sub>3</sub> (geometrical area normalized) at a rotation speed of 2400 rpm.