Electronic Supporting Information

Proton Exchange Membrane and Bio-Fenton Micro Fuel Cells for Energy Harvesting, Gas leakage Detection, and Dye Degradation

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S1. Descriptions of Supporting Videos:

1. Description of Supporting Video 1: Supporting Video 1 shows energy harvesting operation in carbon tape-based PEM fuel cells, while two fuel cells are connected in series combination. Further, the video shows three different Digital Multimeter (DMM), wherein first two DMM reading tells potential values of two individual PEM fuel cells and the third one shows the addition of the potential reading generated in two fuel cells.

2. Description of Supporting Video 2: Supporting Video 2 shows hydrogen sensing principle utilizing attachable and flexible carbon tape-based PEM fuel cell. Two vials, which generate hydrogen via reaction of magnesium and hydrochloric acid are connected with a polymer pipe. A tiny hole is created in the pipe and the attachable fuel cell is attached to the hole. The entire setup is connected with a DMM to read the potential generation in the PEM fuel cell. In the first part of the video, the gas leaks through the pipe we see a potential generation up to ~ 18 mV in the presence of atmospheric air. The end of the video shows the addition of an extra oxygen source, via Fenton's reaction, on the other end of the PEM fuel cell gives the potential value as high as ~ 106 mV. The reading in the PEM fuel cell indicates hydrogen leakage through this pipe.

3. Description of Supporting Video 3: Supporting Video 3 shows the potential generation principle in a Bio-Fenton fuel cell. In a carbon tape-based single electrode setup, one side was coated with Hb and the other side was left bare. The two ends of the electrode were connected with a DMM to measure potential value. On dipping, the electrode set up in a hydrogen peroxide solution gradual rise in potential value was observed in the DMM. The potential value reaches as much as ~ 134 mV.

S2. Repeatability test of the prepared PEM fuel cell:

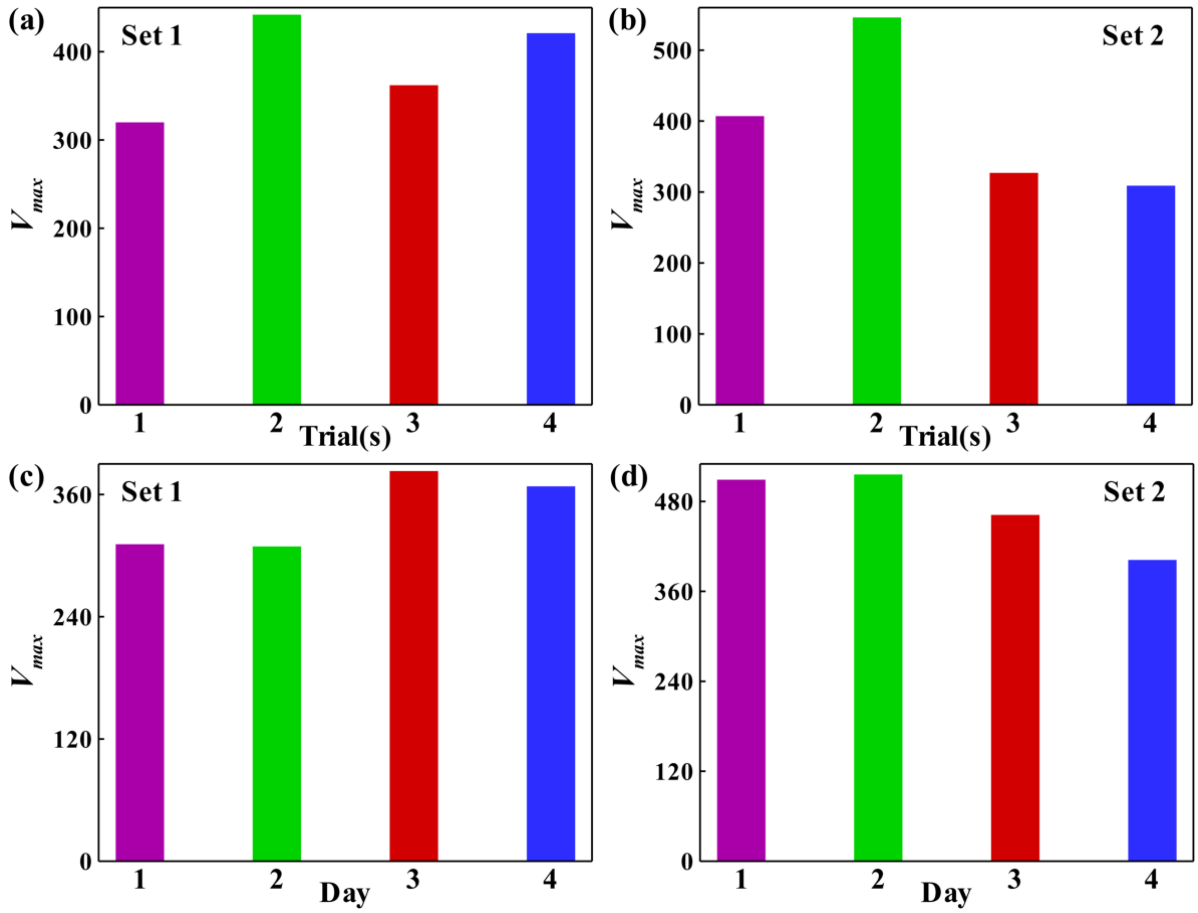

Fig. S1: (a) Shows the maximum potential (V_{max}) generated from Set 1 (without regeneration of Nafion coating) of PEM fuel cell of kind 2, after multiple uses on a single day. (b) Shows the maximum potential (V_{max}) generated from Set 2 (with the regeneration of Nafion coating) of PEM fuel cell of kind 2, after multiple uses on a single day. (c) Shows the maximum potential (V_{max}) generated from Set 1 of PEM fuel cell of kind 2, on storing it for multiple days. (d) Shows the maximum potential (V_{max}) generated from Set 2 of PEM fuel cell of kind 2, on storing it for multiple days.

Reproducibility study of the developed PEM fuel cell of kind 2 has been done to check the reusability of the fuel cell. The study has been performed in two different sets: (i) Set 1: Nf application only once before the first use, and (ii) Set 2: Nf application before each use. **Figure S1 (a)** and **(b)** shows the maximum potential generated (V_{max}) after four consecutive trials on a single day, for Set 1 and Set 2, respectively. **Figure S1 (a)** and **(b)** show that the potential generation by Set 1 and Set 2 is not fading even after 4 trials. Thus, it is evident that both Set 1 and Set 2 can be used multiple times, which is beneficial for the hydrogen leakage sensing as it rules out the requirement of the replacement of the sensor after each use. Slight variations in the obtained results are due to the variation in the rate of generation and transfer of hydrogen to the Nafion coated carbon tape. A controlled release of hydrogen would have given a steady potential.

Another study was also performed to check the durability of the fuel cell. **Figure S1 (c)** and **(d)** show the potential generated from Set 1 and Set 2, respectively, after storing Set 1 and Set 2 PEM fuel cells for 4 days and observing the potential generation on each day. For Set 1, Nf coating was applied only on Day 1, before first use, and for Set 2, Nf coating was applied on each day before using the fuel cell. The figure shows that Set 1 and Set 2 are capable of potential generation even after storing them for multiple days. Thus, it is evident from the figure that the proposed PEM fuel cells can be used multiple times and for a longer period of time.