Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.


Supporting Information

for

# Effect of Carbon Nanotube-based Catalyst Layer Surface Roughness on Polymer Electrolyte Membrane Fuel Cell Performance

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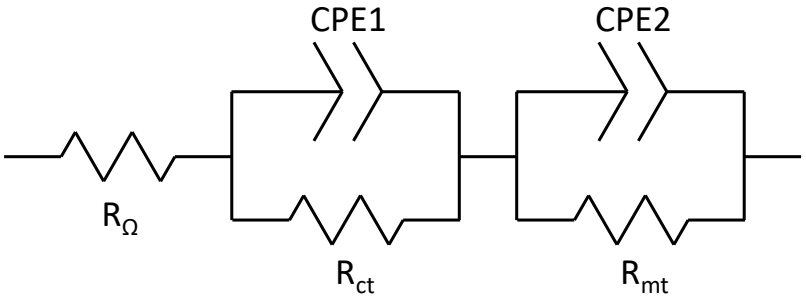


**Figure S1**. Impedance circuit used to evaluate the impedance spectra of the MEAs, where $R_\Omega$ is ohmic resistance, $R_{ct}$ is charge transfer resistance and $R_{mt}$ is mass transport resistance. $R_{ct}$ and $R_{mt}$ are each in parallel with constant phase element (CPE).

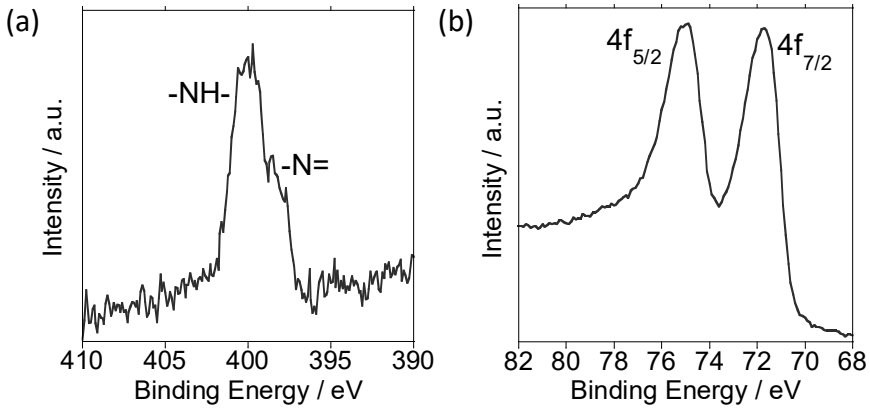


**Figure S2**. XPS survey scans of CNT/PBI/Pt for (a) N 1s and (b) Pt 4f.

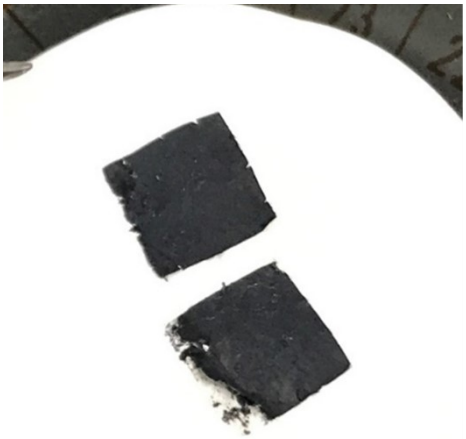

**Figure S3**. Photograph of CNT/PBI/Pt films fabricated using probe sonication in the preparation step.

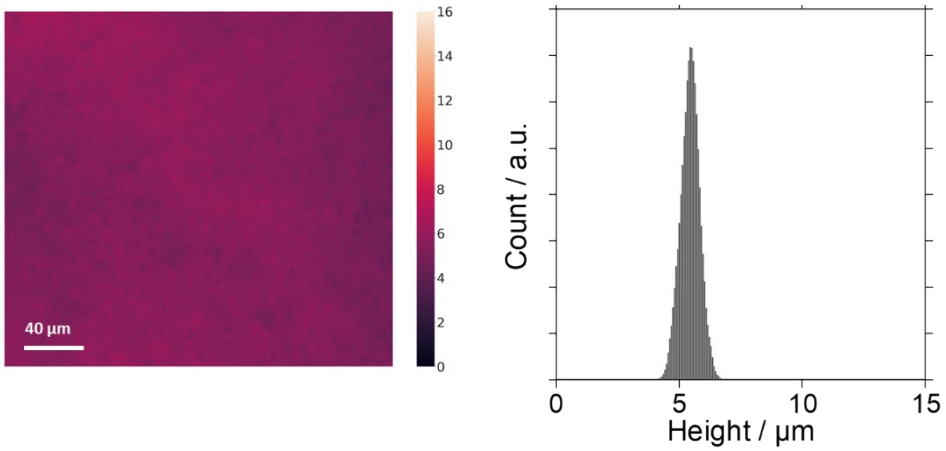


**Figure S4**. Laser microscope image (left) and height distribution (right) of PTFE membrane. Scale bar: 100 µm.

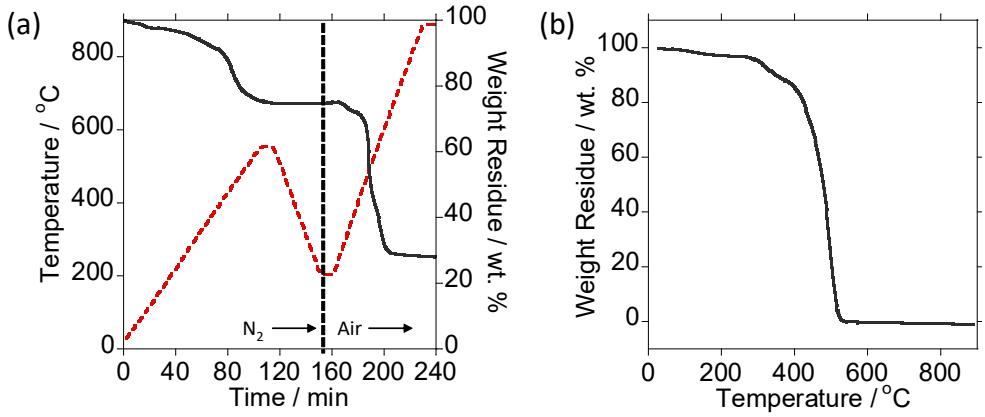


**Figure S5**. TGA curves of (a) CNT/PBI/Pt sheet after Nafion dipping and (b) Nafion obtained from drying 5 wt% Nafion solution.

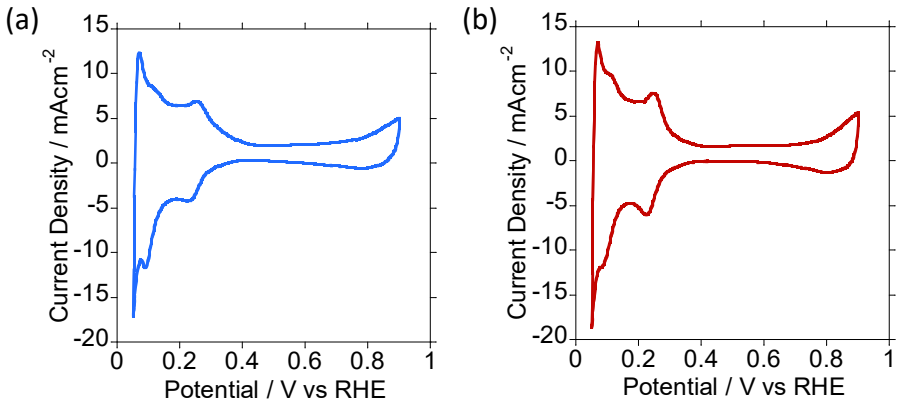


**Figure S6**. In-situ CV curves of (a) top-MEA and (b) bottom-MEA measured at 40 °C and 100% RH.

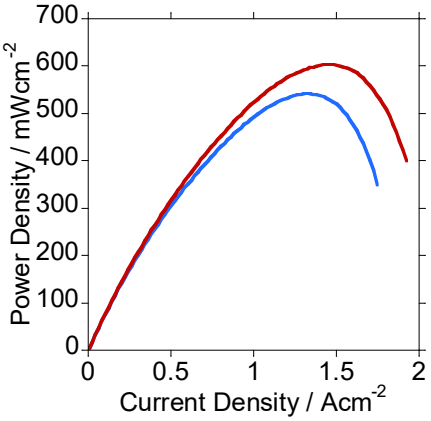


**Figure S7**. Power density curves of top-MEA (blue dotted) and bottom-MEA (red dotted) measured at 80 °C and 100%RH.

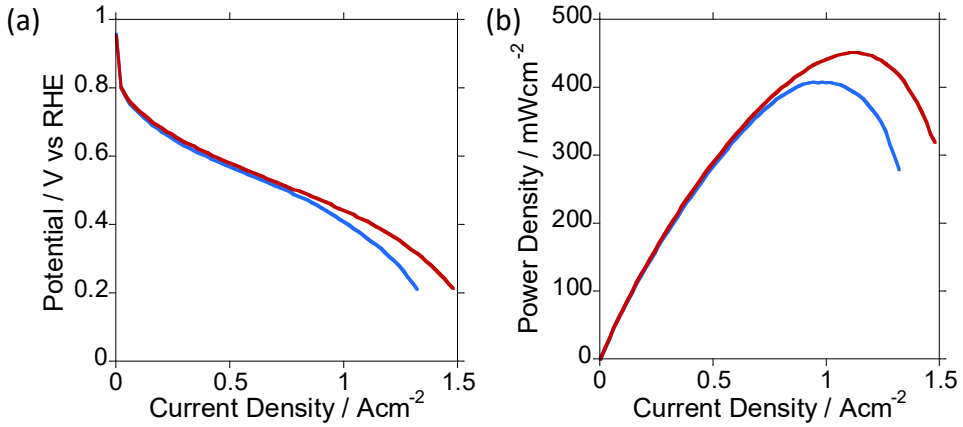


**Figure S8**. (a) Polarization and (b) power density curves of top-MEA (blue) and bottom-MEA (red), both with I/C = 0.29, measured at 80 °C and 100% R.H.

**Table S1**. Summary of resistance for each CLs evaluated at 80 °C and 100 % RH.

| **Current Density / $Acm^{-2}$** | **$R_{\Omega}$ / Ohm $cm^2$** | | **$R_{ct}$ / Ohm $cm^2$** | | **$R_{mt}$ / Ohm $cm^2$** | |
|---|---|---|---|---|---|---|
| 0.1 | Top-MEA | 0.279 | Top-MEA | 1.085 | Top-MEA | 0.309 |
| | Bottom-MEA | 0.144 | Bottom-MEA | 0.589 | Bottom-MEA | 0.250 |
| 1.0 | Top-MEA | 0.159 | Top-MEA | 0.0623 | Top-MEA | 0.630 |
| | Bottom-MEA | 0.135 | Bottom-MEA | 0.0467 | Bottom-MEA | 0.319 |