Supplemental information

Voltammetric and galvanostatic methods for measuring hydrogen crossover in fuel cell

Sida Li, Xuezhe Wei, Haifeng Dai, Hao Yuan, and Pingwen Ming
Figure S1. Fuel cell test bench, Related to STAR Methods.

Figure S2. Schematic diagram of electrochemical methods, Related to STAR Methods.
Figure S3. Signals of current response and voltage excitation in the staircase voltammetric experiment, Related to Figure 4.

Table S1. Quantities applied in the calculation of hydrogen crossover current, Related to STAR Methods.

| Quantity name                              | Unit          | Symbol | Value       |
|--------------------------------------------|---------------|--------|-------------|
| Mole fraction of hydrogen gas              | -             | \(x_{H_2}\) | 8.42\(\times 10^{-4}\) 8.29\(\times 10^{-4}\) 8.50\(\times 10^{-4}\) 8.71\(\times 10^{-4}\) 8.57\(\times 10^{-4}\) |
| Volumetric flow rate of nitrogen gas at STP| SCCM          | \(Q_{N_2}\) | 292.3       |
| Density of nitrogen gas at STP             | g·cm\(^{-3}\) | \(\rho_{N_2}\) | 1.25\(\times 10^{-3}\) |
| Molecular weight of nitrogen gas           | g·mol\(^{-1}\) | \(M_{N_2}\) | 28          |
| Number of electrons transferred in HOR     | -             | \(n\)  | 2           |
| Faraday constant                           | C·mol\(^{-1}\) | \(F\)  | 96485       |
Table S2. Measured results by three methods, Related to Figure 4 and Figure 10.

| Category                | Measurement | Hydrogen crossover rate $J_{H_2}$ (mol·s⁻¹) | Hydrogen crossover current $I_{H_2}$ (A) |
|-------------------------|-------------|---------------------------------------------|----------------------------------------|
| Direct detection method | #1          | $1.831 \times 10^{-7}$                      | $35.34 \times 10^{-3}$                 |
|                         | #2          | $1.803 \times 10^{-7}$                      | $34.79 \times 10^{-3}$                 |
|                         | #3          | $1.849 \times 10^{-7}$                      | $35.67 \times 10^{-3}$                 |
|                         | #4          | $1.894 \times 10^{-7}$                      | $36.55 \times 10^{-3}$                 |
|                         | #5          | $1.864 \times 10^{-7}$                      | $35.97 \times 10^{-3}$                 |
| Average                 |             | $1.848 \times 10^{-7}$                      | $35.66 \times 10^{-3}$                 |
| Standard deviation      |             | $0.034 \times 10^{-7}$                      | $0.66 \times 10^{-3}$                  |
| Slope $K_w$ (Ω⁻¹)       |             |                                            |                                        |
| Potential step method   | #1          | $87.25 \times 10^{-3}$                      | $35.19 \times 10^{-3}$                 |
|                         | #2          | $87.43 \times 10^{-3}$                      | $35.31 \times 10^{-3}$                 |
|                         | #3          | $86.35 \times 10^{-3}$                      | $34.72 \times 10^{-3}$                 |
|                         | #4          | $86.81 \times 10^{-3}$                      | $35.49 \times 10^{-3}$                 |
|                         | #5          | $87.49 \times 10^{-3}$                      | $35.31 \times 10^{-3}$                 |
| Average                 |             | $87.07 \times 10^{-3}$                      | $35.20 \times 10^{-3}$                 |
| Standard deviation      |             | $0.48 \times 10^{-3}$                       | $0.29 \times 10^{-3}$                  |
| PSM at RH45%            | #1          | $89.89 \times 10^{-3}$                      | $34.45 \times 10^{-3}$                 |
|                         | #2          | $88.12 \times 10^{-3}$                      | $34.63 \times 10^{-3}$                 |
|                         | #3          | $88.99 \times 10^{-3}$                      | $34.33 \times 10^{-3}$                 |
|                         | #4          | $88.23 \times 10^{-3}$                      | $34.58 \times 10^{-3}$                 |
|                         | #5          | $89.00 \times 10^{-3}$                      | $34.19 \times 10^{-3}$                 |
| Average                 |             | $88.85 \times 10^{-3}$                      | $34.44 \times 10^{-3}$                 |
| Standard deviation      |             | $0.71 \times 10^{-3}$                       | $0.18 \times 10^{-3}$                  |
| PSM at RH40%            | #1          | $92.09 \times 10^{-3}$                      | $33.90 \times 10^{-3}$                 |
|                         | #2          | $91.60 \times 10^{-3}$                      | $33.91 \times 10^{-3}$                 |
|                         | #3          | $91.58 \times 10^{-3}$                      | $34.10 \times 10^{-3}$                 |
|                         | #4          | $92.27 \times 10^{-3}$                      | $33.48 \times 10^{-3}$                 |
|                         | #5          | $92.26 \times 10^{-3}$                      | $33.93 \times 10^{-3}$                 |
| Average                 |             | $91.96 \times 10^{-3}$                      | $33.86 \times 10^{-3}$                 |
| Standard deviation      |             | $0.35 \times 10^{-3}$                       | $0.23 \times 10^{-3}$                  |
| PSM at RH35%            | #1          | $95.17 \times 10^{-3}$                      | $32.23 \times 10^{-3}$                 |
|                         | #2          | $94.75 \times 10^{-3}$                      | $32.37 \times 10^{-3}$                 |
|                         | #3          | $95.34 \times 10^{-3}$                      | $31.93 \times 10^{-3}$                 |
|                         | #4          | $95.05 \times 10^{-3}$                      | $32.42 \times 10^{-3}$                 |
|                         | #5          | $94.82 \times 10^{-3}$                      | $32.52 \times 10^{-3}$                 |
| Average                 |             | $95.03 \times 10^{-3}$                      | $32.29 \times 10^{-3}$                 |
| Standard deviation      |             | $0.24 \times 10^{-3}$                       | $0.23 \times 10^{-3}$                  |
| Galvanostatic charging method | #1      | $89.35 \times 10^{-3}$                      | $34.49 \times 10^{-3}$                 |
|                         | #2          | $92.11 \times 10^{-3}$                      | $34.55 \times 10^{-3}$                 |
|                         | #3          | $90.58 \times 10^{-3}$                      | $34.36 \times 10^{-3}$                 |
|                         | #4          | $91.25 \times 10^{-3}$                      | $34.23 \times 10^{-3}$                 |
|                         | #5          | $89.91 \times 10^{-3}$                      | $34.51 \times 10^{-3}$                 |
| Average                 |             | $90.64 \times 10^{-3}$                      | $34.43 \times 10^{-3}$                 |
| Standard deviation      |             | $1.09 \times 10^{-3}$                       | $0.13 \times 10^{-3}$                  |