Supporting Information

Electrochemical Ammonia Compression

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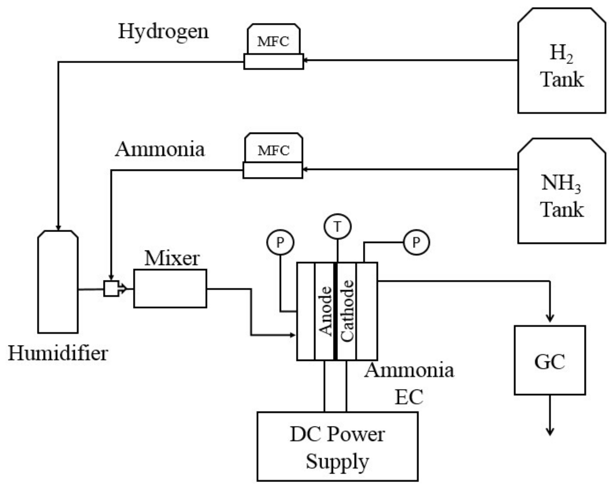

Figure S1: The schematic of electrochemical NH3 compression testing facility for in-situ GC measurement

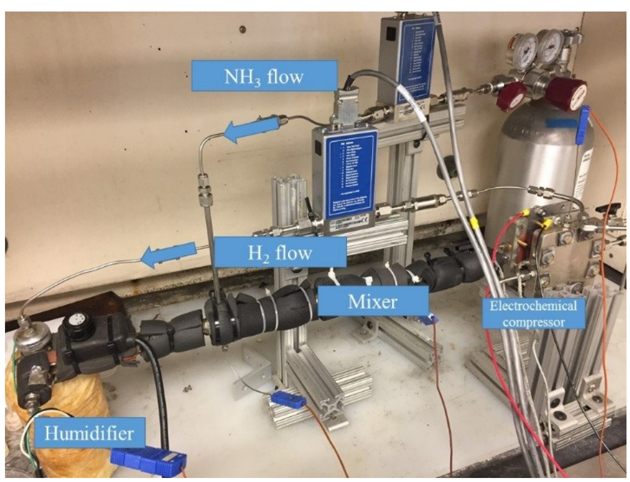

Figure S2: Picture of electrochemical ammonia compression testing facility

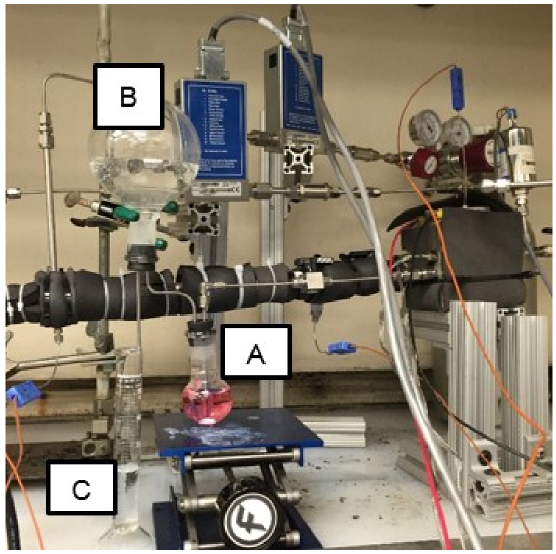

Figure S3: The titration system built for continuous quantitative analysis of NH_3 and H_2

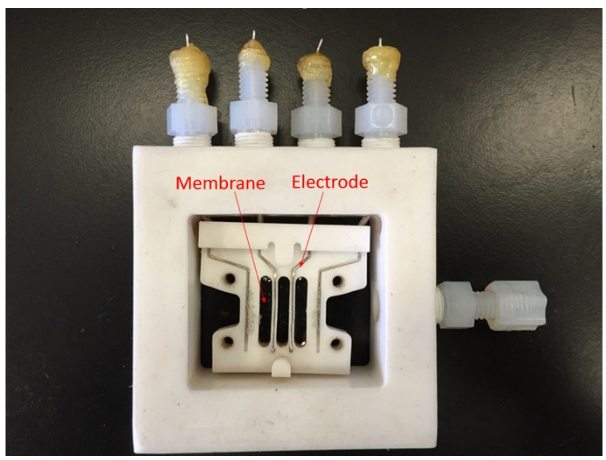

Figure S4: The membrane placed in between electrodes in BekkTech BT-112 for NH_4^+ conductivity measurement

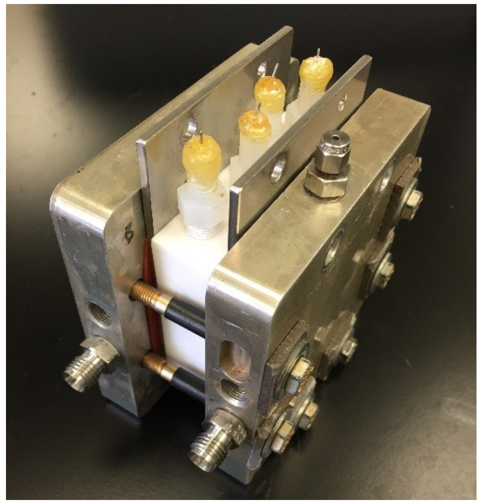

Figure S5: The BekkTech BT-112 module is sandwiched in between original electrochemical compression device, the same device shown in Figure S2 and S3

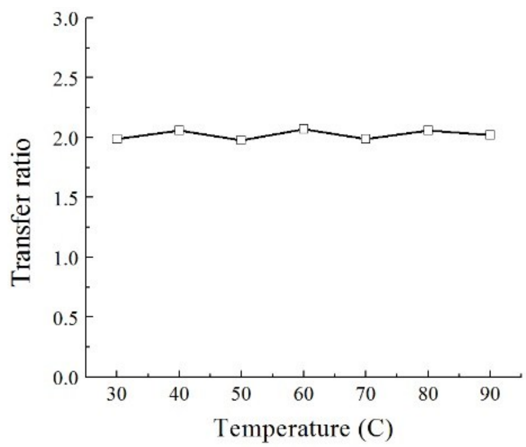

Figure S6: NH_3/H_2 transfer ratio vs. temperature

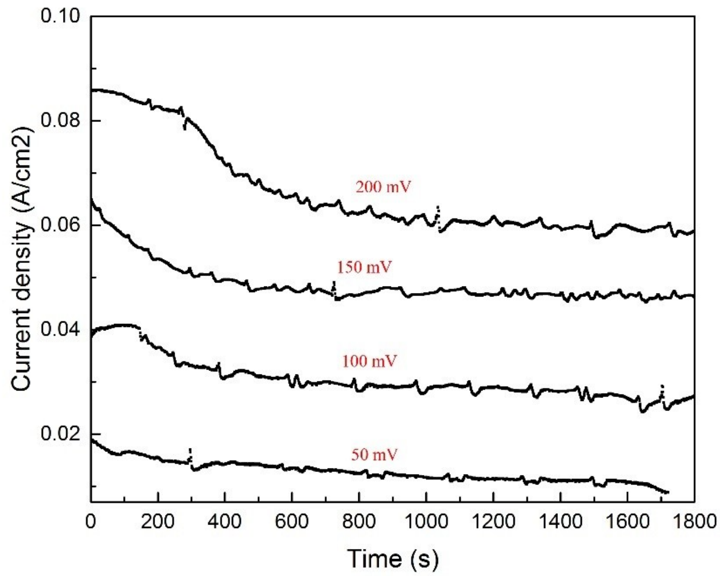

Figure S7: Current density vs time at constant voltage charge (50mV, 100mV, 150mV, 200mV) with cathode back pressure, current density decreases due to cathode pressure built up and eventually stabilizes

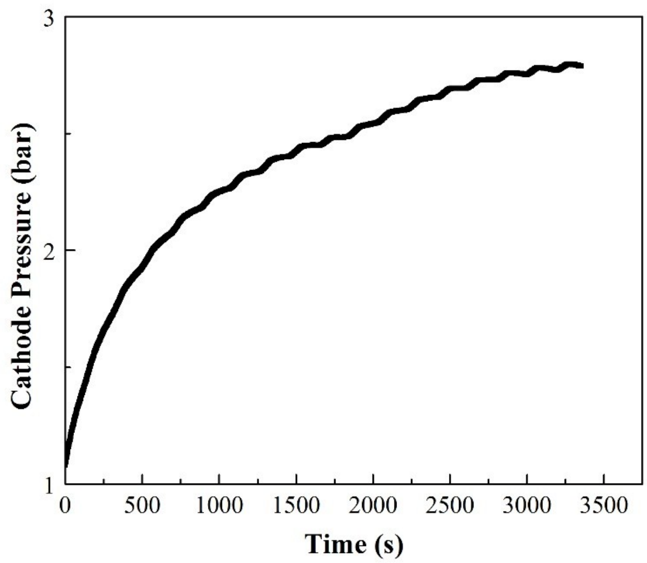

Figure S8: Cathode pressure vs. time at constant voltage of 50 mV

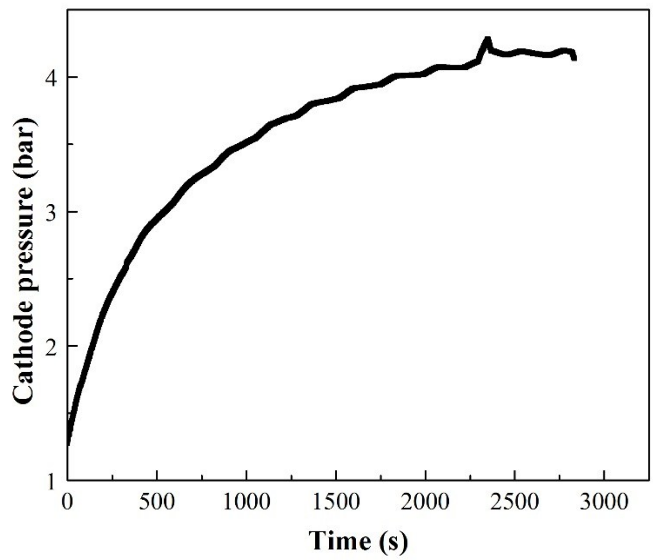

Figure S9: Cathode pressure vs. time at constant voltage of 100 mV

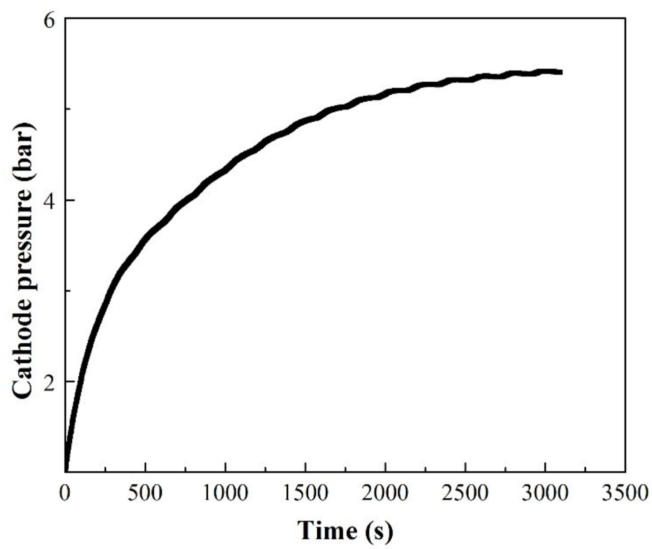

Figure S10: Cathode pressure vs. time at constant voltage of 150 mV

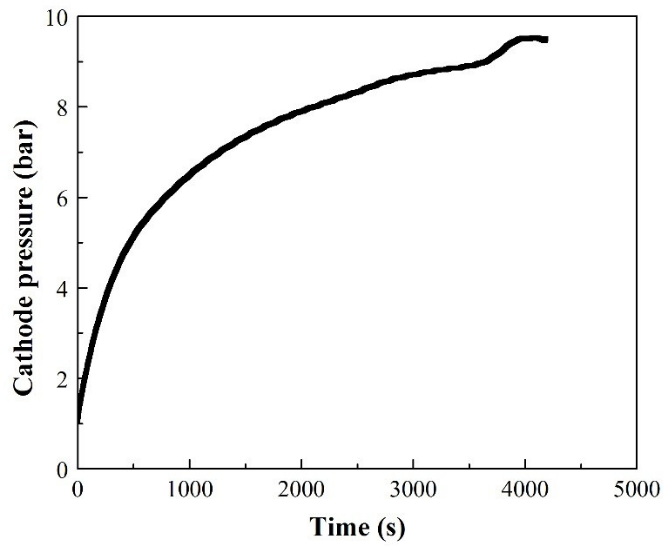

Figure S11: Cathode pressure vs. time at constant voltage of 200 mV

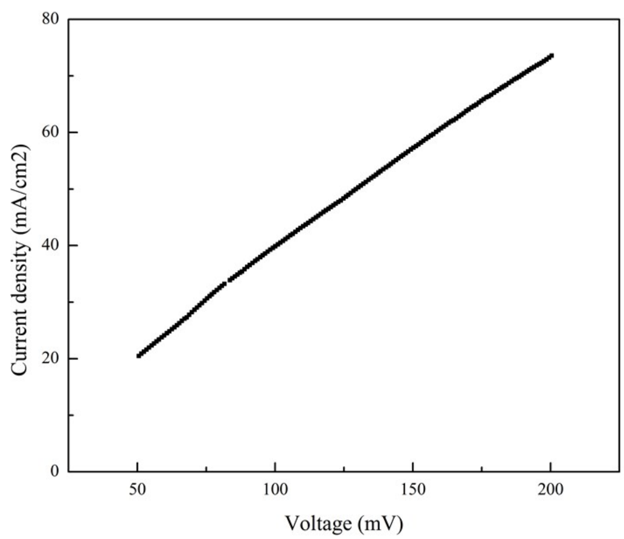

Figure S12: Measured current density vs. voltage in a linear sweep at 0.5 mV/s from 50 mV to 200 mV at 50% RH (H_2 and NH_3 supplied to anode)

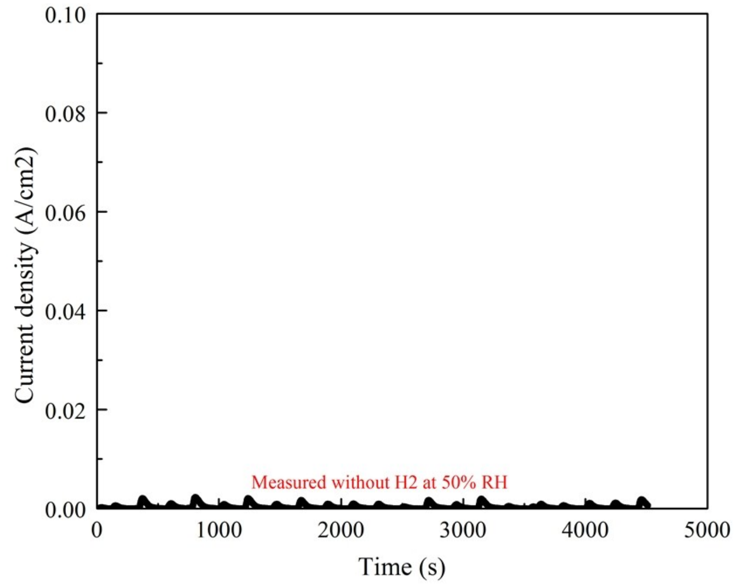

Figure S13: Current density of NH_3 flow at constant voltage 200 mV measured over time without H_2 fed to the anode (humidified NH_3 supplied to anode)

Table S1 – Feed composition in the inlet and measured composition in outlet (cathode) using titration method

Inlet feed ratio	**Measured gas molar ratio in outlet (NH_3/H_2)**
4.0	2.55
2.5	2.17
2.0	2.06

Table S2: Ammonia composition adjusted based on crossover amount due to concentration gradient

Feed Ratio	H_2 peak area (V*sec)	H_2 concentration	Original NH_3 peak area(V*sec)	Original NH_3 concentration	NH_3 crossover peak area(V*sec)	NH_3 peak area adjusted(V*sec)	NH_3 concentration adjusted	Original Gas composition ratio	Gas composition ratio adjusted
4:1	0.50	0.29	0.43	0.67	0.05	0.38	0.59	2.30	2.03
2.5:1	0.52	0.31	0.42	0.66	0.03	0.39	0.61	2.16	2.00

The adjusted gas ratio in the final column was the measured value after correcting for crossover of NH_3. For measuring the cross over amount, both anode and cathode pressure were maintained at around 1 atm.

Table S3: Comparison between titration measured flowrate and theoretical

Feed NH_3/H_2 (sccm)	Theoretical H_2 (mol/s)	Theoretical NH_3 (mol/s)	Titration measured H_2 (mol/s)	Titration measured NH_3 (mol/s)
100/50	7.25e-07	1.45e-06	8.77±0.61e-07	1.89±0.13e-06
100/50	7.25e-07	1.45e-06	8.62±0.60e-07	1.86±0.13e-06
100/50	7.25e-07	1.45e-06	8.90±0.62e-07	1.94±0.14e-06

The compression efficiency calculation:

The compression efficiency in a continuous compression system is defined in Equation S1 as the ratio between power of compression and power input. The isothermal compression work is calculated based on Equation S2, which is equal to the Nernst potential multiplied by the current. The real work input is calculated in Equation S3. Therefore the compression efficiency can be derived in Equation S4. The isothermal compression process of EC achieved by thermal management similarly implemented in PEMFC has less irreversible loss than isentropic mechanical compressor.

$$\eta_c = \frac{W_{compression}}{W_{input}} \quad (S1)$$

$$W_{compression} = \frac{RT_{EC}}{nF} \ln\left(\left(\frac{P_{H2,\ outlet}}{P_{H2,\ inlet}}\right)^{\frac{1}{2}} * \left(\frac{P_{NH3,\ outlet}}{P_{NH3,inlet}}\right)\right) \times I \quad (S2)$$

$$W_{input} = U_{cell} \times I \quad (S3)$$

$$\eta_c = \frac{W_{compression}}{W_{input}} = \frac{\frac{RT_{EC}}{nF}\ln\left(\left(\frac{P_{H2,\ outlet}}{P_{H2,\ inlet}}\right)^{\frac{1}{2}} * \left(\frac{P_{NH3,\ outlet}}{P_{NH3,inlet}}\right)\right)}{U_{cell}} \quad (S4)$$

At 50 mV of voltage supply and anode pressure around 1 bar, the cathode pressure is measured to be 2.8 bar in a continuous compression flow, and the compression ratio is 2.8, which satisfies the compression ratio required by the mechanical compressor in the ammonia vapor compression system, and the Nernst voltage is calculated by equation 6 to be 47 mV. Therefore, the electrochemical compression efficiency is 93% based on equation 10, which is much higher than 65% given by the mechanical compressor.