Supporting information

for

High indirect energy consumption in AEM-based CO_2 electrolyzers demonstrates the potential of bipolar membranes

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Electrochemical setup

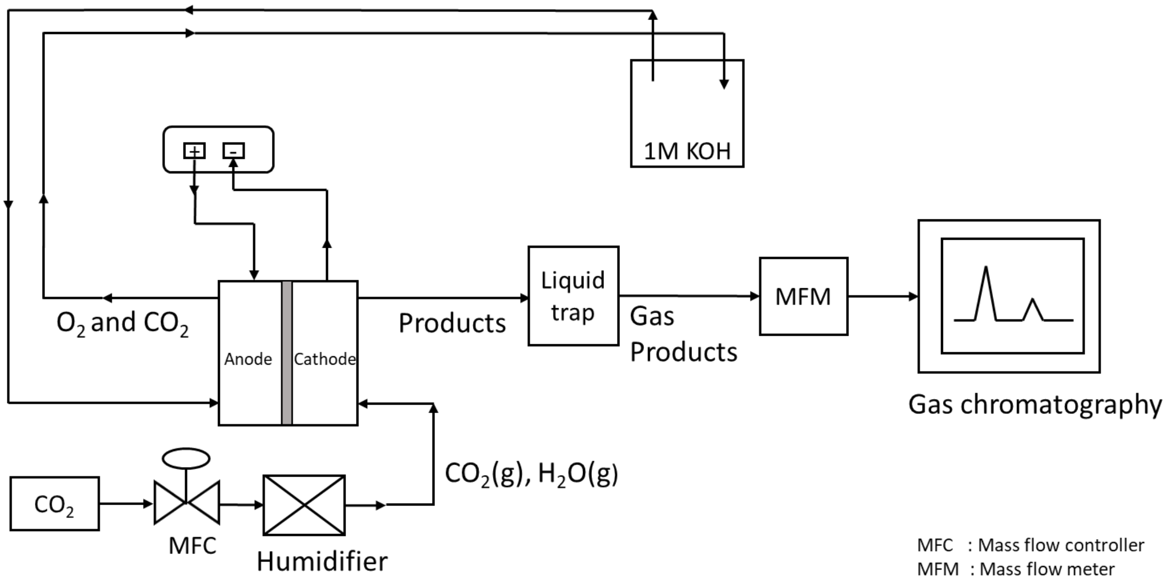

Figure S1: System design for CO_2 electro reduction.

pH for electrochemical experiments at 300 mA cm^{-2}

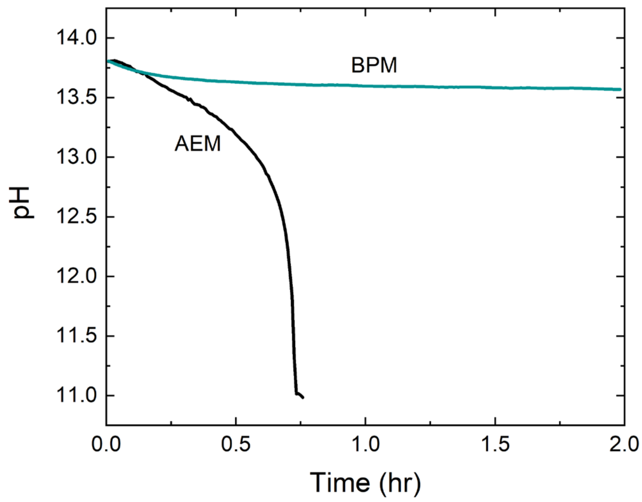

Figure S2: pH of the AEM- and BPM-based cell.

Table S1: Literature comparison of MEA-cells with Ag as cathodic catalyst with an AEM as membrane. Single pass conversion is defined as the ratio of CO_2 converted into CO vs inlet flow rate CO_2. CO_2 utilization is defined as the ratio of CO_2 converted into CO vs the total CO_2 consumed.

CO2 inlet flow rate (sccm)	**Current density (mA/cm^2)**	**Faradaic efficiency to CO (%)**	**Single pass conversion (%)**	**CO_2 utilization (%)**	**Membrane used**	**Reference**
100	100	100	-	50	Sustainion X37-50	Larrazabal et. al[1]
	300	50	-	40		
30	100	-	38	-	Sustainion X37-50	Jeng et. al[2]
120	100	-	10	-		
	300	-	20	-		
100	100	84	2	-	Sustainion X37-50	Wheeler et. al[3]
40	100	90	10.5	40	Sustainion X37-50	This work
	300	40	14	25		

Calculation of Faradaic efficiency

To estimate the Faradaic efficiency of gaseous products, the mole fractions of CO and H_2 were estimated from GC injections. The volume fraction of gas products from GC is equal to the mole fraction for ideal gases. Since the sum of mole fractions is equal to 1, the mole fraction of CO_2 exiting was calculated as,

$$x_{CO2,out} = 1 - (x_{CO} + x_{H2}) \quad \text{(S1)}$$

After calculating the mole fractions of all gaseous products, the volumetric flow rate at the outlet of the reactor measured with the MFM and used to calculate the moles of each product.

$$n_{CO} = \frac{P\dot{V}_{outlet} \times x_{CO}}{RT} \quad \text{(S2)}$$

$$n_{H2} = \frac{P\dot{V}_{outlet} \times x_{H2}}{RT} \quad \text{(S3)}$$

$$FE_{CO} = \frac{n_{CO} \times n^{e} \times F}{I} \times 100\ \% \quad \text{(S4)}$$

$$FE_{H2} = \frac{n_{H2} \times n^e \times F}{I} \times 100\ \% \qquad \text{(S5)}$$

Here: n_{CO} is moles s^{-1} of CO produced, n^e number of electrons involved in CO_2RR (2 for CO), *F* is Faradays constant 96485 C mol^{-1} and *I* applied current (in Amperes).

As an example, the Faradaic efficiencies of the experiments with 1M KOH, Sustainion at 100 mA cm^{-2} are added in Fig. S3:

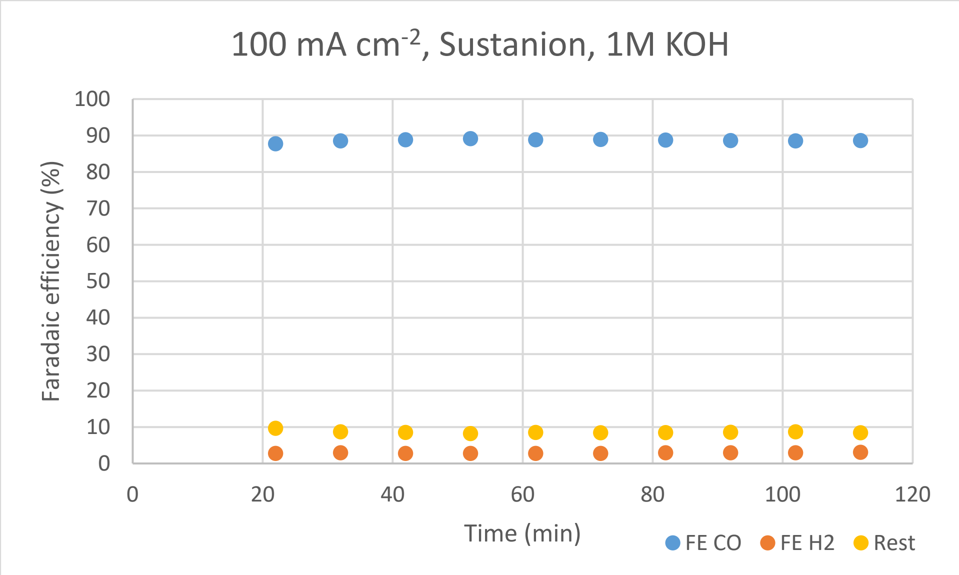

Figure S3: Faradaic efficiencies of experiment with 1M KOH, Sustanion at 100 mA cm^{-2}.

Outlet flowrate measurements

The gas flowrate at the exit of the reactor was measured continuously during electrolysis as shown in Fig S4. The FE of CO and H_2 was then calculated using Eq. S4 and Eq. S5.

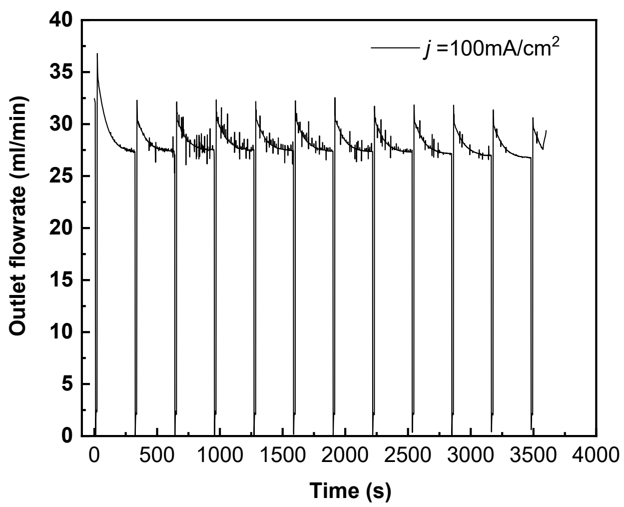

Figure S4: Outlet gas flowrate measured during electrolysis at a current density of 100 mA/cm^2 (shown for the first hour of the experiment). The drop in flowrate every 5 min are due to the periodic GC injections.