Electronic Supplementary Material (ESI) for Energy & Environmental Science.


# Blue Energy Fuels: Converting Ocean Wave Energy to Carbon-Based Liquid Fuels via $CO_2$ Reduction

*Siu-Fung Leung[1], Hui-Chun Fu[1], Maolin Zhang[1], Ali H. Hassan[1], Tao Jiang[2], Khaled N. Salama[1], Zhong Lin Wang,[3] and Jr-Hau He[1,4]**

[1]*Computer, Electrical and Mathematical Sciences and Engineering, King Abdullah University of Science and Technology, Thuwal 23955-6900, Kingdom of Saudi Arabia.*

[2]*CAS Center for Excellence in Nanoscience, Beijing Key Laboratory of Micro-nano Energy and Sensor, Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences, Beijing 100083, China.*

[3]*School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0245, USA*

[4]*Department of Materials Science and Engineering, City University of Hong Kong, Hong Kong SAR, China*

*Corresponding author e-mail: jrhau.he@kaust.edu.sa

**Supplementary information**

*Calculation about the energy generated by $CO_2RR$ system based on 1 $km^2$ TENGs*

Maximum daily production of formic acid in this work by TENGs with area of 0.04 $m^2$: 2.798 μmol

Daily production of formic acid by TENGs with area of 1 $km^2$: 69.95 mol

(Eppinger and Huang, 2017)Energy density of formic acid: 1.77 kWh/ L, Density of formic acid: 1.22 g/ mL, Molar mass of formic acid: 46.02538 g.

Energy density of formic acid produced daily by TENGs with area of 1 $km^2$= 69.95 mol * 46.02538 g /1.22 g / 1000 * 1.77 kWh = 4.67 kWh

[2]2015 World population: 7.358 x $10^9$, 2015 global energy consumption: 21.78 x $10^{12}$ kWh

The daily energy consumption per capita in the world = 21.78 x $10^{12}$ / 7.358 x $10^9$ / 365 = 8.315 KWh

Percentage: (Energy density of formic acid produced daily by TENGs with area of 1 $km^2$) / (The daily energy consumption per capita in the world) = 4.67/ 8.315 = 56 %

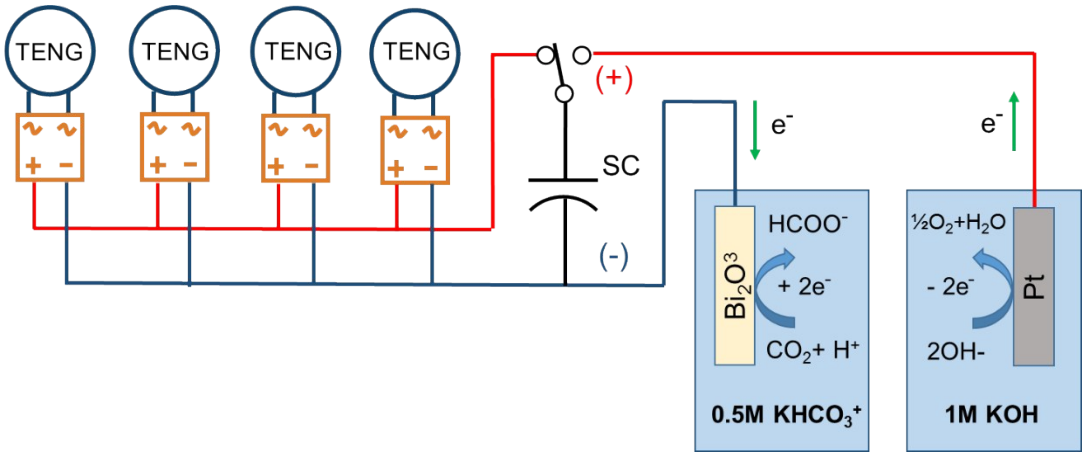


**Figure S1.** Detailed schematic diagram of the wave energy-driven $CO_2RR$ system

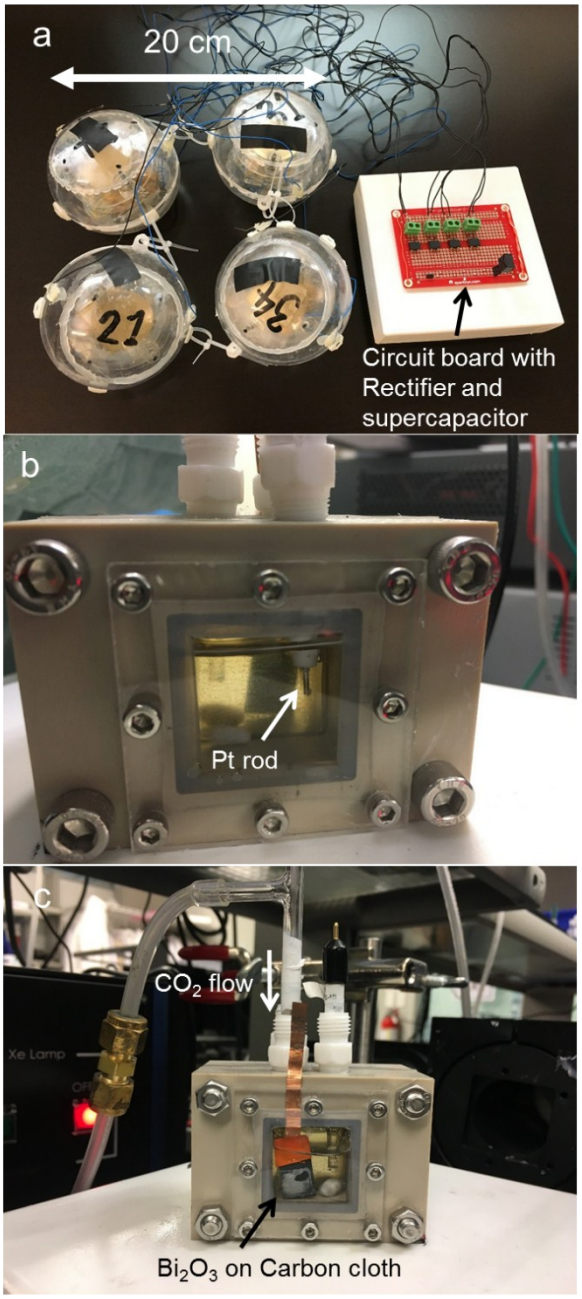


**Figure S2.** Optical images of the (a) spherical TENGs with the charge storage circuit board, electrochemical cell for (b) OER and (c) $CO_2$RR.

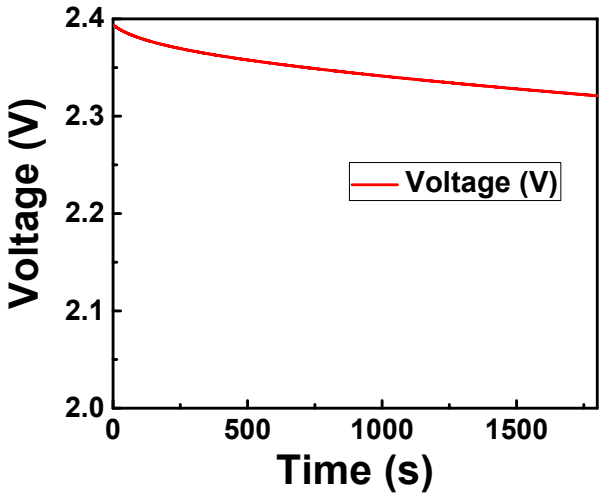


Figure S3. Self-discharge characteristic of the 0.01 F supercapacitor after charged to 2.4 V.

| FE (HCOOH) | Mean (%) | Standard deviation (%) |
|---|---|---|
| $V_{dis}$ : 3.9 V | 76 | 6.245 |
| $V_{dis}$ : 2.9 V | 96 | 3.606 |
| $V_{dis}$ : 2.4 V | 99.67 | 3.055 |

Table S1. The statistics of the $FE_{HCOOH}$ by the three discharge voltages

| | Mechanical Energy Input to TENG (J/ cycle) | Energy Stored into Capacitor (mJ/ cycle) | Energy Converted in Chemical Product (mJ/ cycle) |
|---|---|---|---|
| $V_{dis}$ : 3.9 V | 96.90 | 58 | 40.02 |
| $V_{dis}$ : 2.9 V | 48.45 | 24 | 23.28 |
| $V_{dis}$ : 2.4 V | 24.23 | 10.75 | 10.75 |

Average KE in one complete cycle = $1/4\ m\ \omega^2 a^2$

Table S2. Energies at different stages in the conversion process

Reference


- Eppinger, J., and Huang, K.W. (2017). Formic Acid as a Hydrogen Energy Carrier. ACS Energy Lett *2*, 188-195.