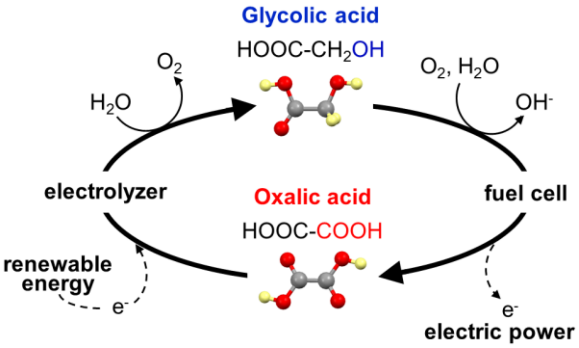
Direct electric power charge and discharge without CO_2 emission using an alcohol/carboxylic acid redox couple

Miho Yamauchi[1]
[1]*International Institute for Carbon-Neutral Energy Research, Kyushu University, Fukuoka, Japan*

E-mail:yamauchi@i2cner.kyushu-u.ac.jp

An excessive increase of CO_2 in the atmosphere is regarded as the most probable cause of global warming. A substantive transition from fossil-based systems to systems operated by electricity that is generated using renewable energy, i.e., “renewable electricity”, seems to be the optimal answer to this environmental issue. A lack of efficient distribution techniques for unstably supplied and unevenly distributed renewable electricity is one of the fundamental impediments to its practical use. Thus, electric power storage in high-energy chemicals, called “energy carriers”, has received much attention for the efficient storage and on-demand supply of renewable electricity.[1]Here, we demonstrate an electric power circulation method that does not emit CO_2 and is based on the glycolic acid (GC)/oxalic acid (OX) redox couple (Scheme 1). [2] Direct electric power storage in GC ensures considerable high energy density storage and good transportability through OX electroreduction with significantly high selectivity (>98%) using pure anatase-type titania (TiO_2) spheres under mild conditions in the potential region of -0.5 to -0.7 V vs. the RHE at 50 ºC (Figure 1). The most desirable characteristic of this electroreduction is the suppression of hydrogen evolution even in acidic aqueous media (Faraday efficiency of 70–95%, pH 2.1). We also successfully generated power without CO_2 emissions via selective electrooxidation of GC with an alkaline fuel cell.



Scheme 1 Carbon-neutral energy cycling using the **GC**/**OX** redox couple. Grey, red and yellow spheres represent carbon, oxygen and hydrogen atoms, respectively.

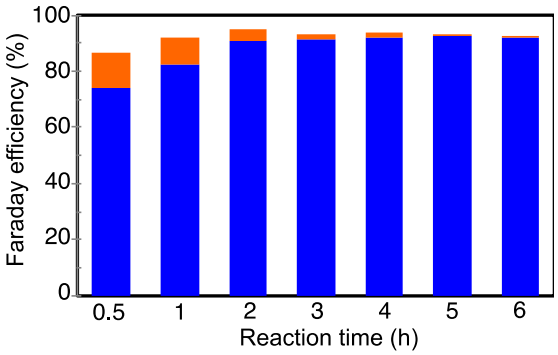


Figure 1. Faraday efficiencies for the formation of GC (blue) and glyoxlic acid(orange) at -0.7 V vs. RHE and 50 ºC.

[1]T. Matsumoto, M. Sadakiyo, M. L. Ooi, S. Kitano, T. Yamamoto, S. Matsumura, K. Kato, T. Takeguchi, M. Yamauchi.,*Scientific Report*, **4**, 5620 (2014)
[2] R. Watanabe, M. Yamauchi, M. Sadakiyo, R. Abe, T. Takeguchi, *Energy &Environmental Science*, in press

MihoYAMAUCHI
Associate Professor
International Institute for Carbon-Neutral Energy Research
Kyushu University
Fukuoka, Japan
+81-92-802-6874
yamauchi@i2cner.kyushu-u.ac.jp

Education
2001 PhD,Chemistry,University of Tsukuba

Professional Experience
Technical Officer, Department of Chemistry, University of Tsukuba, 2001-2003
Assistant Professor, Department of Chemistry, Kyushu University, 2003-2008
Associate Professor, Catalysis Research Center, Hokkaido University, 2008-2011
Associate Professor, International Institute for Carbon-Neutral Energy Research, Kyushu University, 2012-

Fields of Research
energy-related chemistry, solid state chemistry, nanomaterials, catalysis, hydrogen-related chemistry

Publications

1. T. Matsumoto, M. Sadakiyo, M. L. Ooi, T. Yamamoto, S. Matsumura, K. Kato, T. Takeguchi, N. Ozawa, M. Kubo, M Yamauchi, *Physical Chemistry Chemical Physics*, in press
2. R. Watanabe, M. Yamauchi, M. Sadakiyo, R. Abe, T. Takeguchi, *Energy & Environmental Science*, in press
3. T. Matsumoto, M. Sadakiyo, M. L. Ooi, S. Kitano, T. Yamamoto, S. Matsumura, K. Kato, T. Takeguchi, M. Yamauchi, *Scientific Report*, **4**, 5620 (2014)
4. M. Sadakiyo, H. Kasai, K. Kato, M. Takata, M. Yamauchi, *Journal of American Chemical Society*,**136**, 1702-1705 (2014)
5. M. Yamauchi, R. Abe, T. Tsukuda, K. Kato and M. Takata, *Journal of American Chemical Society*, **133**, 1150–1152 (2011)