Inversely Polarized Thermo-electrochemical Conversion via the Reaction of an Organic Redox Couple on Titanium Oxide Electrode

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Keywords: Thermo-electrochemical cell, Seebeck coefficient, Titanium dioxide, Carboxylic acid, Proton

The thermo-electrochemical (TE) conversion is a powerful tool to utilize widely distributed low-grade heat energies, such as waste, geothermal, and body heat. In particular, the TE cell can generate electric power by using the temperature differences.[1] Considering application of body heat, utilization of biocompatible redox couples is indispensable. Previously, we reported that pyruvic acid is electrochemically reduced on TiO_2/Ti mesh electrode with considerably high Faradaic efficiency. Here in this study, we demonstrate TE conversion based on redox reactions of biocompatible pyruvic acid and lactic acid on TiO_2/Ti mesh electrode as shown in Figure 1.

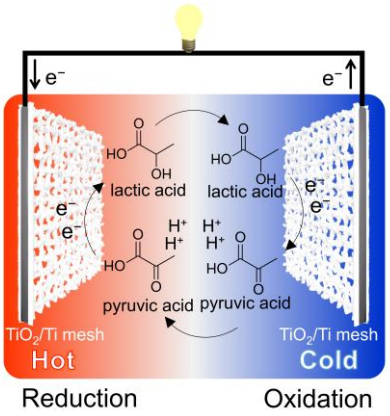

Figure 1 A scheme of thermo-electrochemical (TE) cell.

The TiO_2/Ti mesh electrode was prepared according to our previous report.[2] The XRD pattern of the prepared electrode represents that anatase type TiO_2 is contained in the electrode.

Figure 2 shows difference in open-circuit potential ($\Delta V - V_0$) plotted to the temperature difference (ΔT) between two electrodes in the TEC cell. The larger ΔT resulted in the larger $\Delta V - V_0$. This result revealed that heat energy is converted to electric power and reduction reaction of pyruvic acid occurred at hot side. The Seebeck coefficient value, which indicates the performance of a TE cell, is estimated to be 1.40 mV K^{-1}, whereas the value calculated from thermodynamic parameter for this system is −2.20 mV K^{-1}, which is contradict to the observation. DFT calculation figured out that the adsorption of intermediate species and protons on TiO_2 controls current polarity, resulting in the inversed polarization in the TE conversion on TiO_2/Ti mesh electrode.

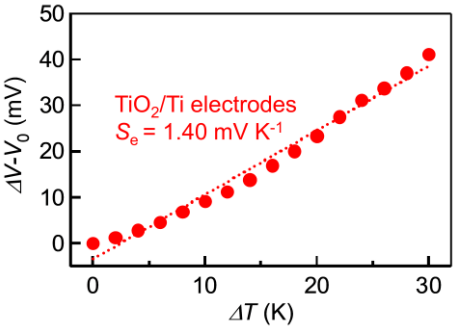

Figure 2 Difference in the open-circuit potential ($\Delta V - V_0$) and temperature difference (ΔT) of the TE cell using TiO_2/Ti mesh electrodes. V_0 is the initial open-circuit potential differences.

1) Dupont, M. F., MacFarlane, D. R., Pringle, J. M., *Chem. Commun.* **53**, 6288-6302 (2017).
2) M. Sadakiyo, S. Hata, X. Cui, M. Yamauchi, *Sci. Rep.*, **7**, 17032 (2017).