Effect of temperature on battery performance of organic-zinc redox flow batteries

Global "sukima" ideas

Atsushi Kaiho*, Tomoya Yamaji, Inaba Kenichi, Tomoya Nakajima, Keisuke Mitsui, Hideki Ichihara and Ryo Sakai

Nippon Kayaku Co., Ltd, Tokyo, Japan, *Email: atsushi.kaiho@nipponkayaku.co.jp*

Introduction

Recently, organic compounds have attracted attention as active materials for redox flow batteries. Compared with inorganic compounds, organic compounds can easily control the physical properties such as redox potential, redox stability, and solubility by changing the chemical structure. We have found a novel organic cathode material with high chemical stability and cost-competitive. We have demonstrated the organic-zinc redox flow batteries have same battery performance comparable to that of vanadium. In this study, we investigated the temperature characteristics of the organic-zinc redox flow batteries.

Open circuit voltage of organic-zinc redox flow batteries.

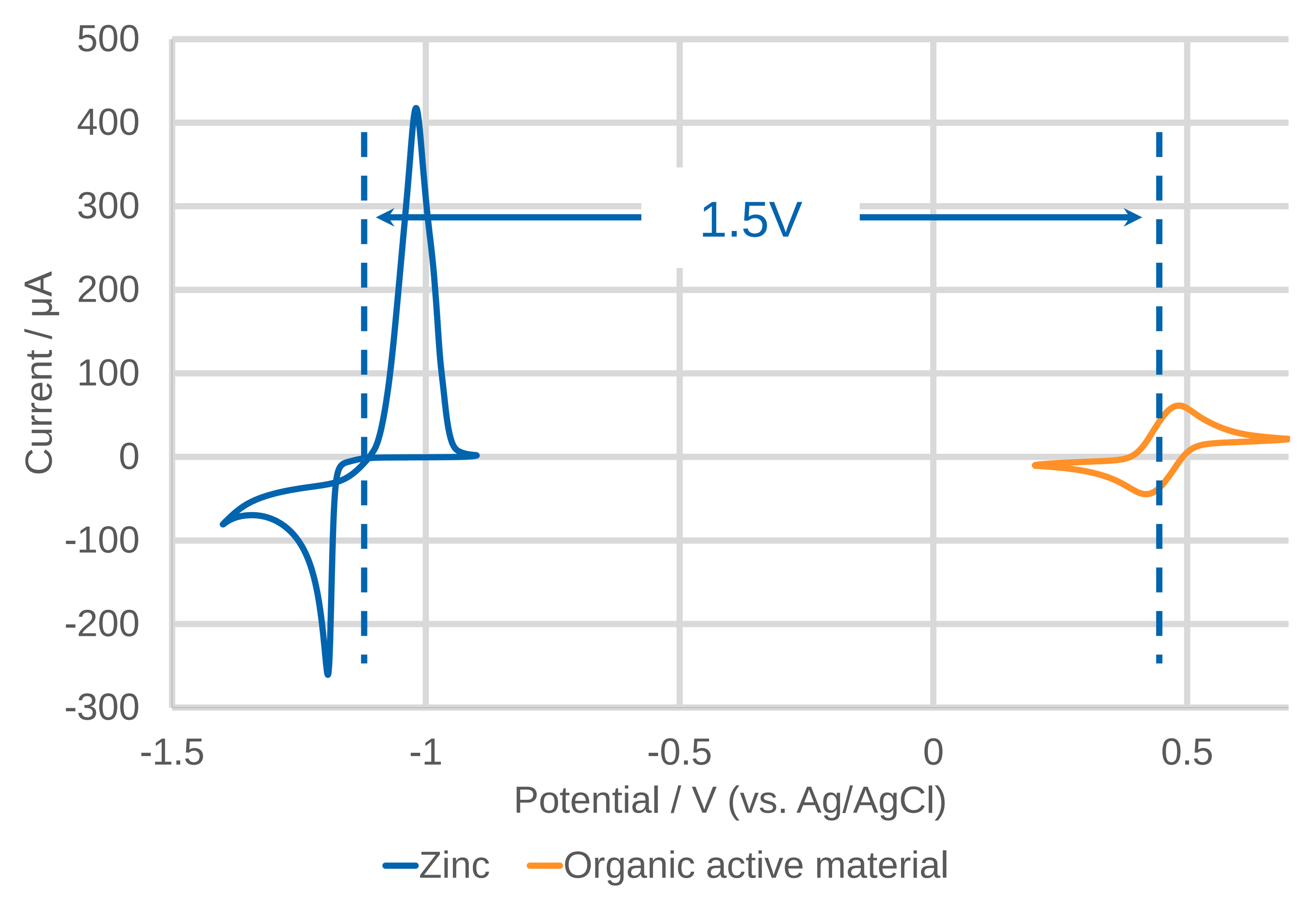

Figure 1. Cyclic voltammetry of the organic active material and Zinc at pH 3.

The redox chemistry of organic active material was assigned as two proton coupled two electron process by Nernst equation.

Physical property of each electrolyte.

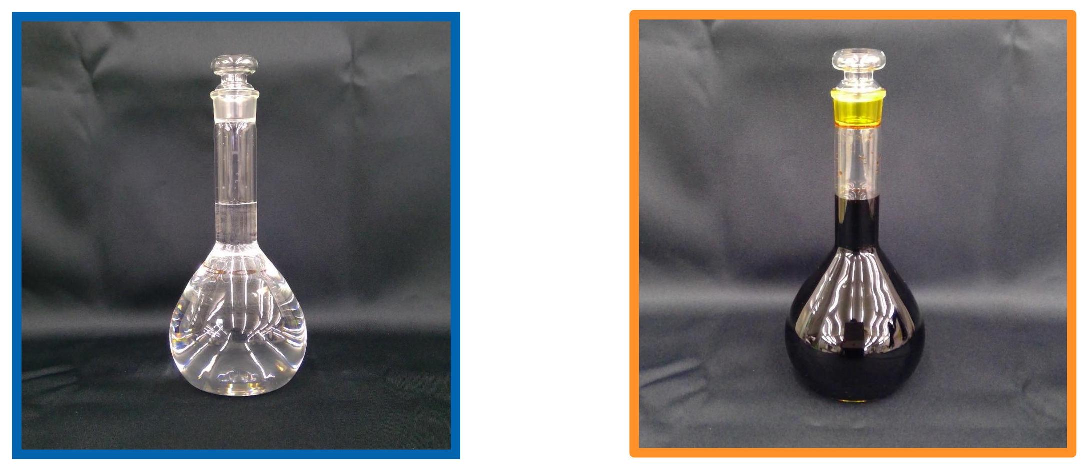

Figure 2. Pictures of Negolyte(left) and posolyte(right).

Table 1. physical property of each electrolyte at different temperature.

		Negolyte	Posolyte
Concentration		1.1M	0.55M
pH		2.98	3.63
Density (gcm^{-3})	20 °C	1.21	1.18
	40 °C	1.20	1.17
	60 °C	1.19	1.16
Kinematic Viscosity (cSt)	20 °C	1.98	12.59
	40 °C	1.24	4.34
	60 °C	0.86	2.00

Charge-discharge test at different temperature.

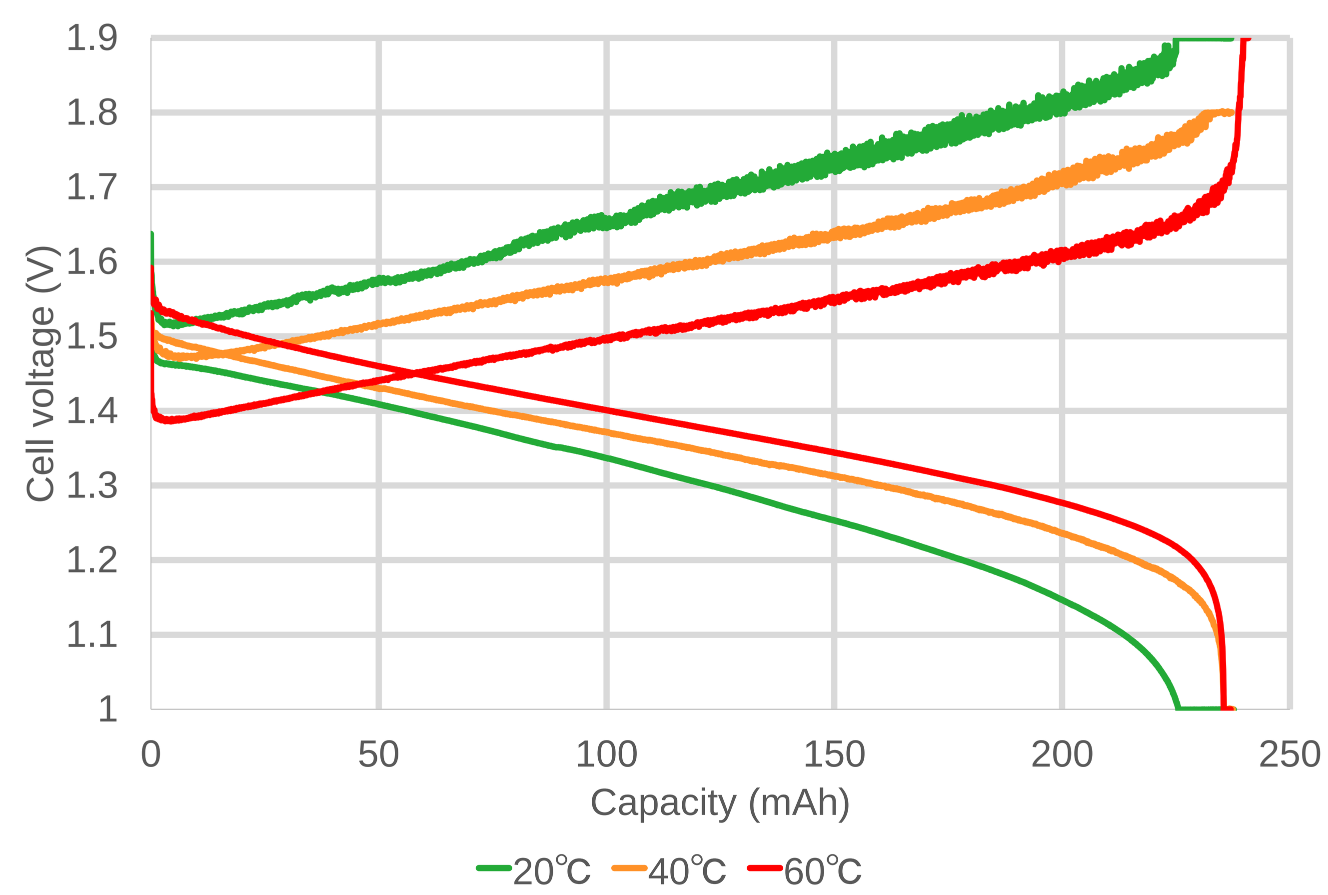

Figure 3. Charge-discharge curves of organic-zinc redox flow batteries. (Electrode for positive side: carbon felt 50mm×10mm, Membrane: Nafion, Current density: 40 mA/cm^2 CCCV, Note: Zinc plate was set at negative side.)

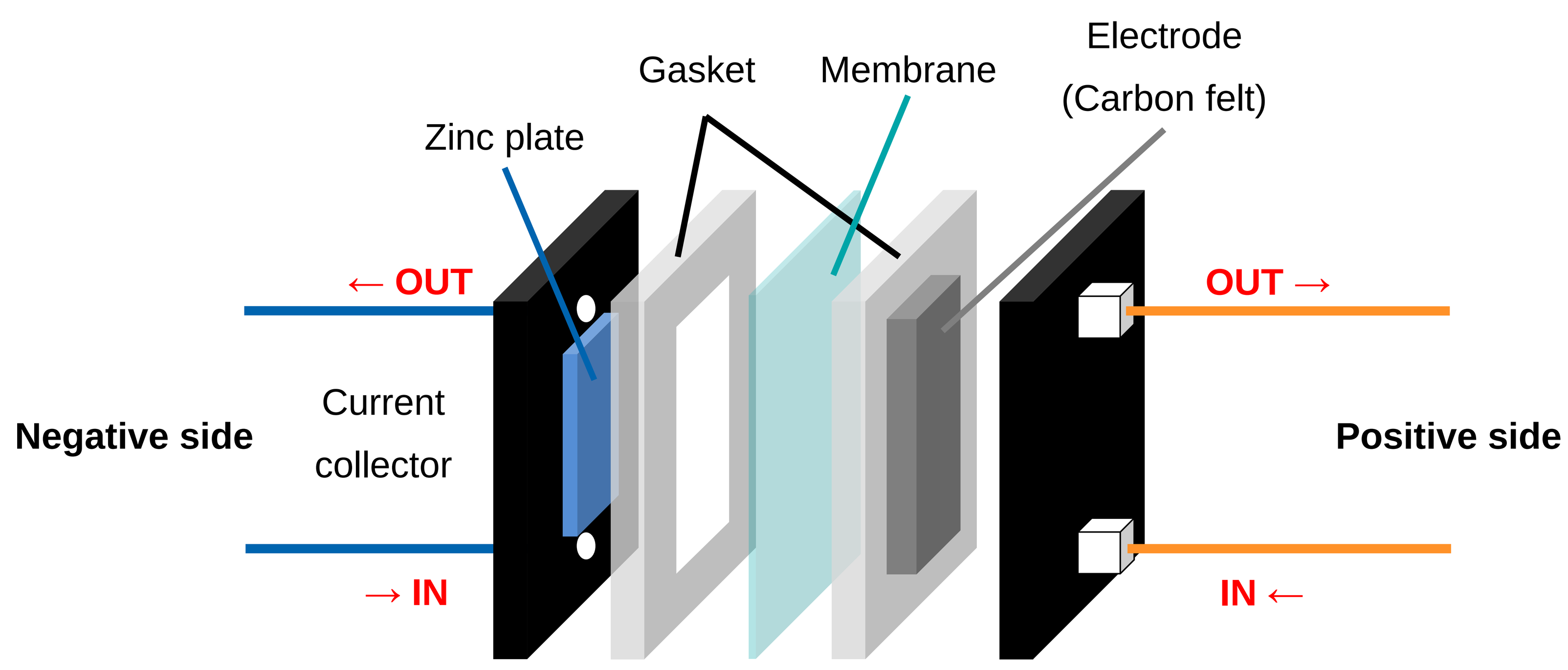

Figure 4. Schematic diagram of organic-zinc redox flow batteries.

Table 2. Battery performance of each temperature.

	20 °C	40 °C	60 °C
Coulombic eff.	100.2%	100.1%	98.4%
Potential eff.	68.0%	81.8%	87.7%
Energy eff.	76.5%	81.9%	88.7%
Energy density (Wh/L)	19.11	19.51	20.36
Cell resistivity (Ωcm^2)	9.64	3.80	2.46

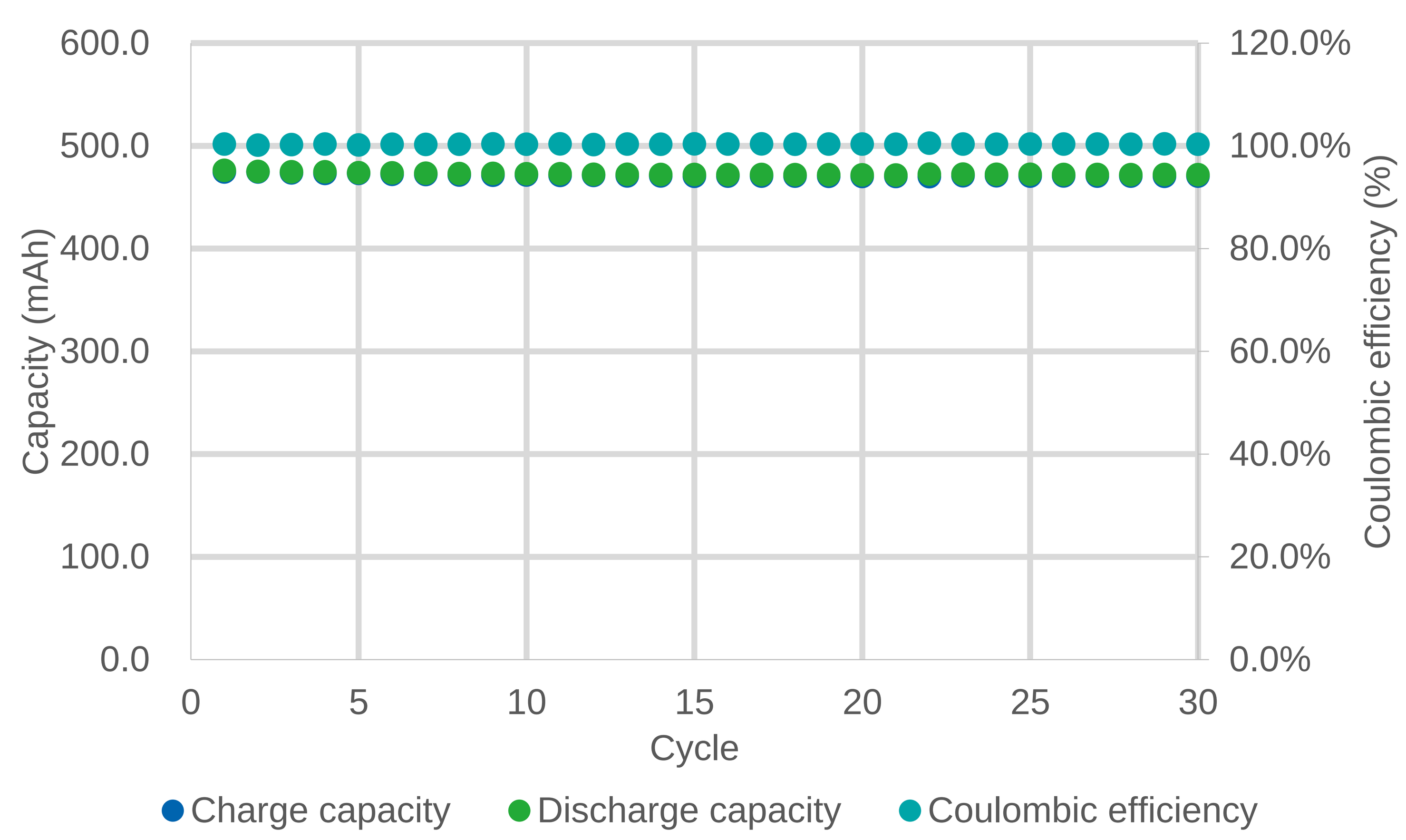

Figure 5. long cycling test at 20 °C.

Conclusion

In this study, we investigated the effect of temperature on the cell performance of organic-zinc redox flow batteries. Improvement of cell resistance was observed by raising the temperature, and a good capacity retention rate was observed at 20 °C. It is expected that it provides an electrolyte which is safer and has a low environment friendly by using a earth abandant organic material. We will further develop the electrolyte system so that it can be put into practical use.