Supporting information

Enhanced thermal electromotive force in lithiated CoP-BA/NiPBA tertiary battery

Takayuki Shibata[1*], Tomoya Ishizawa[1], Ichiro Nagai[1], Hitoshi Ohnuki[1], and Yutaka Moritomo[2]**

[1] Faculty of Marine Technology, Tokyo University of Marine Science and Technology, Etchujima 2-1-6, Ko-to-ku, Tokyo 135-8533, Japan

[2] Faculty of Pure and Applied Science, University of Tsukuba, Tennodai 1-1-1, Tsukuba, Ibaraki 305-8571, Japan

* Correspondence: tshiba0@kaiyodai.ac.jp

** Correspondence: moritomo.yutaka.gf@u.tsukuba.ac.jp

Table S1. Component ratio of Fe, Co, and Ni for Na-CoPBA and Na-NiPBA determined by electron probe microanalysis.

Compound	mole%		
	Fe	Co	Ni
Na-CoPBA	21.85 ± 0.55	25.05 ± 0.67	-
Na-NiPBA	23.61 ± 1.14	-	28.40 ± 1.51

Table S2. Component ratio of C, H, and N for Na-CoPBA and Na-NiPBA determined by CHN analysis.

Compound	wt%		
	C	H	N
Na-CoPBA	18.53	1.90	20.89
Na-NiPBA	17.68	2.32	21.08

Numerical data for Fig. 4

Li-CoPBA (E_0 = 0.30 V)

heating process

ΔT (°C) ΔE (mV)

+0.000000e+00 +2.000000e-02

+2.830000e+00 +1.295000e+00

+6.750000e+00 +2.964000e+00

+1.040000e+01 +4.869000e+00

+1.410000e+01 +7.022000e+00

cooling process

ΔT (°C) ΔE (mV)

+1.410000e+01 +7.022000e+00

+1.040000e+01 +5.302000e+00

+6.600000e+00 +3.396000e+00

+2.900000e+00 +1.452000e+00

+0.000000e+00 +3.200000e-02

Li-NiPBA (E_0 = 0.30 V)

heating process

ΔT (°C) ΔE (mV)

+0.000000e+00 -1.310000e-02

+3.170000e+00 -1.685700e+00

+7.120000e+00 -4.777000e+00

+1.084000e+01 -7.771900e+00

+1.453000e+01 -1.050200e+01

cooling process

ΔT (°C) ΔE (mV)

+1.453000e+01 -1.050200e+01

+1.090000e+01 -8.112400e+00

+7.100000e+00 -5.163000e+00

+3.300000e+00 -2.346800e+00

+1.100000e-01 -2.807500 e-02

Li-CoPBA (E_0 = 0.42 V)

heating process

ΔT (℃) ΔE (mV)

+0.000000e+00 +0.000000e+00

+3.600000e+00 +2.200000e+00

+7.200000e+00 +4.300000e+00

+1.080000e+01 +6.400000e+00

+1.430000e+01 +8.300000e+00

cooling process

ΔT (℃) ΔE (mV)

+3.600000e+00 +1.800000e+00

+7.100000e+00 +4.200000e+00

+1.070000e+01 +6.300000e+00

+1.420000e+01 +8.200000e+00

+0.000000e+00 +0.000000e+00

Li-NiPBA (E_0 = 0.42 V)

heating process

ΔT (℃) ΔE (mV)

+0.000000e+00 +0.000000e+00

+4.600000e+00 -3.500000e+00

+8.400000e+00 -7.300000e+00

+1.230000e+01 -1.070000e+01

+1.620000e+01 -1.400000e+01

cooling process

Δ*T* (℃) Δ*E* (mV)

+3.500000e+00 -2.800000e+00

+7.300000e+00 -6.100000e+00

+1.100000e+01 -9.600000e+00

+1.580000e+01 -1.360000e+01

+0.000000e+00 +0.000000e+00

Na-CoPBA (E_0 = 0.46 V)

heating process

Δ*T* (℃) Δ*E* (mV)

+0.000000e+00 +0.000000e+00

+4.700000e+00 +2.800000e+00

+8.600000e+00 +4.700000e+00

+1.240000e+01 +6.800000e+00

+1.630000e+01 +8.100000e+00

cooling process

Δ*T* (℃) Δ*E* (mV)

+1.630000e+01 +8.000000e+00

+1.160000e+01 +5.700000e+00

+7.700000e+00 +4.000000e+00

+3.900000e+00 +2.100000e+00

+0.000000e+00 +0.000000e+00

Na-NiPBA (E_0 = 0.46 V)

heating process

Δ*T* (℃) Δ*E* (mV)

+0.000000e+00 +0.000000e+00

+4.620000e+00 -2.200000e+00

+8.360000e+00 -4.000000e+00

+1.215000e+01 -5.900000e+00

+1.579000e+01 -7.800000e+00

cooling process

Δ*T* (℃) Δ*E* (mV)

+1.563000e+01 -7.800000e+00

+1.095000e+01 -5.600000e+00

+7.240000e+00 -3.600000e+00

+3.410000e+00 -1.800000e+00

+0.000000e+00 +0.000000e+00

Numerical data for Fig. 8

LTB1

Cycle, V_{TB} (mV) at T_H, V_{TB} (mV) at T_L, Q_{TB} (mAh/g) at T_H, Q_{TB} (mAh/g) at T_L, W_{TB} (μAh/g) at T_H, W_{TB} (μAh/g) at T_L

1, 19.7, 22.0, 0.68, 0.73, 6.3, 7.3

2, 18.7, 23.1, 0.59, 0.77, 5.3, 8.2

3, 18.4, 23.4, 0.53, 0.78, 4.9, 8.4

4, 18.4, 23.7, 0.52, 0.78, 4.7, 8.7

5, 18.6, 23.9, 0.52, 0.78, 4.6, 8.7

6, 18.6, 24.2, 0.51, 0.80, 4.6, 8.9

7, 19.0, 24.3, 0.51, 0.79, 4.7, 8.9

8, 18.9, 24.3, 0.50, 0.78, 4.6, 8.9

9, 18.7, 24.4, 0.49, 0.78, 4.4, 8.9

10, 18.6, 24.4, 0.49, 0.77, 4.4, 8.7

LTB2

Cycle, V_{TB} (mV) at T_H, V_{TB} (mV) at T_L, Q_{TB} (mAh/g) at T_H, Q_{TB} (mAh/g) at T_L, W_{TB} (μAh/g) at T_H, W_{TB} (μAh/g) at T_L

1, 28.5, 29.6, 0.86, 1.31, 11.1, 16.6

2, 25.0, 29.5, 0.67, 1.23, 7.5, 15.4

3, 24.7, 29.2, 0.61, 1.14, 6.9, 14.2

4, 24.4, 28.9, 0.58, 1.09, 6.5, 13.3

5, 23.9, 28.7, 0.56, 1.04, 6.1, 12.5

6, 23.8, 28.5, 0.54, 1.00, 5.8, 11.9

7, 23.9, 28.3, 0.53, 0.96, 5.6, 11.4

8, 23.5, 28.2, 0.51, 0.90, 5.4, 11.0

9, 22.6, 28.0, 0.48, 0.92, 4.8, 10.8

10, 23.4, 28.0, 0.49, 0.90, 5.1, 10.4

STB

Cycle, V_{TB} (mV) at T_H, V_{TB} (mV) at T_L, Q_{TB} (mAh/g) at T_H, Q_{TB} (mAh/g) at T_L, W_{TB} (μAh/g) at T_H, W_{TB} (μAh/g) at T_L

1, 25.0, 23.3, 2.44, 2.02, 31.7, 21.9

2, 22.1, 23.3, 1.72, 1.97, 17.8, 21.5

3, 21.8, 23.3, 1.64, 1.89, 16.9, 20.7

4, 21.6, 23.2, 1.59, 1.84, 16.3, 20.0

5, 21.6, 23.1, 1.56, 1.80, 15.8, 19.5

6, 21.7, 23.1, 1.51, 1.76, 15.5, 19.0

7, 21.5, 23.1, 1.47, 1.72, 15.1, 18.6

8, 21.6, 23.1, 1.43, 1.69, 14.5, 18.2

9, 21.3, 23.0, 1.40, 1.66, 14.2, 17.8

10, 21.3, 23.0, 1.36, 1.61, 13.9, 17.2