Supporting information

Criteria for evaluating lithium-air batteries in academia to correctly predict the practical performance in industry

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Table S1. Parameters used in energy density simulation of lithium–oxygen batteries

Carbon electrode	Capacity	2000	2000	8000	$mAh/g^{electrode}$
	Mass loading	1.0	4.0	1.0	mg/cm^2
	Thickness	100	300	100	μm
	Porosity	95	95	95	%
Electrolyte in carbon electrode	injection ratio	100	60	60	%
	Mass loading	10.4	41.7	6.27	mg/cm^2
Separator	Mass loading	5.12	1.08	1.08	mg/cm^2
	Thickness	260	20	20	μm
	Porosity	91	45	45	%
Electrolyte in separator	Mass loading	26.5	0.89	0.89	mg/cm^2
Gas-diffusion layer	Mass loading	4.11			mg/cm^2
	Thickness	110			μm
Lithium foil	Mass loading	2.67			mg/cm^2
	Thickness	50			μm
Cupper foil	Mass loading	7.16			mg/cm^2
	Thickness	8			μm
Total weight		56.96	44.93	23.18	mg/cm^2
Total electrolyte		36.9	25.91	7.16	mg/cm^2
E/C		36.9	6.47	1.79	g/Ah
Average discharge voltage		2.7			V
Areal capacity		1	4	4	mAh/cm^2
Energy density		47.4	230.3	465.9	Wh/kg

Table S2. Summarized version of energy density estimation

carbon	electrolyte	lithium	other components	Energy density	E/C	Cycle number	ref number
mg/cm2	mg/cm2	mg/cm2	mg/cm2	Wh/kg	g/Ah		
1.00	8.30	2.67	2.88	543.4	2.8	6	3
5.40	28.20	5.34	24.32	172.0	7.1	37	3
30.00	40.82	8.54	10.48	411.7	3.0	2	4
30.00	40.82	8.54	10.48	298.1	4.2	3	4
30.00	40.82	8.54	10.48	205.1	6.1	4	4
30.00	40.82	8.54	10.48	103.5	12.1	8	4
0.20	59.80	11.00	9.00	393.8	4.7	11	5
0.20	59.80	11.00	9.00	37.5	49.8	170	5
7.50	87.50	26.70	16.39	195.5	8.8	7	6
7.50	87.50	26.70	16.39	81.5	19.4	40	6
7.50	87.50	26.70	16.39	54.3	29.2	45	6
7.50	87.50	26.70	16.39	27.2	58.3	315	6
0.20	140.13	21.36	16.39	3.1	700.6	165	11
0.40	52.00	2.67	16.39	37.8	52.0	190	12
1.50	57.50	2.67	16.39	17.2	115.0	100	13
1.50	57.50	2.67	16.39	8.6	230.0	400	13
0.65	53.25	2.67	16.39	24.3	81.9	300	14
0.01	84.62	2.67	16.39	0.4	6001.1	260	15
0.45	52.25	2.67	16.39	16.9	116.1	144	16
0.50	52.50	2.67	16.39	9.0	210.0	180	17
1.00	99.00	10.00	16.39	21.4	99.0	90	18
0.70	44.00	26.70	16.39	21.5	62.9	146	19
0.40	52.00	2.67	16.39	7.6	260.0	200	20
1.00	55.00	10.68	16.39	16.6	110.0	109	21
0.10	25.63	13.35	16.39	2.5	512.6	550	22
6.66	83.30	10.68	16.39	46.1	41.7	23	23

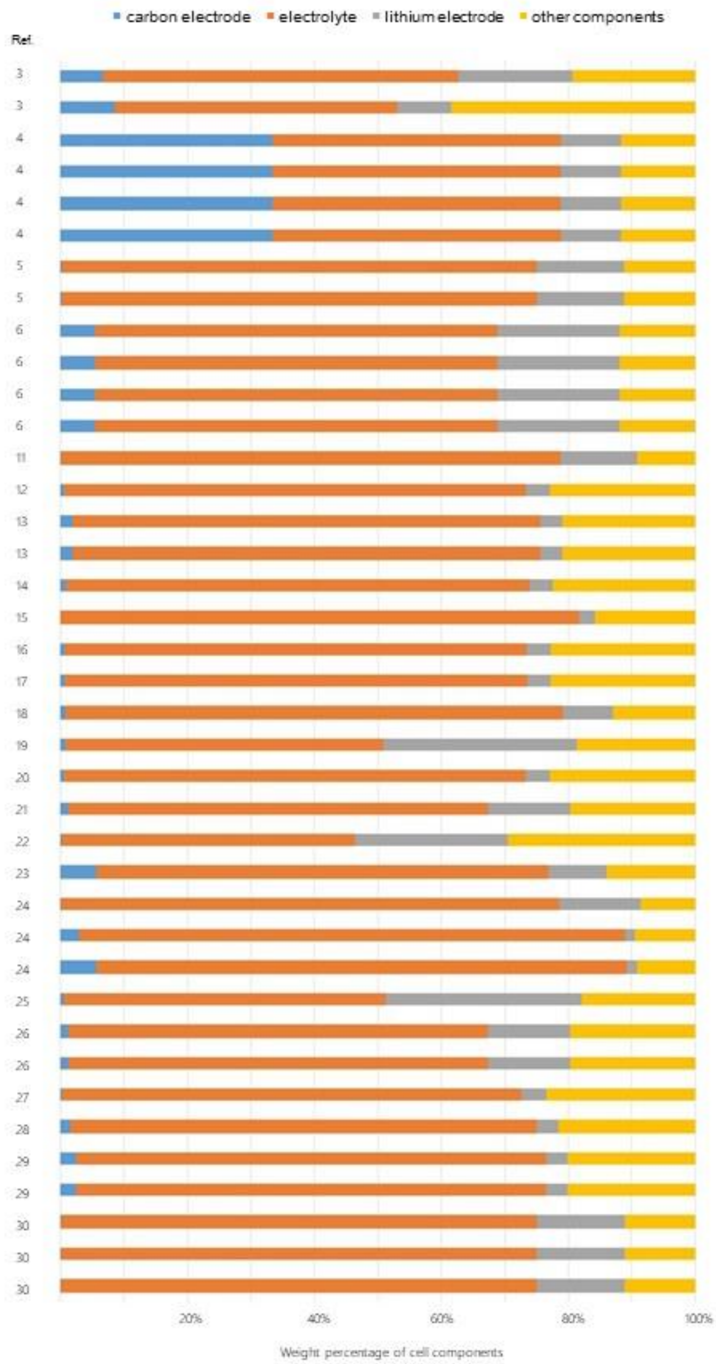
0.25	148.50	24.03	16.39	3.6	594.0	50	24
5.00	148.50	2.67	16.39	31.3	74.3	15	24
10.00	148.50	2.67	16.39	30.4	74.3	20	24
0.50	52.50	32.04	18.45	7.7	175.0	200	25
1.00	55.00	10.68	16.39	16.6	110.0	40	26
1.00	55.00	10.68	16.39	3.3	550.0	170	26
0.10	50.50	2.67	16.39	19.4	101.0	237	27
1.20	56.00	2.67	16.39	10.6	186.7	160	28
2.00	60.00	2.67	16.39	13.2	150.0	105	29
2.00	60.00	2.67	16.39	58.0	30.0	18	29
0.10	110.00	20.29	16.39	1.9	1100.0	2000	30
0.10	110.00	20.29	16.39	1.9	1100.0	100	30
0.10	110.00	20.29	16.39	1.8	1100.0	300	30

Table S3. Summarized version of energy density estimation for *"Advanced type of LABs"*

carbon	electrolyte	lithium	other components	Energy density	E/C	Cycle number	ref number
mg/cm2	mg/cm2	mg/cm2	mg/cm2	Wh/kg	g/Ah		
1.00	8.30	2.67	2.88	543.4	2.8	6	3
5.40	28.20	5.34	2.88	183.6	7.1	37	3
30.00	40.82	8.54	2.88	449.7	3.0	2	4
30.00	40.82	8.54	2.88	325.7	4.2	3	4
30.00	40.82	8.54	2.88	224.0	6.1	4	4
30.00	40.82	8.54	2.88	113.0	12.1	8	4
0.20	59.80	11.00	2.88	421.1	4.7	11	5
0.20	59.80	11.00	2.88	40.1	49.8	170	5
7.50	87.50	26.70	2.88	209.9	8.8	7	6
7.50	87.50	26.70	2.88	87.5	19.4	40	6
7.50	87.50	26.70	2.88	58.3	29.2	45	6
7.50	87.50	26.70	2.88	29.2	58.3	315	6
0.20	140.13	21.36	2.88	3.2	700.6	165	11
0.40	52.00	2.67	2.88	43.6	52.0	190	12
1.50	57.50	2.67	2.88	19.5	115.0	100	13
1.50	57.50	2.67	2.88	9.8	230.0	400	13
0.65	53.25	2.67	2.88	27.9	81.9	300	14
0.01	84.62	2.67	2.88	0.4	6001.1	260	15
0.45	52.25	2.67	2.88	19.5	116.1	144	16
0.50	52.50	2.67	2.88	10.4	210.0	180	17
1.00	99.00	10.00	2.88	23.1	99.0	90	18
0.70	44.00	26.70	2.88	24.1	62.9	146	19
0.40	52.00	2.67	2.88	8.8	260.0	200	20
1.00	55.00	10.68	2.88	18.7	110.0	109	21
0.10	25.63	13.35	2.88	3.0	512.6	550	22
6.66	83.30	10.68	2.88	50.2	41.7	23	23

0.25	148.50	24.03	2.88	3.8	594.0	50	24
5.00	148.50	2.67	2.88	33.1	74.3	15	24
10.00	148.50	2.67	2.88	32.1	74.3	20	24
0.50	52.50	32.04	2.88	8.6	175.0	200	25
1.00	55.00	10.68	2.88	18.7	110.0	40	26
1.00	55.00	10.68	2.88	3.7	550.0	170	26
0.10	50.50	2.67	2.88	22.4	101.0	237	27
1.20	56.00	2.67	2.88	12.1	186.7	160	28
2.00	60.00	2.67	2.88	14.9	150.0	105	29
2.00	60.00	2.67	2.88	65.7	30.0	18	29
0.10	110.00	20.29	2.88	2.0	1100.0	2000	30
0.10	110.00	20.29	2.88	2.0	1100.0	100	30
0.10	110.00	20.29	2.88	2.0	1100.0	300	30

Figure S1 . Weight percentage of cell components in LABs used for energy density simulation



Note S1. Supplementary comments for energy density simulation

For calculating the weight of the electrolyte, the specific gravity was set as 1.1 g/cm^3. If the amount of electrolyte is not specified, the sum of the amount of the electrolyte in the carbon positive electrode and the electrolyte in the separator was taken as the total amount of the electrolyte. The amount of the electrolyte in the carbon electrode was estimated as 5 times the weight of carbon electrode. The electrolyte in the separator was set to 26.5 mg/cm^2 for glass fiber based separator and 0.89 mg/cm^2 for PO separator. If it not mentioned in the literatures, 50 μm thickness Li foil (2.67 mg/cm^2), 8 μm thickness Cu foil (7.16 mg/cm^2) 110 μm thickness carbon fiber based membrane (4.11 mg/cm^2) were utilized as negative electrode, current collector and gas-diffusion layer. The details of the energy density estimation in Figure 2 was described in Supporting data file.

Figure S2. Summary of electrolyte injection technique

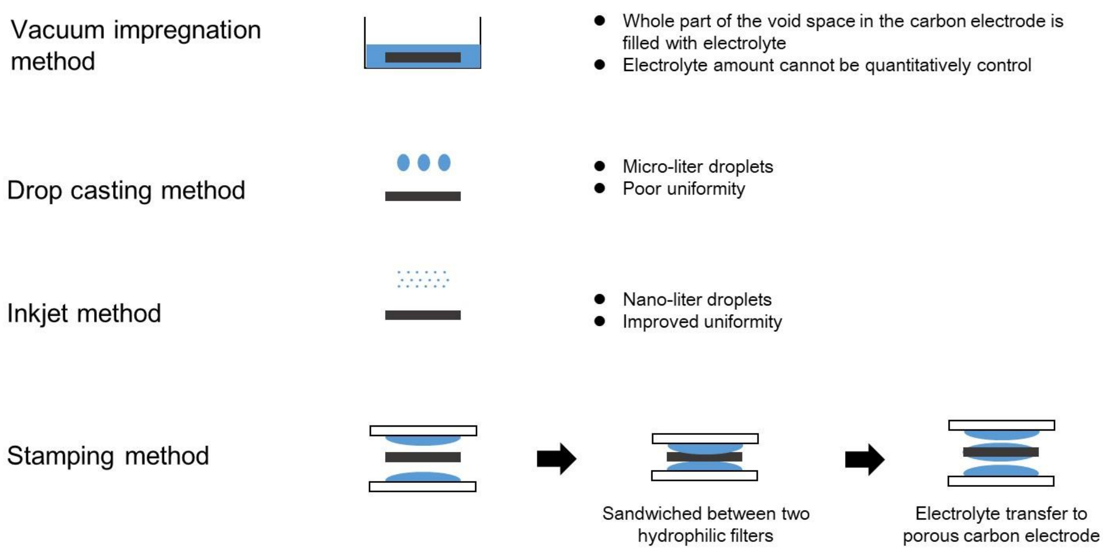


Figure S3. Unique degradation mechanism in LABs with lean-electrolyte

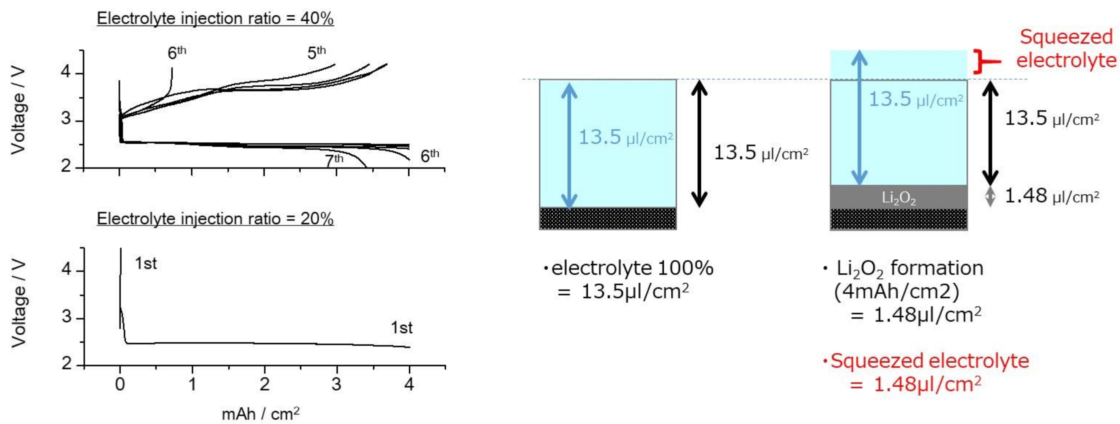


Figure S4. Schematic illustration of proposed standard LAB cell