Supporting information

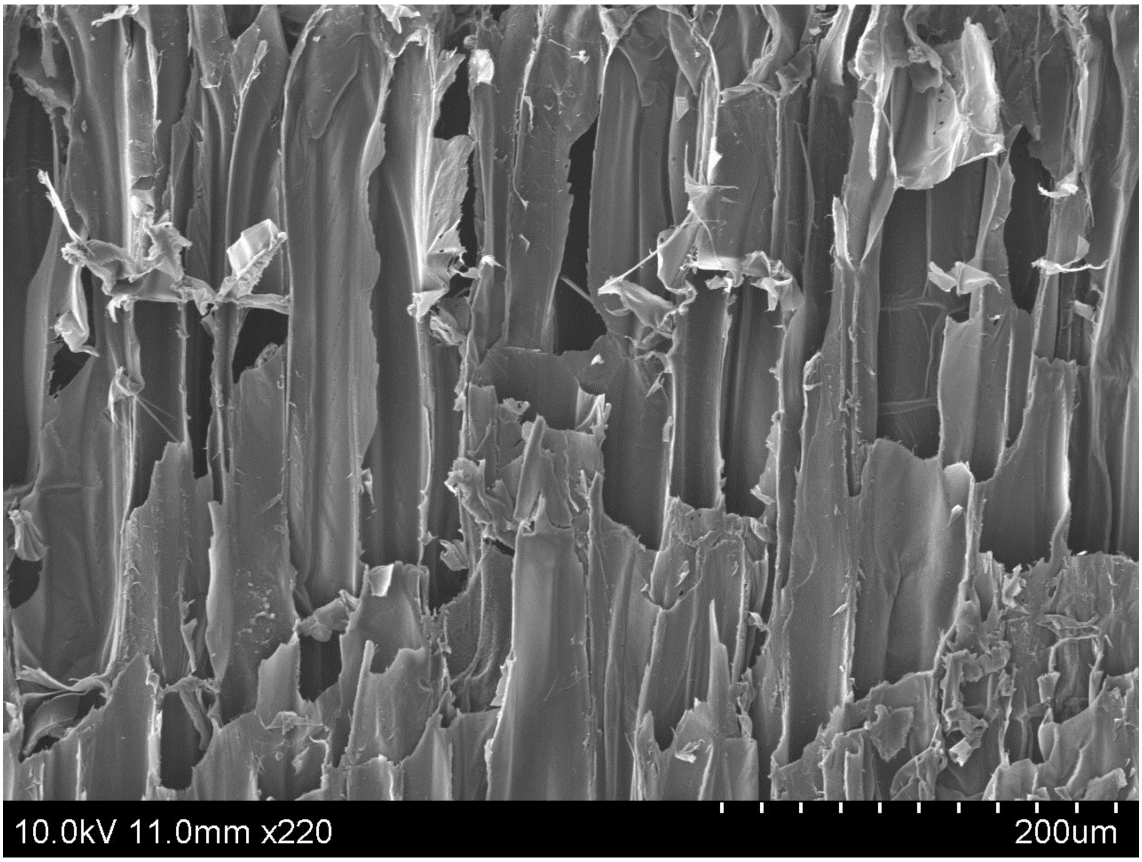

Figure S1. SEM image of the cross section of the cathode. Open channels can be observed which ensures unobstructed flow for CO_2 gas.

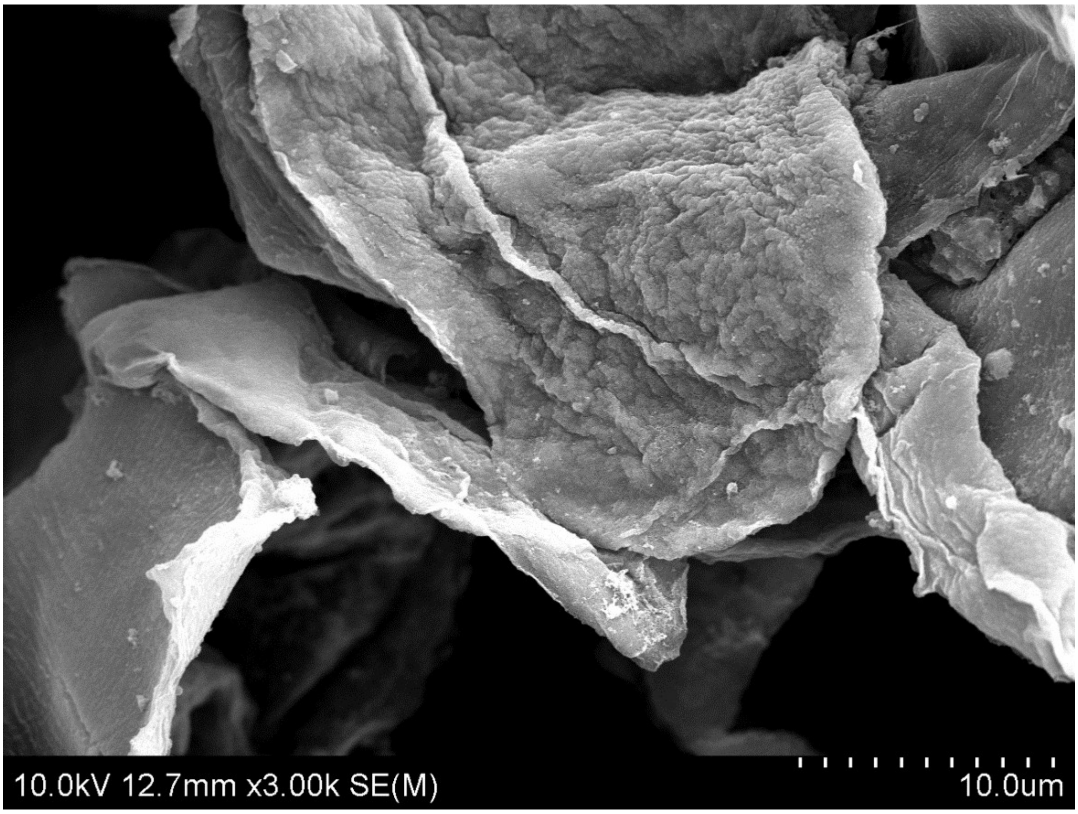

Figure S2. SEM image of the cathode showing petal-like structures, which increases the surface area of the cathode. The high surface area provides the platform for a high-capacity Li-CO_2 battery.

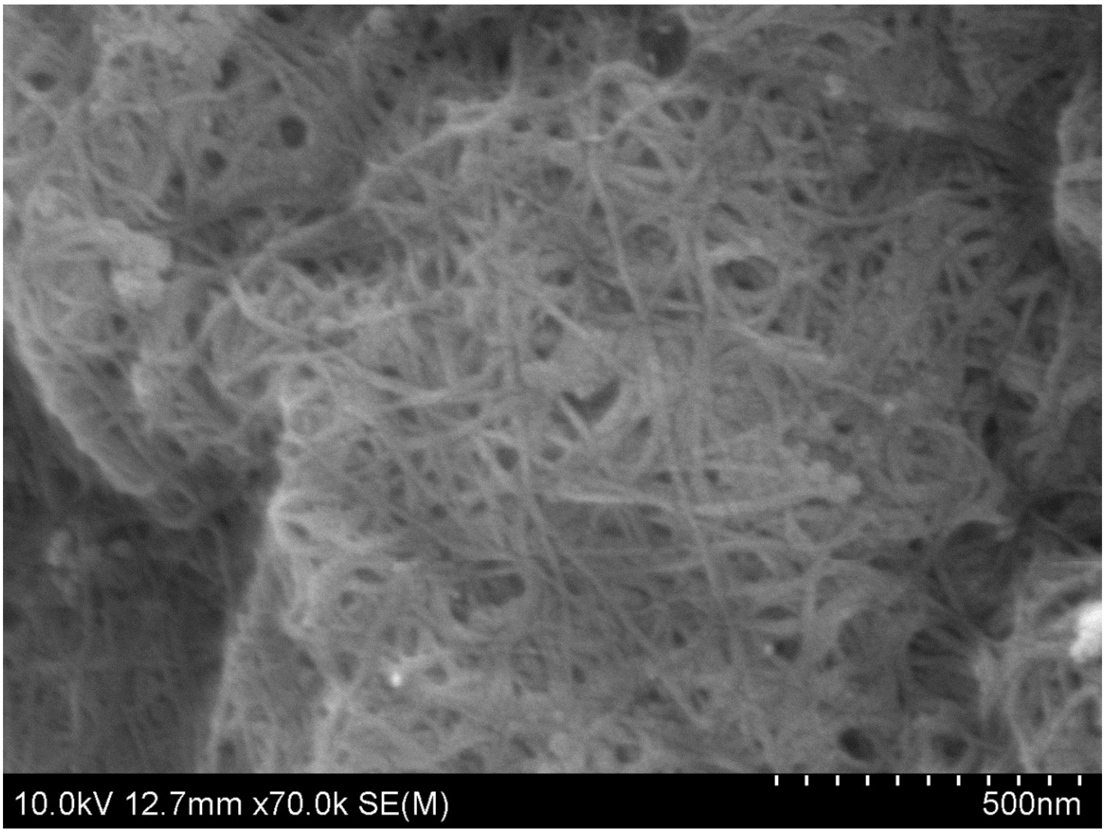

Figure S3. Zoomed-in SEM image of the cathode depicting the interconnected CNT network on the surface. The conformal CNT coating ensures the electronic conductivity throughout the cathode, providing more accessible active sites for discharge product growth.

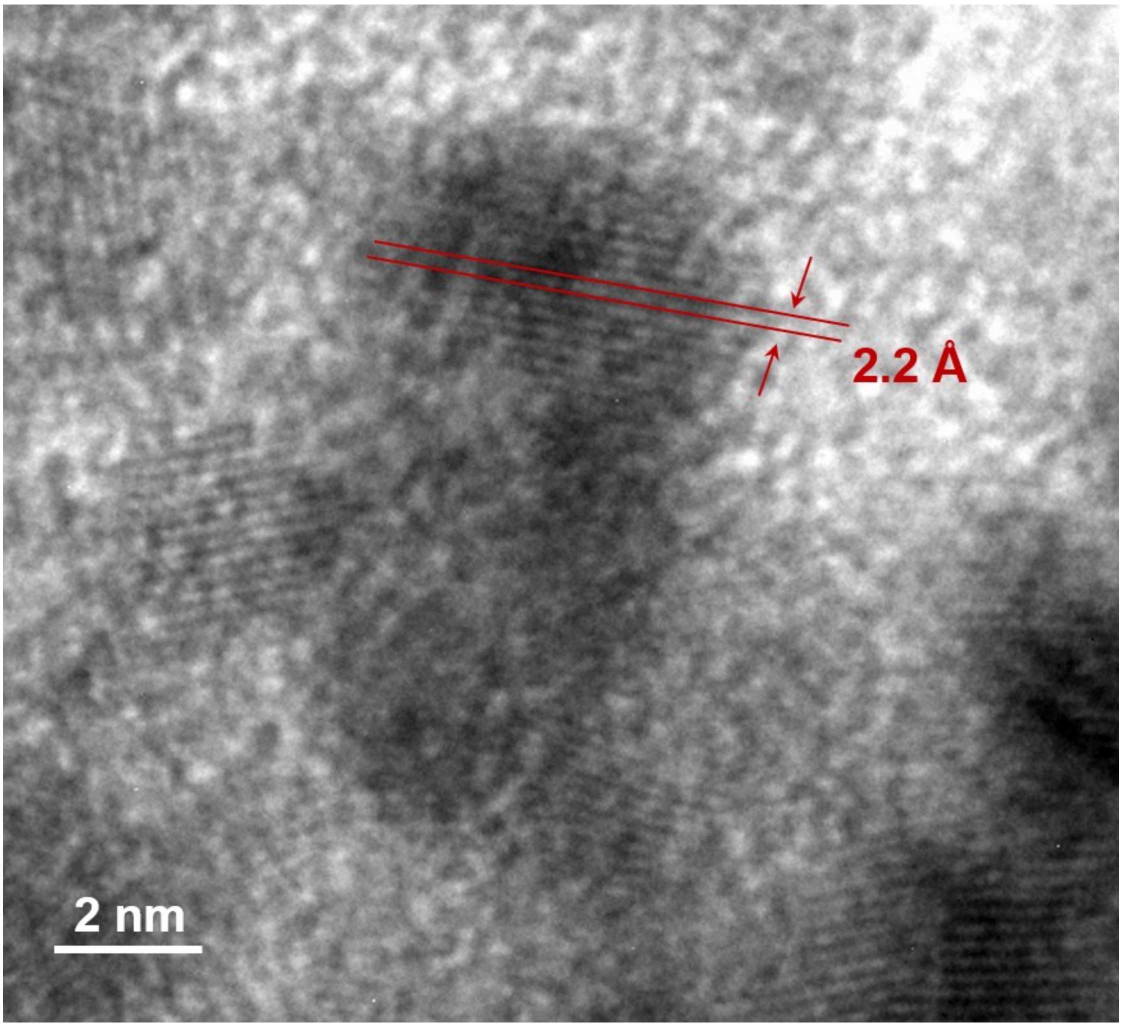

Figure S4. High magnification TEM image of a nanocatalyst particle. The lattice spacing of 2.2 Å can be observed, corresponding to the (111) plane of Ru.

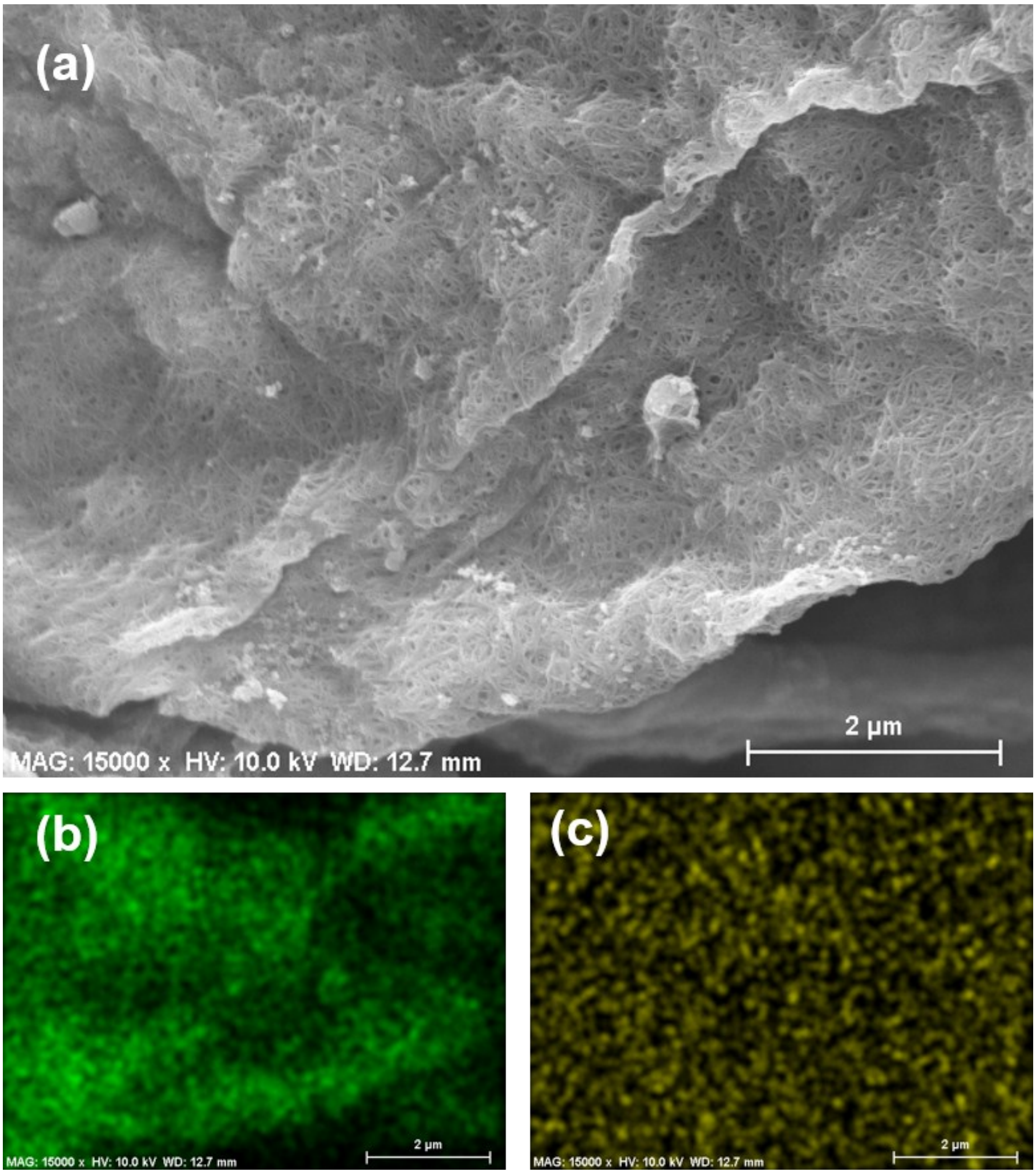

Figure S5. SEM image (a) and elemental mapping (b-c) of the cathode showing uniform distribution of ruthenium(b) and carbon (c).

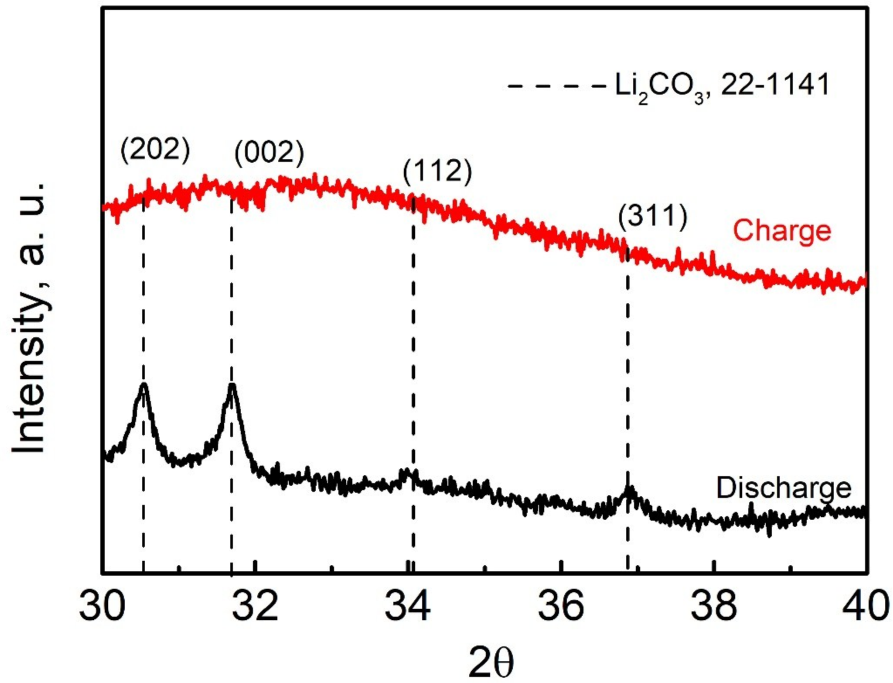

Figure S6. XRD of the cathode after discharge and charge, showing the characteristic peaks of Li_2CO_3 after discharge.

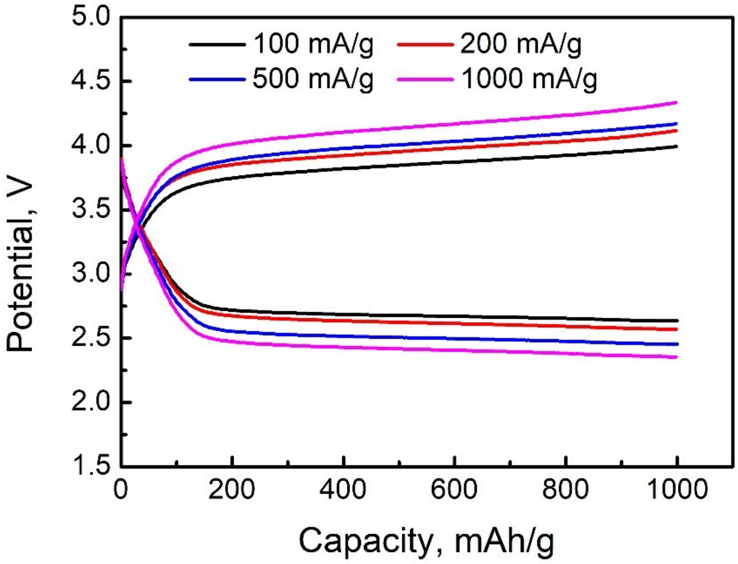

Figure S7. The charge/discharge profile of Li-CO_2 batteries under different current densities. Low overpotential of 1.85 V is achieved even at a high current density of 1000 mA/g due to the decoupled transport pathways.

Table S1. Comparisons of electrode thickness, areal capacity, and stability of various Li-CO_2 batteries.

Cathode materials	**Electrode thickness**	**Areal capacity (mAh/cm2)**	**Cycle life**	**Ref.**
Flexible wood/CNT/Ru	**2000 µm**	**11**	**200 cycles**	**This work**
Graphene	< 500 µm	~3.8	20 cycles	1
CNTs	N/A	~3.4	60 cycles	2
CNTs	~100 µm	~12[a]	100 cycles	3
Mo2C/CNT	N/A	~0.8	40 cycles	4
Ketjen Black	N/A	~3.4	9 cycles	5
B/N-doped holey graphene	N/A	~4.5	200 cycles	6
N-doped graphene/Cu	N/A	~3.5	50 cycles	7
Porous carbon	N/A	~1.2	N/A	8
N-doped graphene/Ni	N/A	~1.2	101 cycles	9
Carbon nanofiber/Ir	N/A	6.14	120 cycles	10
Super P/Ru	N/A	~1.4	70 cycles	11

Note:

a. The cell was measured at an elevated temperature of 55 ^{o}C, while other cells at room temperature.

Reference:

[1] Zhang, Zhang, et al. "The first introduction of graphene to rechargeable Li–CO_2 batteries." *Angewandte Chemie International Edition* 54.22 (2015): 6550-6553.

[2] Li, Chao, et al. "A Rechargeable Li-CO_2 Battery with a Gel Polymer Electrolyte." *Angewandte Chemie* 129.31 (2017): 9254-9258.

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[4] Hou, Yuyang, et al. "Mo_2C/CNT: An Efficient Catalyst for Rechargeable Li–CO_2 Batteries." *Advanced Functional Materials* 27.27 (2017).

[5] Liu, Yali, et al. "Rechargeable Li/CO_2–O_2 (2: 1) battery and Li/CO_2 battery." *Energy & Environmental Science* 7.2 (2014): 677-681.

[6] Qie, Long, et al. "Highly Rechargeable Lithium-CO_2 Batteries with a Boron-and Nitrogen-Codoped Holey-Graphene Cathode." *Angewandte Chemie International Edition* 56.24 (2017): 6970-6974.

[7] Zhang, Zhang, et al. "Identification of cathode stability in Li–CO_2 batteries with Cu nanoparticles highly dispersed on N-doped graphene." *Journal of Materials Chemistry A* 6.7 (2018): 3218-3223.

[8] Qiao, Yu, et al. "Li-CO_2 Electrochemistry: A New Strategy for CO_2 Fixation and Energy Storage." *Joule* 1.2 (2017): 359-370.

[9] Zhang, Zhang, et al. "Verifying the Rechargeability of Li-CO_2 Batteries on Working Cathodes of Ni Nanoparticles Highly Dispersed on N-Doped Graphene." *Advanced Science* 5.2 (2018): 1700567.

[10] Wang, Chengyi, et al. "Fabricating Ir/C Nanofiber Networks as Free-Standing Air Cathodes for Rechargeable Li-CO_2 Batteries." *Small* (2018): 1800641.

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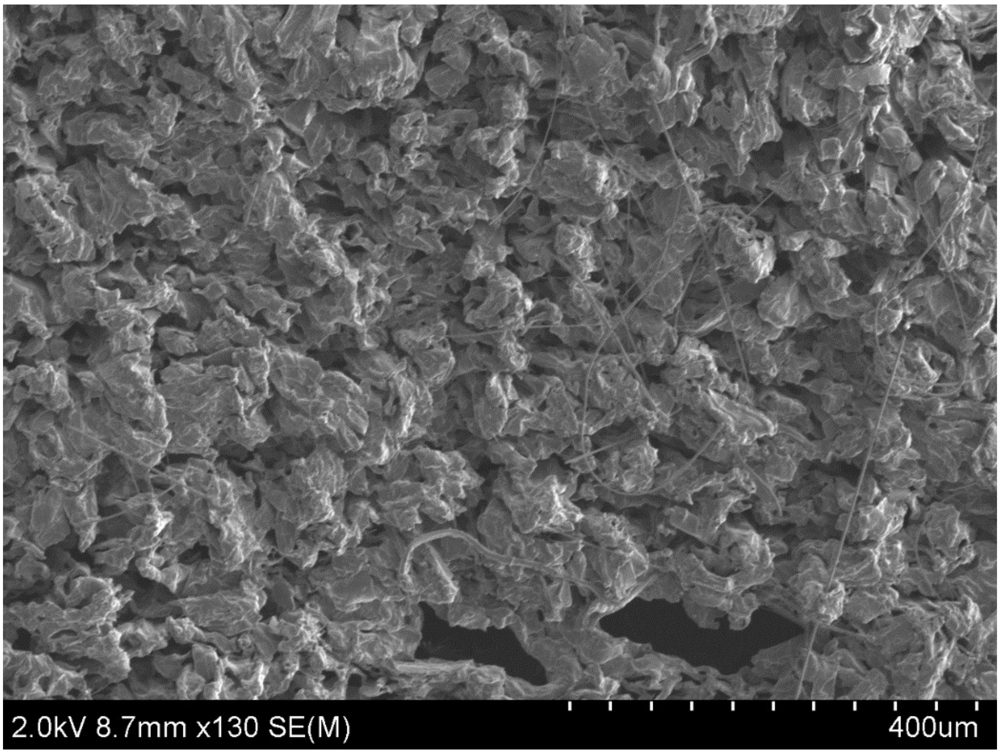

Figure S8. SEM image of the cathode after 100 cycles indicating the petal like structures are well preserved.

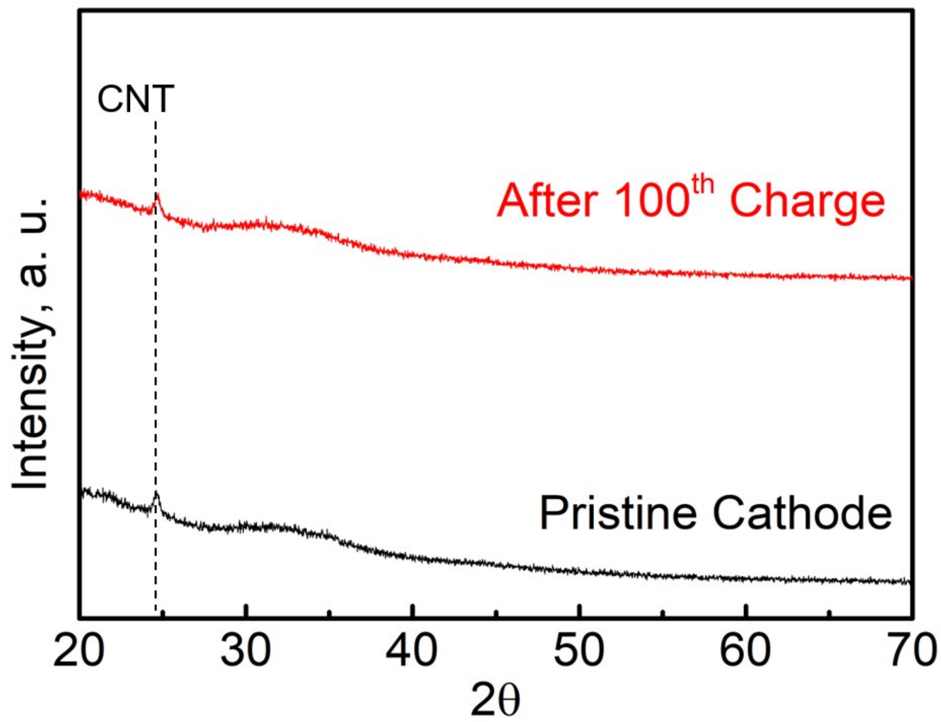

Figure S9. XRD of the pristine cathode and the cathode after 100 cycles, showing no structure change after prolonged cycling. The broad peak at 32° can be attributed to non-crystallized species in balsa wood.

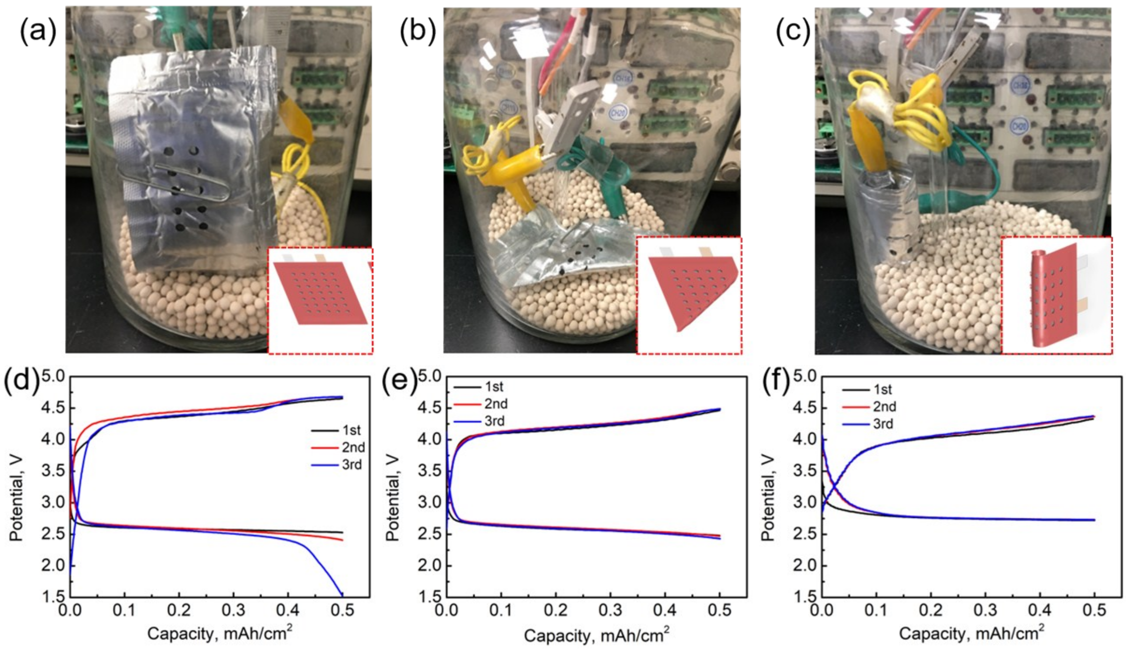

Figure S10. Electrochemical test of the Li-CO_2 pouch cell depicting the flexibility of the Li-CO_2 battery. (a-c) Photo of the pristine pouch cell (a), folded pouch cell (b), and the rolled pouch cell (c) during electrochemical testing. (d-f) Discharge/charge profile of the Li-CO_2 battery pouch cell when the cell is as assembled (d), folded (e), and rolled (f), respectively.