Supplementary Information

Upcycling of spent graphite and iron housing from waste lithium-ion batteries for fabricating cost-effective high-capacity anode

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S1.1. Degree of degradation of pristine and spent graphite

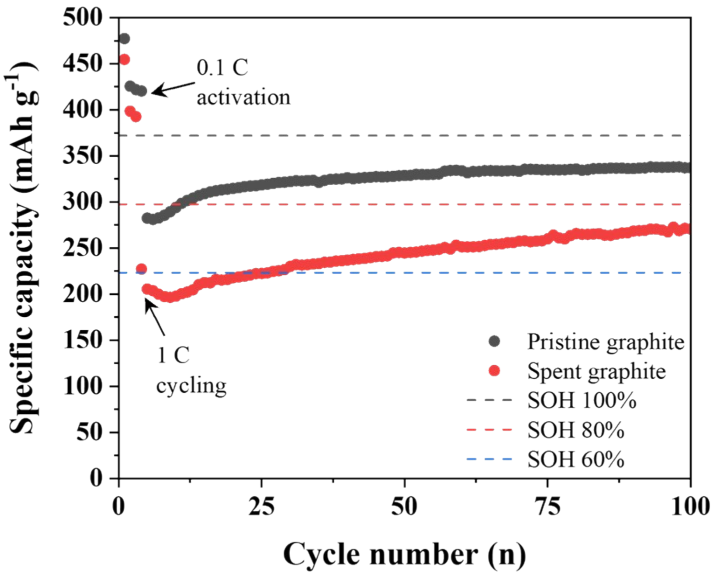

Figure S1. Discharge profile of coin type pristine graphite (PG) and spent graphite (SG) half-cell.

S1.2. Iron housing of LIBs

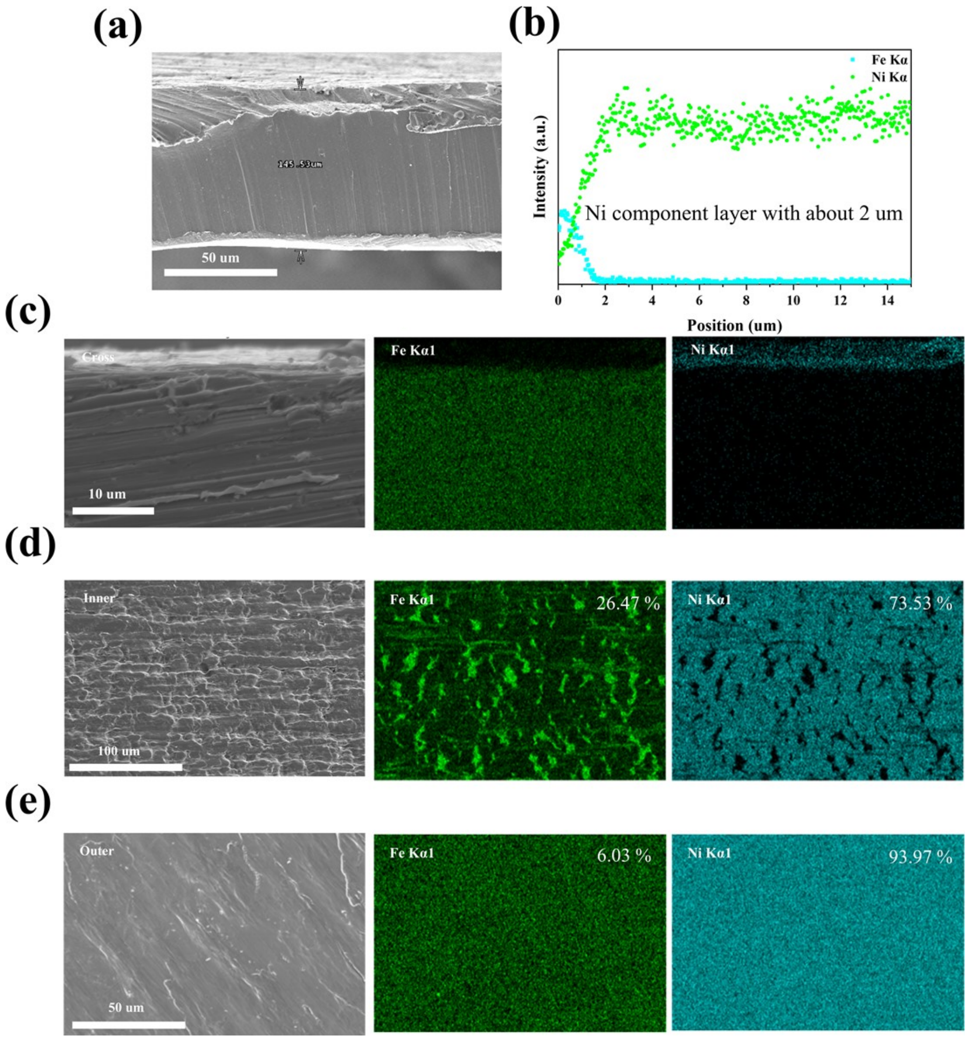

Figure S2. (a) Cross-sectional SEM image of the iron housing and (b) corresponding EDX line profile. SEM and corresponding EDX mapping images of (c) cross-, (d) inner-, and (e) outer-sections of the iron housing.

S1.3. Morphological characterization of F–SGO before heat treatment

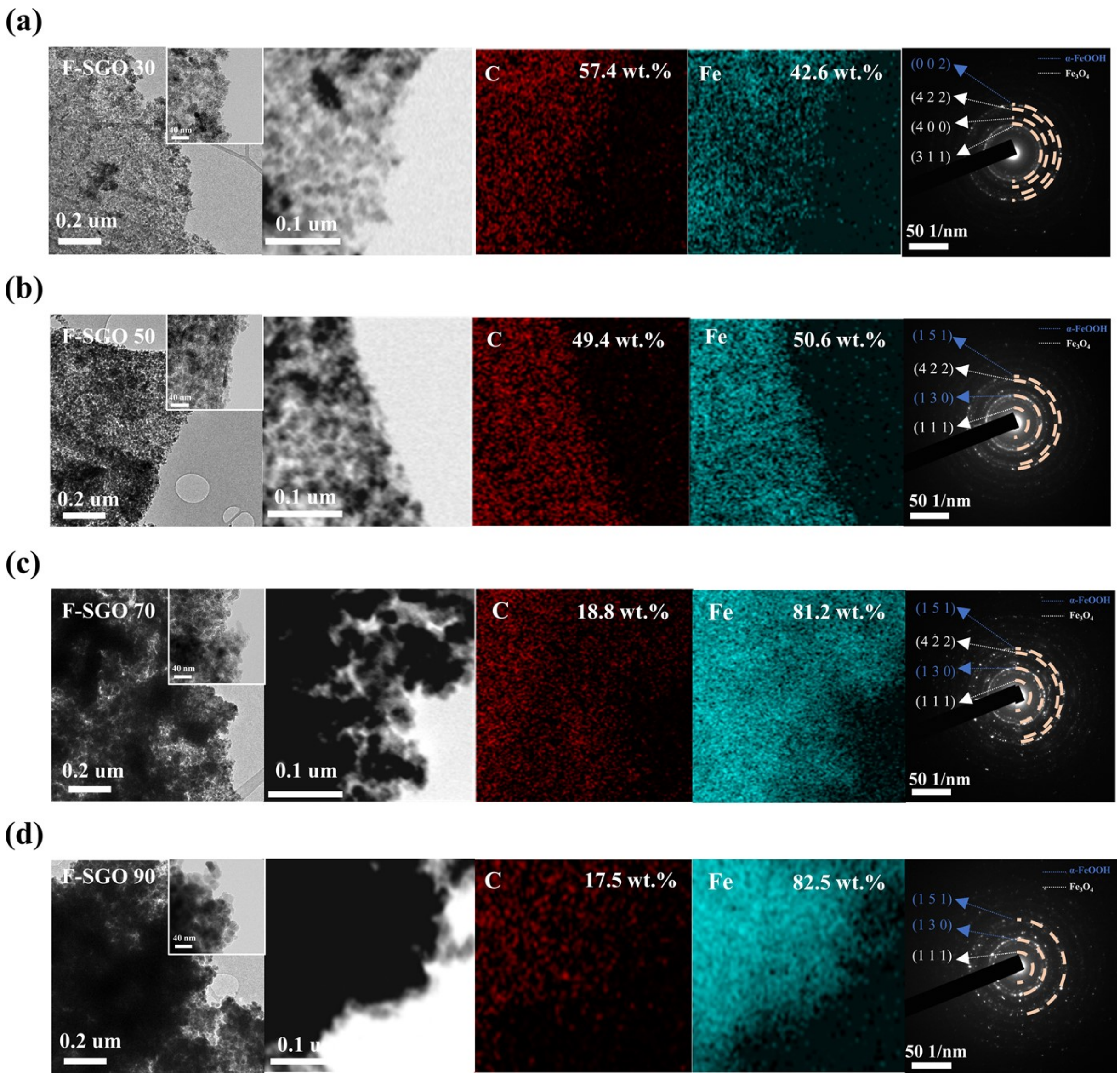

Figure S3. HR-TEM and corresponding EDX mapping images and SAED patterns of (a) F–SGO 30, (b) F–SGO 50, (c) F–SGO 70, and (d) F–SGO 90.

Table S1. Element composition of F-SGO 30 detected by TEM-EDX.

Element	Weight%	Atomic%
C	33.01	53.93
O	25.68	31.50
Na	0.00	0.00
S	0.11	0.07
Cl	0.07	0.04
K	0.00	0.00
Mn	0.38	0.14
Fe	40.76	14.32
Ni	0.00	0.00
Total	100.00	100.00

S1.4. Physical characterizations of F–SGO before and after heat treatment

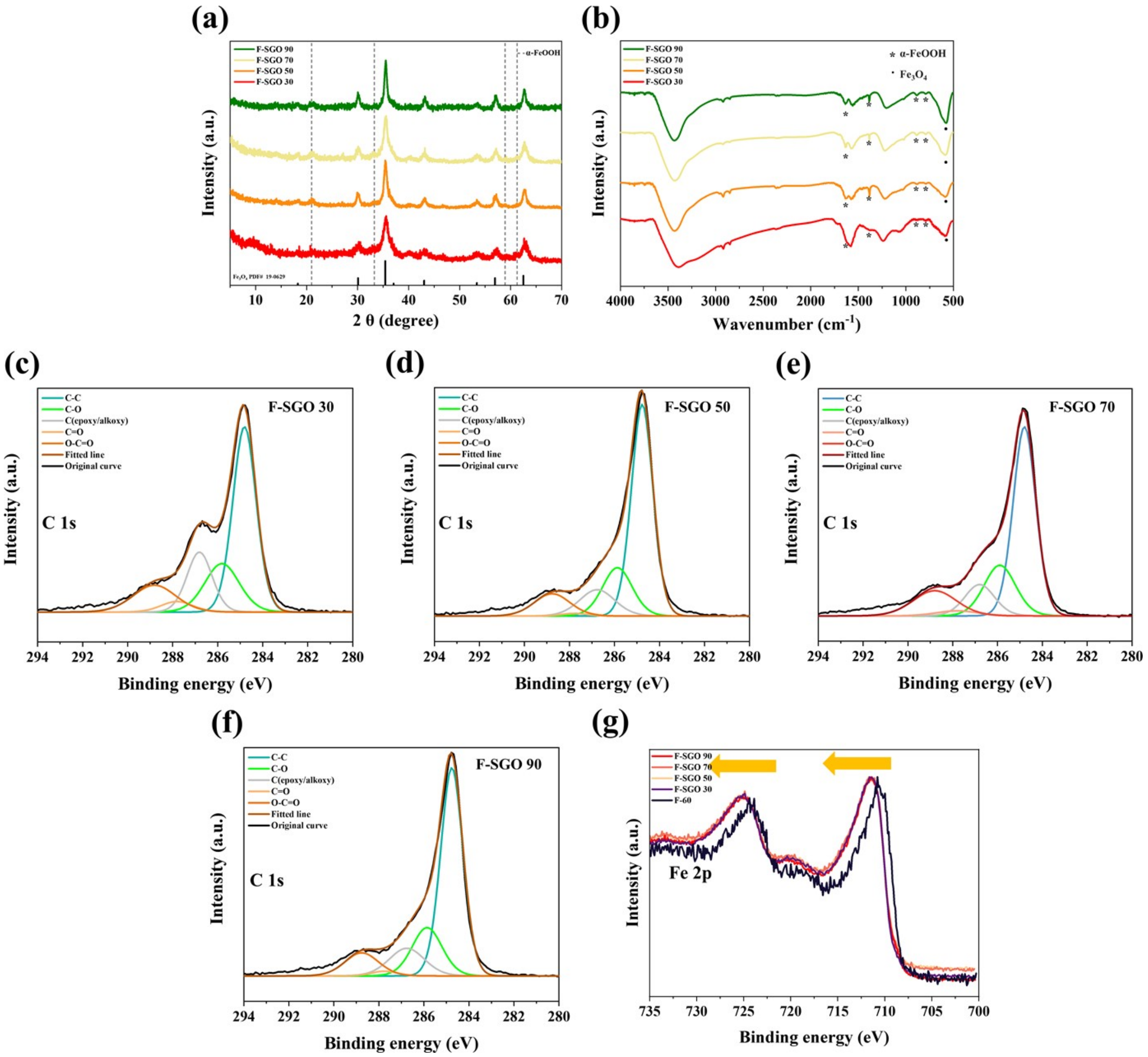

Figure S4. (a) XRD patterns, (b) FT-IR spectra, and C 1s XPS analysis of (c) F–SGO 30, (d) F–SGO 50, (e) F–SGO 70, and (f) F–SGO 90. (g) Fe 2p XPS profiles of F-SGO30, 50, 70, and 90.

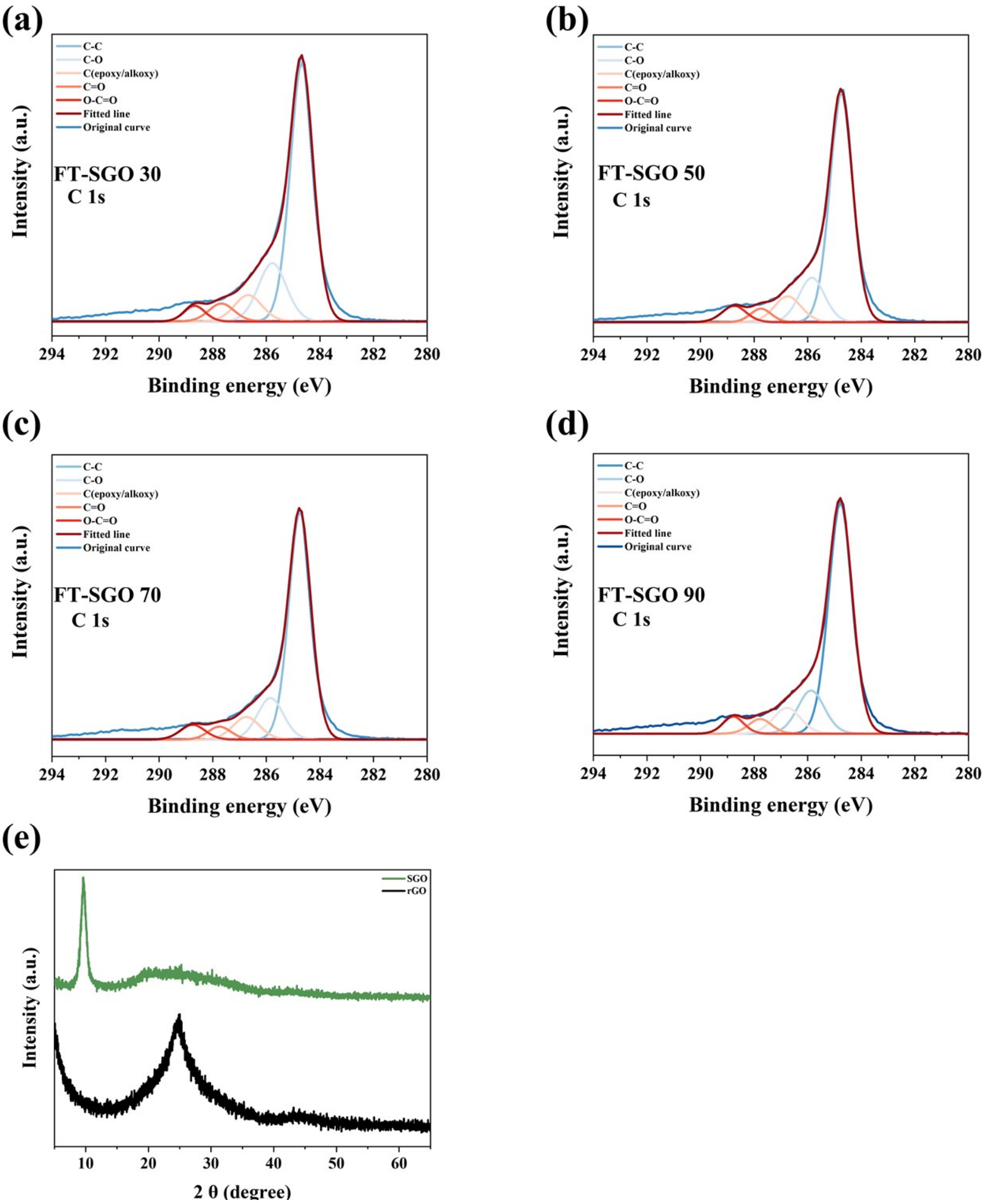

Figure S5. C 1s XPS analysis of (a) FT-SGO 30, (b) FT–SGO 50, (c) FT–SGO 70, and (d) FT–SGO 90. (e) XRD patterns of SGO (green) and rGO (black).

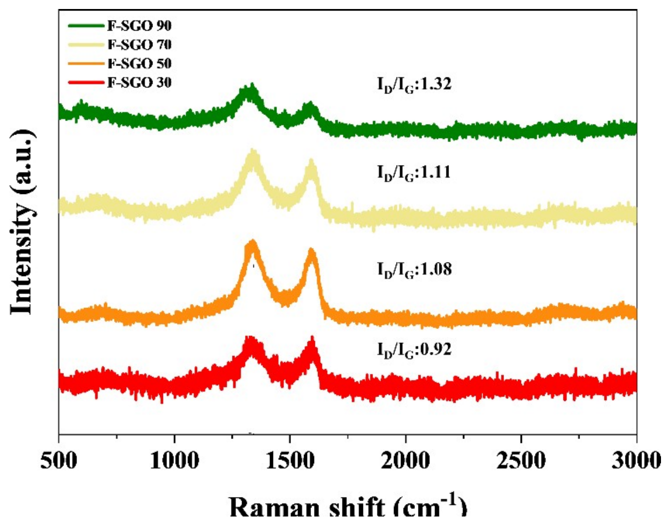

Figure S6. Raman spectra of F–SGO at different reaction times.

S1.5. Volume expansion of anode before cycling and after 100th cycle

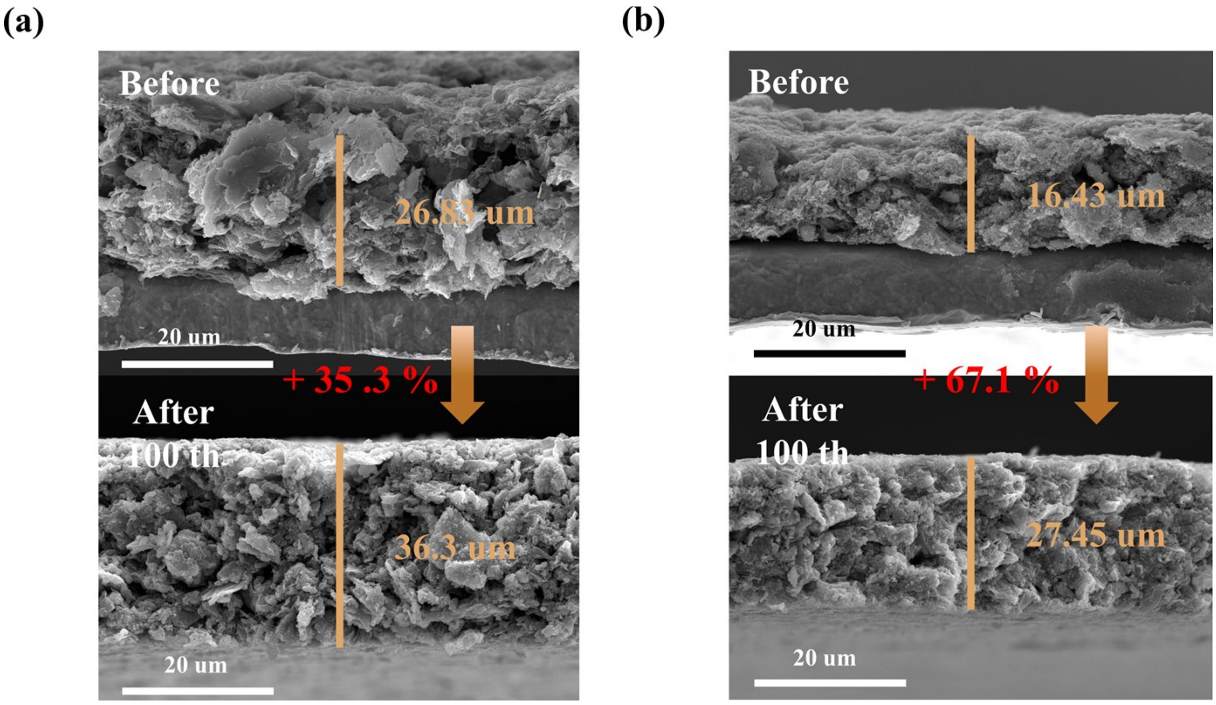

Figure S7. SEM images before and after 100th cycle at a current density of 1 A g^{-1} for (a) FT–SGO 30 and (b) FT–SGO 90.

S1.6. Physical characterizations of FT-SGO

Table S2. Zeta potentials of FT and GO

Zeta potential (mV)				
	1st	**2nd**	**3rd**	**Average**
FT	55.09	54.77	52.98	54.28
SGO	−40.37	−38.58	−41.09	−40.01

Table S3. Electrochemical impedance spectroscopy (EIS) data for FT–SGO anode at different reaction times

		6030_450	**6050_450**	**6070_450**	**6090_450**
R_s(Ω)	0 th	4.58	5.29	6.853	6.49
R_{ct}(R) (Ω)	0 th	37.45	51.618	73.16	76.85

Table S4. Economic analysis of the upcycling process and graphite-silicon monoxide with a 9:1 weight ratio

Materials	Conditions	Unit price	Cost	Reference
H_2SO_4	8.42 mL	0.01 ($ mL^{-1})	0.0841 ($)	http://www.daejungchem.co.kr/02_product/search/?search_value=7664-93-9
H_2O_2	2.26 mL	0.0076 ($ mL^{-1})	0.0171 ($)	http://www.daejungchem.co.kr/02_product/search/?search_value=7664-93-9
$KMno_4$	1.6 g	0.0118 ($ g^{-1})	0.0188 ($)	http://www.daejungchem.co.kr/02_product/search/?search_value=7664-93-9
NaCl	3 g × 1 g product/0.4 g per rep	0.0144 ($ g^{-1})	0.108 ($)	https://www.junsei.co.jp/product_search/search_seihin_result_e.html
Electricity price	2.5 V × 0.18 A × 0.5 h ×1 g product/0.4 g per rep (potentiostat) + 0.164 kWh (ultrasonication) + 0.355 kWh (tube furnace)	0.1219 ($/KW h)	0.0632 ($)	https://doi.org/10.1016/j.jpowsour.2020.229163
Argon price	25.3 L (including purification and synthesis)	0.009 ($ L^{-1})	0.227 ($)	http://www.higas.co.kr/
Graphite anode	0.753 g	0.2378 ($ g^{-1})	0.179 ($)	https://www.sigmaaldrich.com/KR/ko/product/aldrich/907154
SiO anode	0.247 g	6.593 ($ g^{-1})	1.628 ($)	https://www.sigmaaldrich.com/KR/ko/product/aldrich/336823

* All price calculations are based on the retail price and 1 g of product.

* Most chemical prices are in Korean Won and all costs are converted to US Dollars using the exchange rate as of February 10, 2023.

* Theoretical capacity calculation was based on the following equation:

$$774\ mAh\ g^{-1} \times 0.336 + 924\ mAh\ g^{-1} \times 0.664 = 873.6\ mAh\ g^{-1}$$

- 774 and 924 $mAh\ g^{-1}$ represent the theoretical capacities of reduced graphene oxide and Fe_3O_4, respectively.
- The weight ratios of reduced graphene oxide and Fe_3O_4 based on TGA were 0.336 and 0.664, respectively.