Supporting Information for

Atomically Dispersed Ruthenium Catalysts with Open Hollow Structure for Lithium–Oxygen Batteries

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Supplementary Figures and Tables

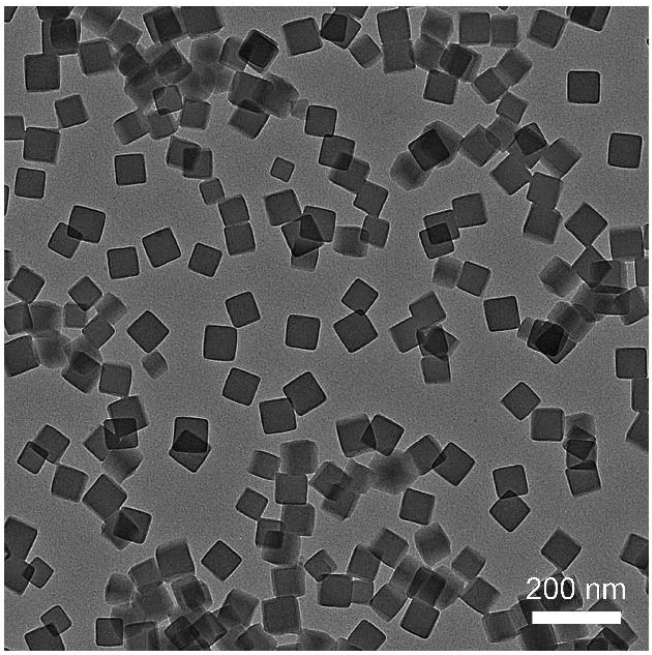

Fig. S1 TEM image of ZIF-8

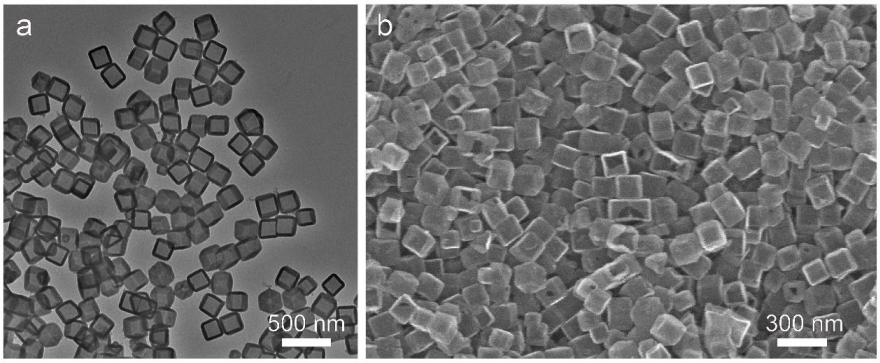

Fig. S2 (**a**) TEM image, (**b**) SEM image of h-ZIF-8

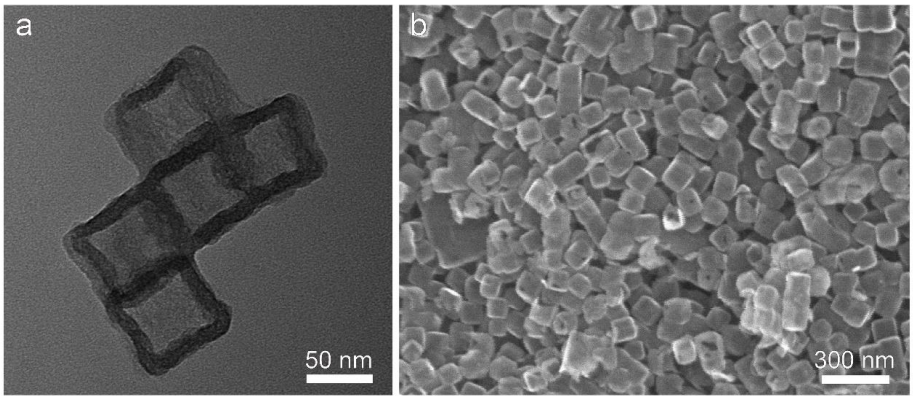

Fig. S3 (**a**) TEM image, (**b**) SEM image of h-NC

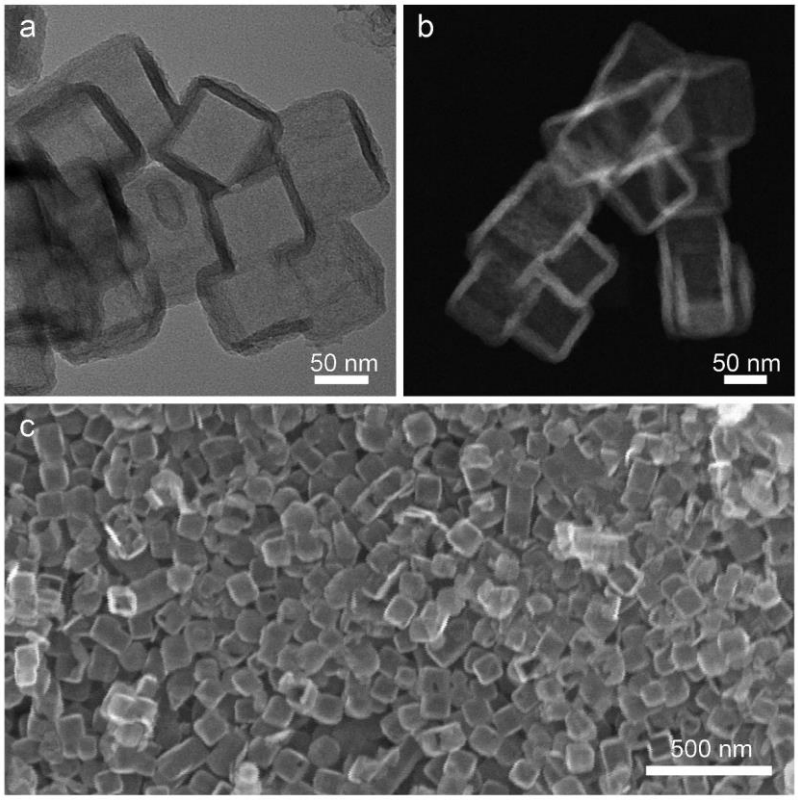

Fig. S4 (**a**) TEM image, (**b**) HAADF-STEM image and (**c**) SEM image of h-RuNC

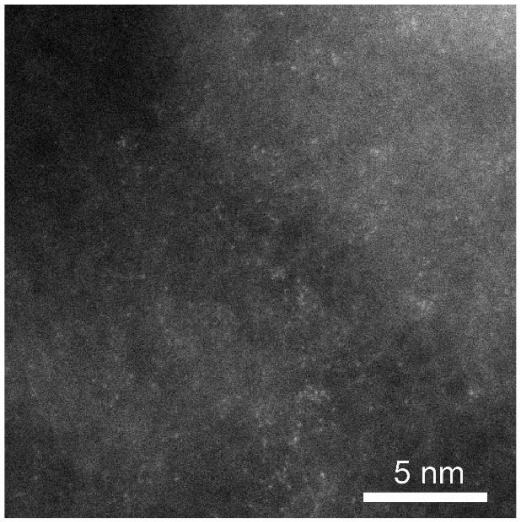

Fig. S5 AC HAADF-STEM image of h-RuNC

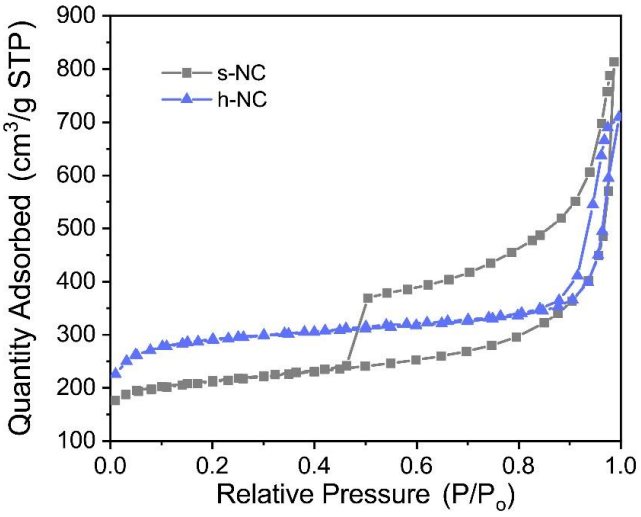

Fig. S6 N_2 adsorption-desorption isotherm of s-NC and h-NC with mesoporous

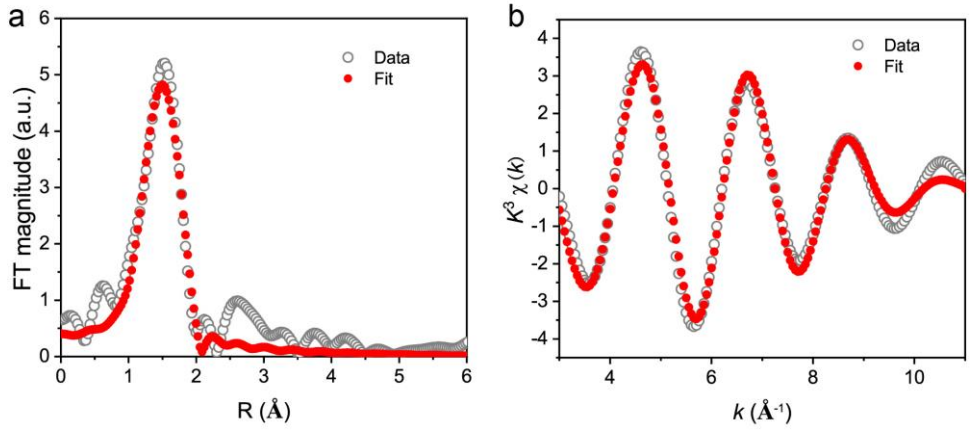

Fig. S7 Ru K-edge EXAFS fitting curves of h-RuNC at R space (**a**) and k space (**b**)

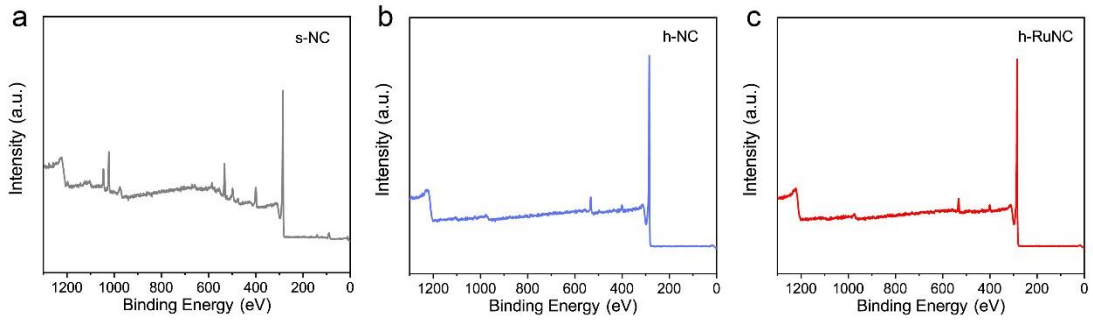

Fig. S8 XPS survey spectra of (**a**) s-NC, (**b**) h-NC and (**c**) h-RuNC

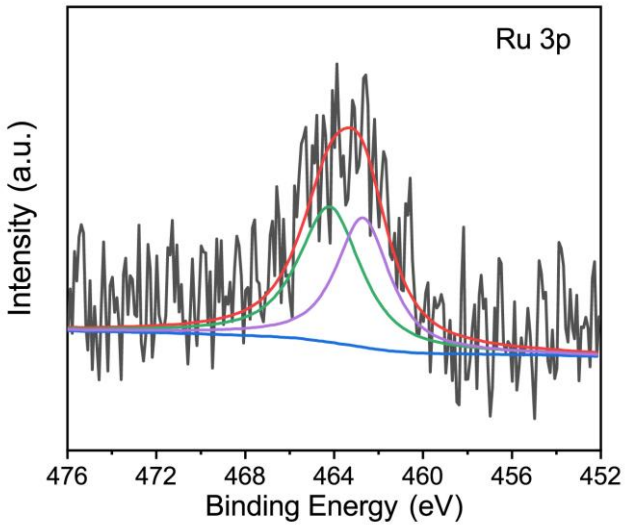

Fig. S9 XPS Ru 3*p* spectrum of h-RuNC

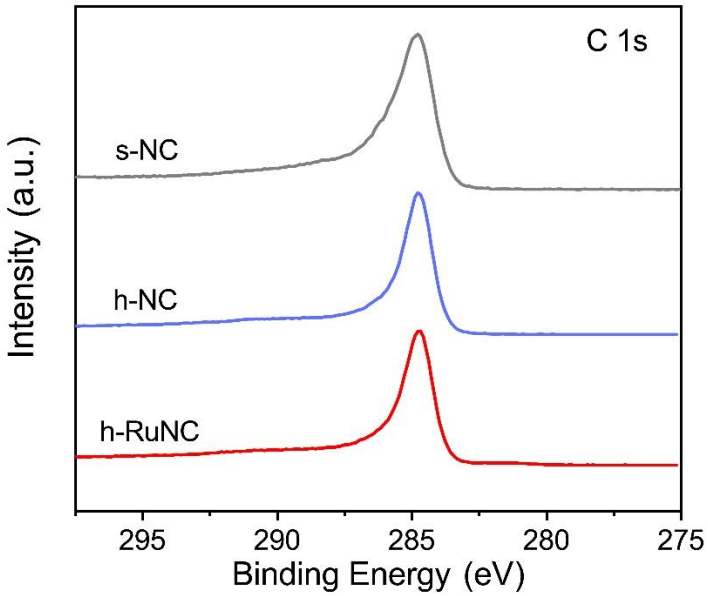

Fig. S10 XPS C 1*s* spectra of s-NC, h-NC and h-RuNC

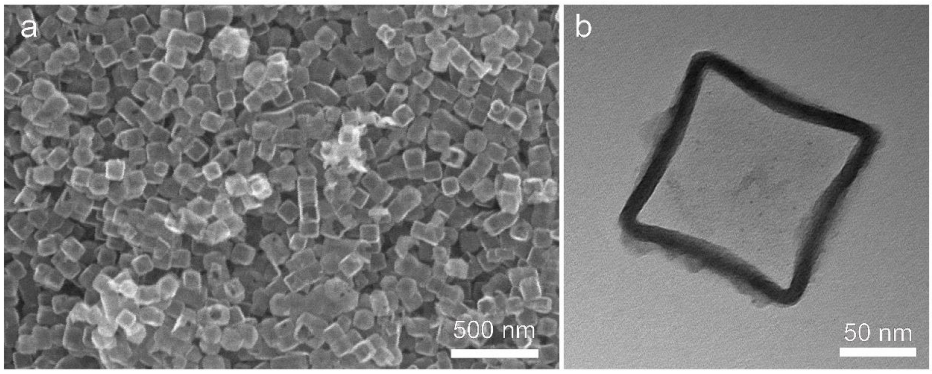

Fig. S11 (**a**) SEM image, (**b**) TEM image of h-Ru_{NP}NC

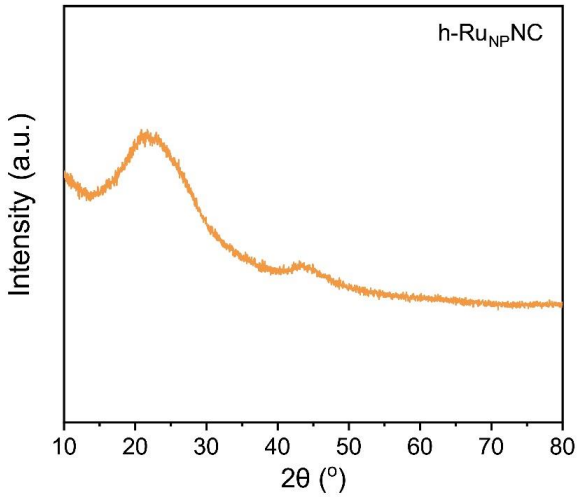

Fig. S12 XRD pattern of h-Ru_{NP}NC

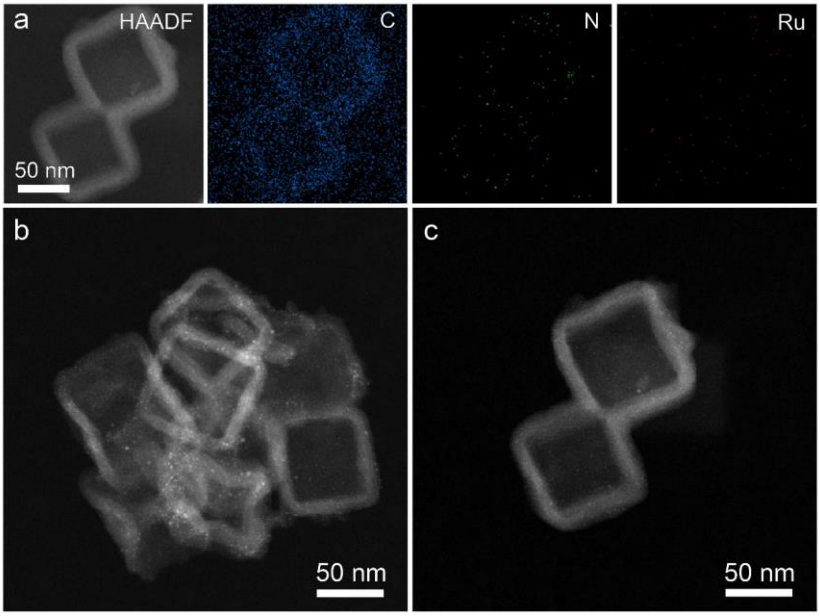

Fig. S13 HAADF-STEM images and corresponding elemental mapping images of h-Ru_{NP}NC

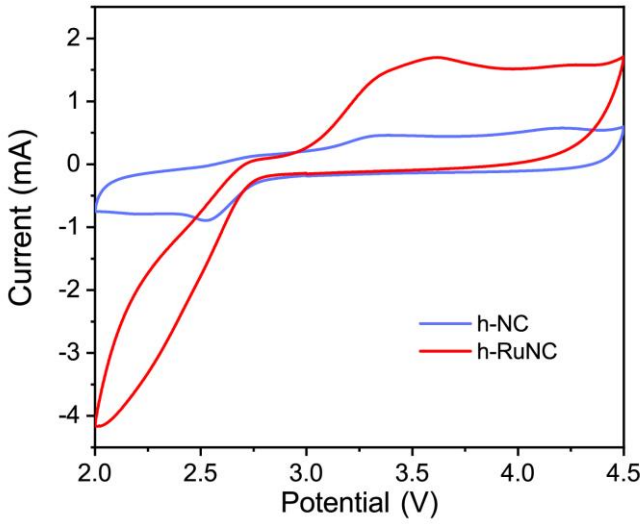

Fig. S14 Cyclic voltammetry curves of h-NC and h-RuNC

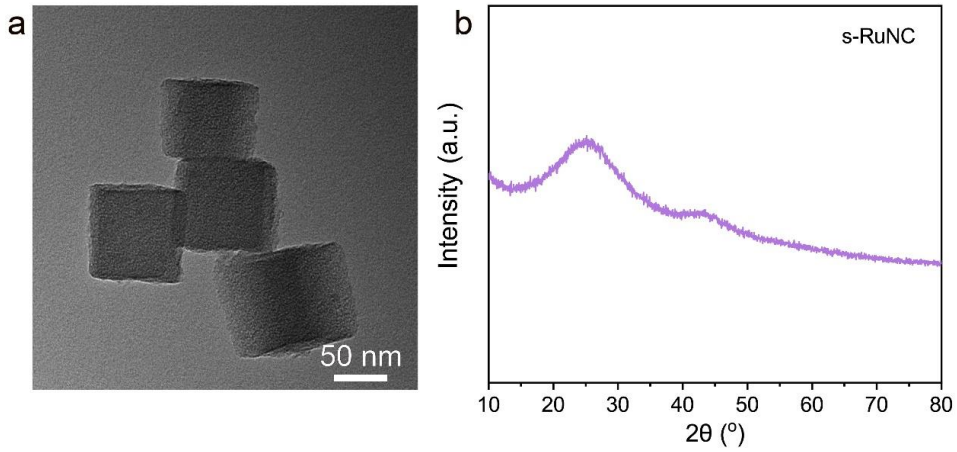

Fig. S15 (**a**) TEM image. (**b**) XRD pattern of s-RuNC

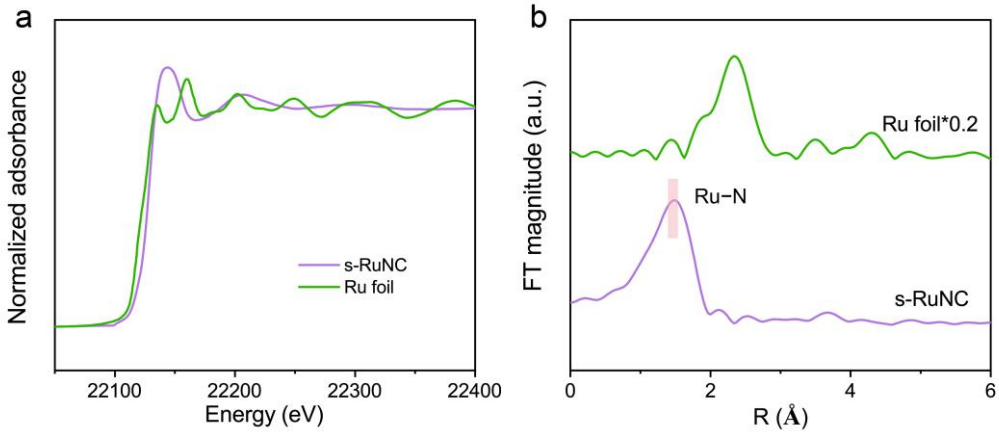

Fig. S16 (**a**) Normalized XANES spectra of Ru K-edge. (**b**) Fourier-transform EXAFS spectra of R space

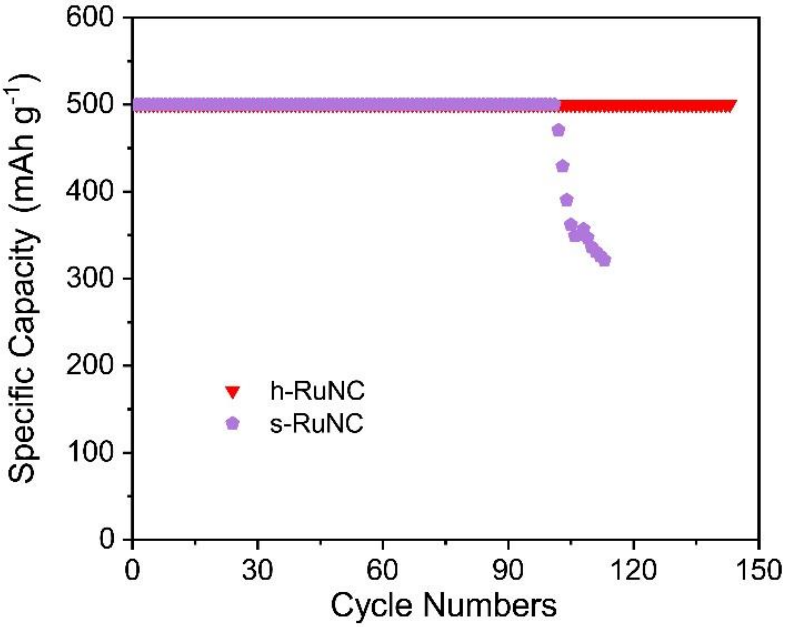

Fig. S17 Cycling performances of h-RuNC and s-RuNC

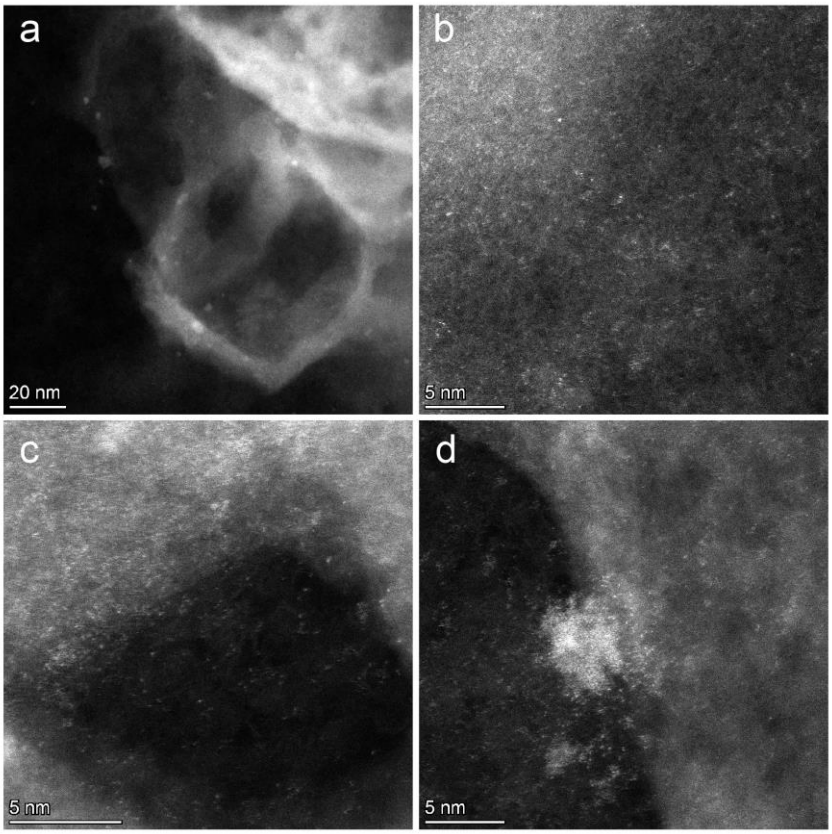

Fig. S18 AC HAADF-STEM image of h-RuNC after 150 cycles

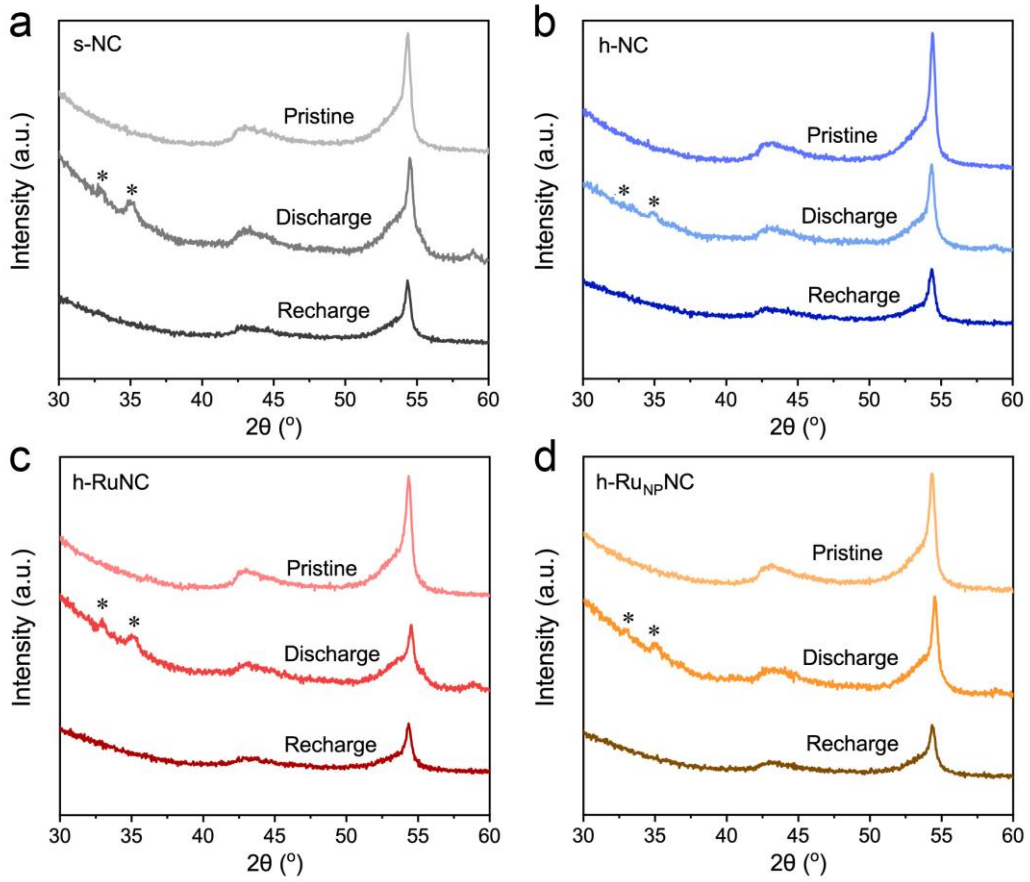

Fig. S19 XRD patterns of s-NC (**a**), h-NC (**b**), h-RuNC (**c**) and h-Ru$_{NP}$NC (**d**) at different state of batteries during discharging and charging processes

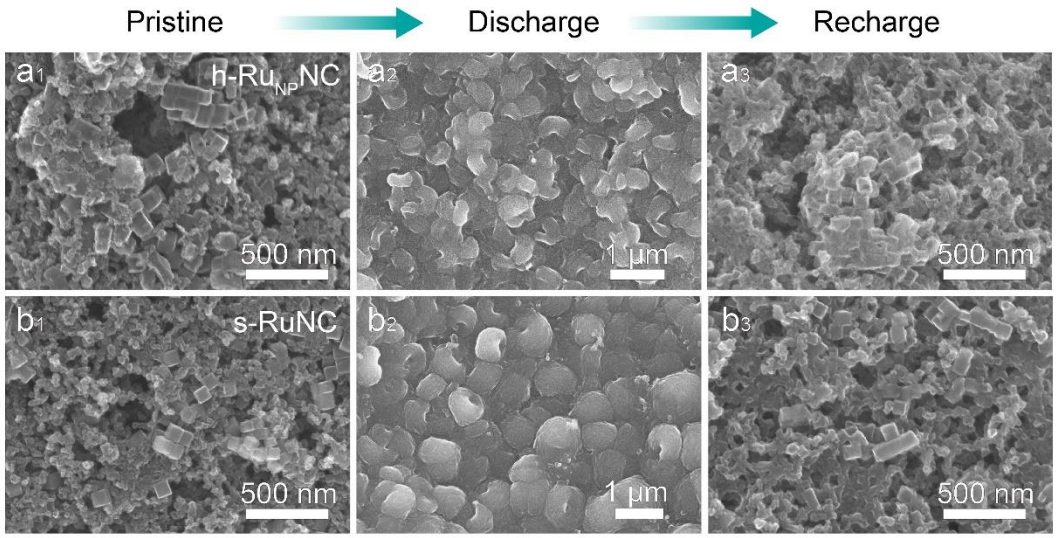

Fig. S20 SEM images of the cathodes at different state based on (**a$_1$-a$_3$**) h-Ru$_{NP}$NC and (**b$_1$-b$_3$**) s-RuNC: (**a$_1$, b$_1$**) pristine, (**a$_2$, b$_2$**) after full discharge, (**a$_3$, b$_3$**) recharge

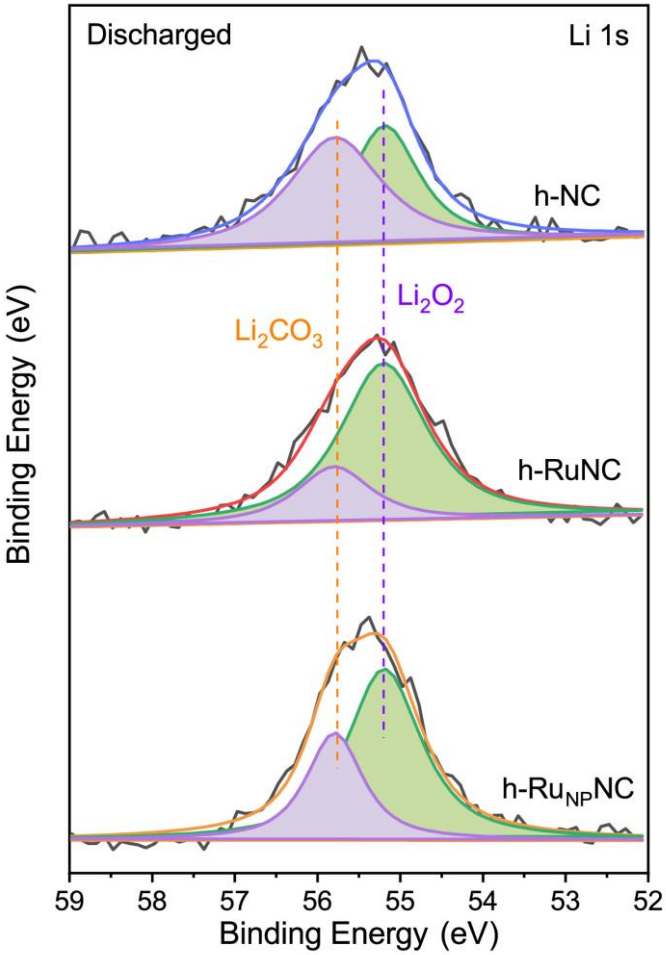

Fig. S21 XPS spectra of h-NC, h-RuNC and h-Ru_{NP}NC after discharged

Table S1 Fitting parameters of h-RuNC

Sample	Path	R (Å)	Coordination Number	ΔE_0 (eV)	σ^2 (Å^2)	R factor
h-RuNC	Ru-N	1.48(1)	3.9(8)	11.5(4)	0.0093(1)	2.125

Table S2 ICP-OES analysis results of the as-synthesized catalysts

Catalyst	h-RuNC	h-Ru_{NP}NC
Ru (%)	1.24	2.70