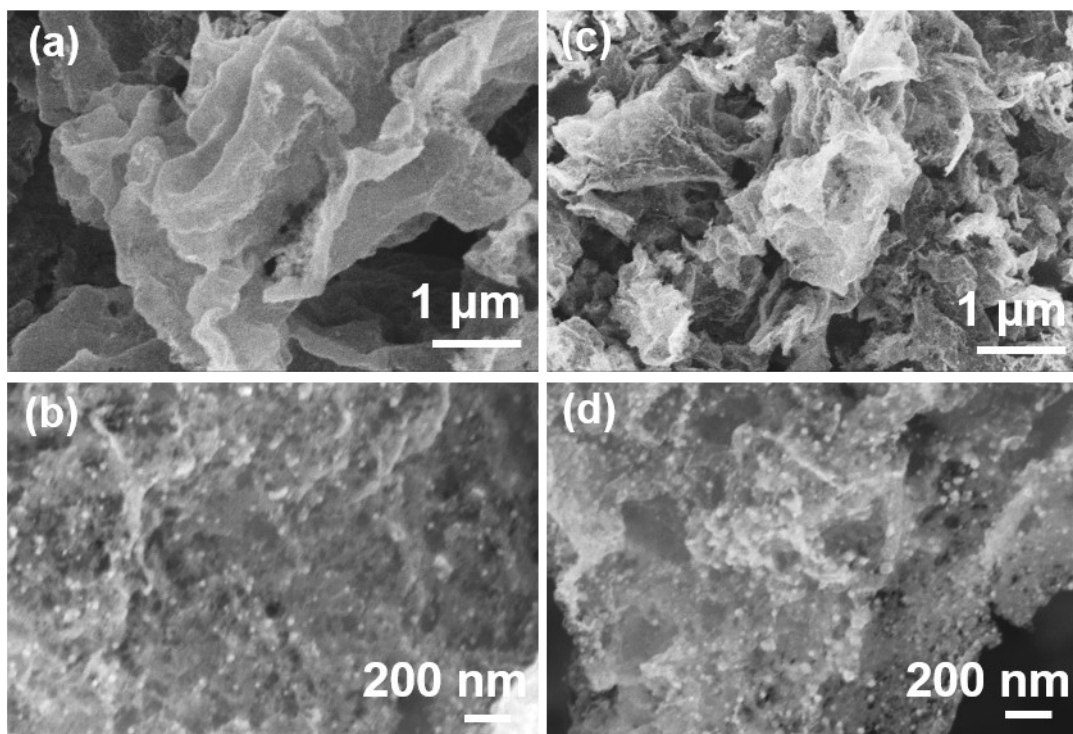
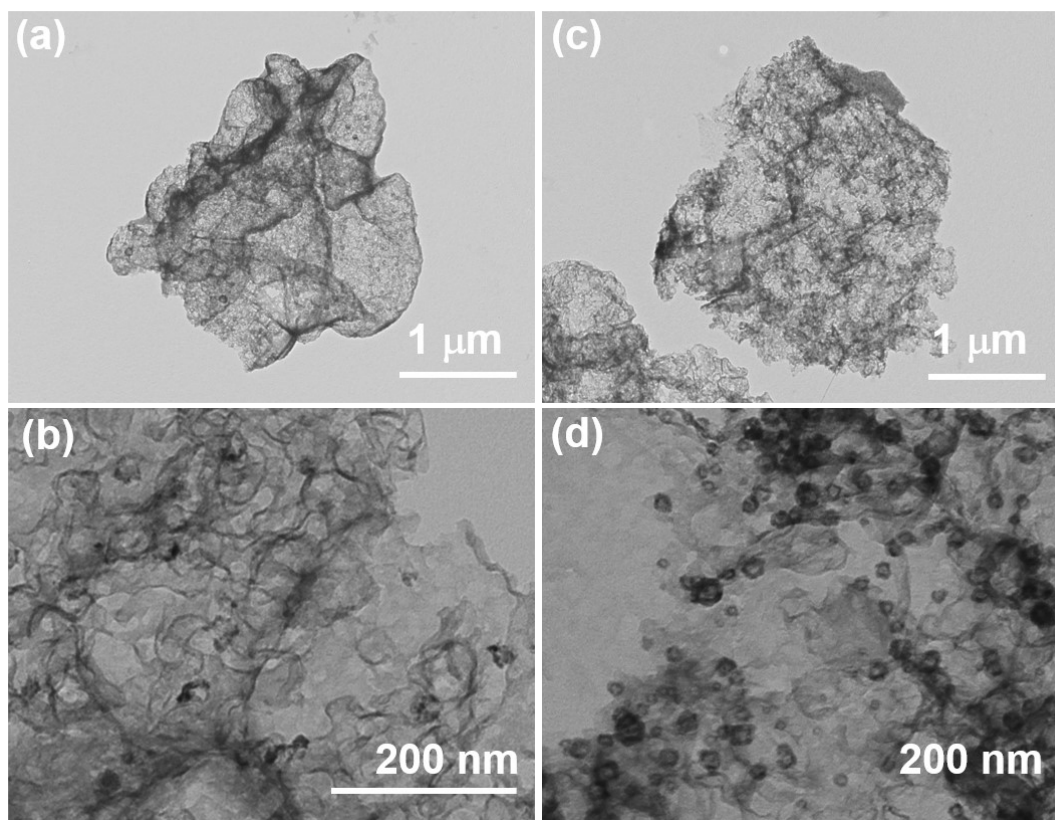


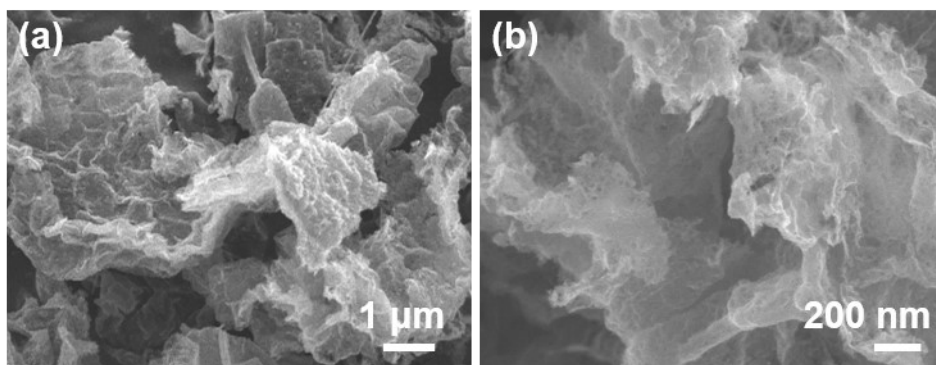
Supplementary Materials



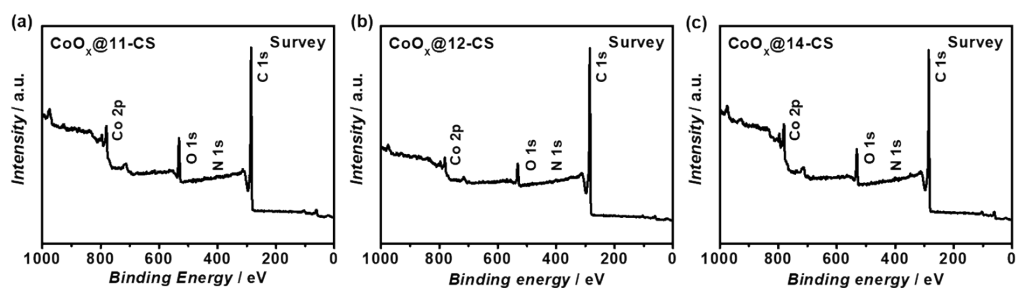
**Fig. S1** SEM images of (a-b) CoO<sub>x</sub>@11-CS and (c-d) CoO<sub>x</sub>@12-CS.



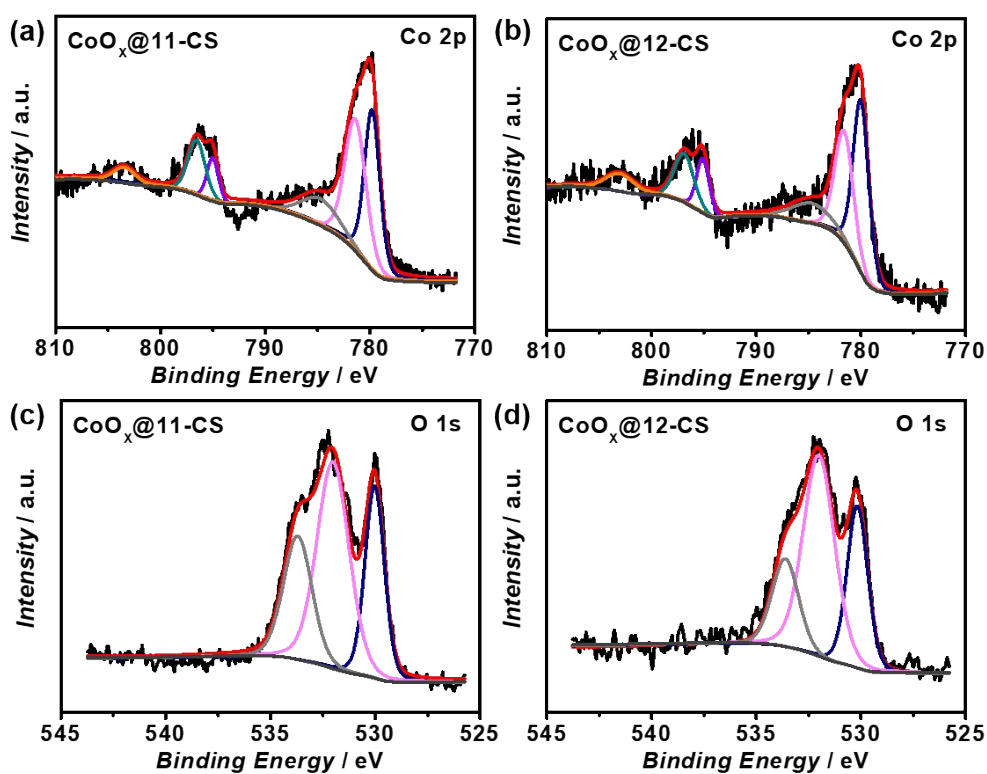
**Fig. S2** TEM images of (a, b) CoO<sub>x</sub>@11-CS and (c, d) CoO<sub>x</sub>@12-CS.



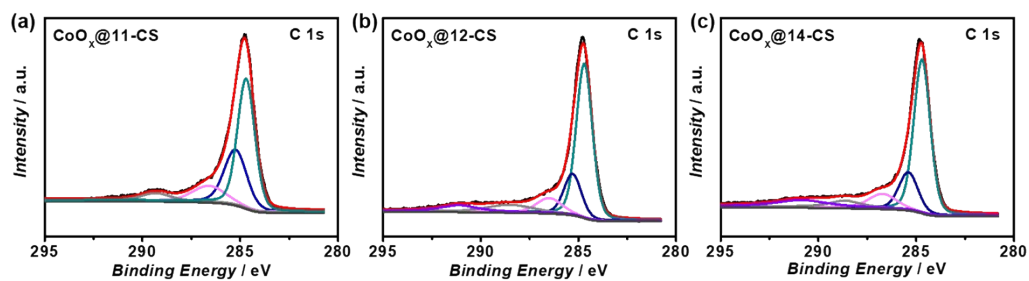
**Fig. S3** SEM images of 12-CS.



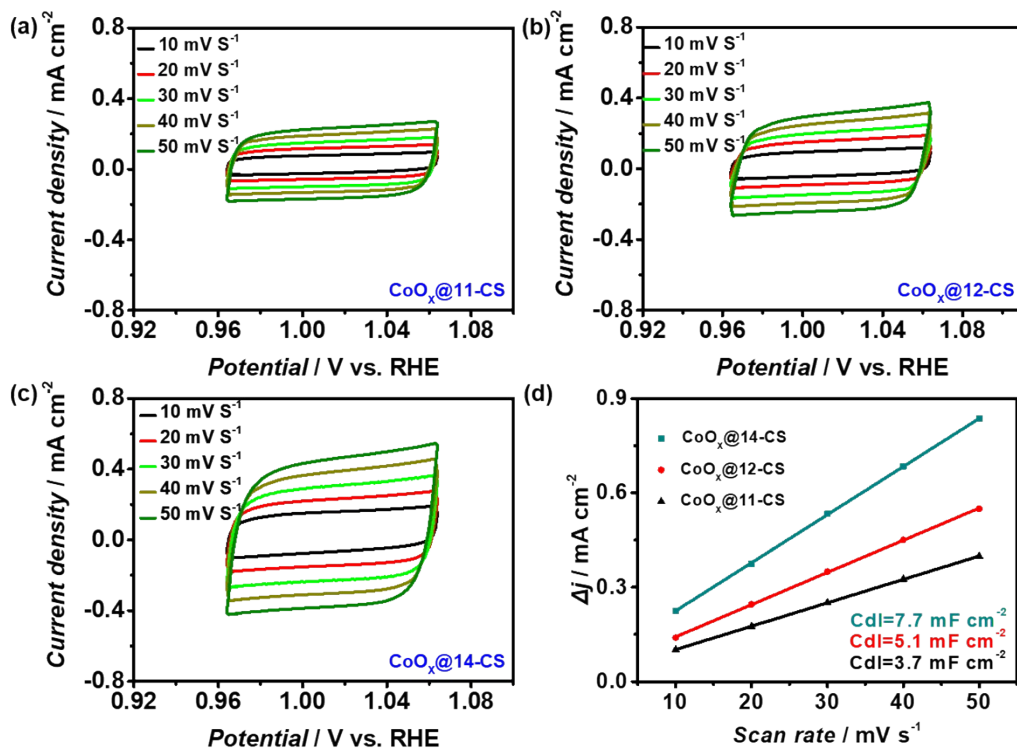
**Fig. S4** XPS survey spectra of CoO<sub>x</sub>@CS.



**Fig. S5** High resolution XPS spectra: (a, b) Co 2p region and (c, d) O 1s region.



**Fig. S6** High resolution XPS spectra: (a-c) C 1s region.



**Fig. S7** (a-c) CV curves at different scan rates in a potential window (0-0.1 V vs. Ag/AgCl) and (d) the corresponding double-layer capacitance calculated.

**Table S1** Performance comparison of cobalt oxide-based catalysts for ORR and OER

Air catalysts	$E_{\text{OER}}$ ( $j=10 \text{ mA cm}^{-2}$ )	$E_{\text{ORR1/2}}$	$E = E_{\text{OER}} - E_{\text{ORR1/2}}$	Power /Energy density ( $\text{mW cm}^{-2}$ )/ ( $\text{Wh kg}_{\text{Zn}}^{-1}$ )	Stability	$\Delta E$	Ref.
$\text{Co}_3\text{O}_4$ microspheres/ Cu nanoparticles hybrid	-	-	1.0 V	-	110 h (0.05 mA $\text{cm}^{-2}$ )	1.0 V (0.05 mA $\text{cm}^{-2}$ )	24
CoOx nanoplates	1.536 V	-	-	-	10000 s (5 mA $\text{cm}^{-2}$ )	-	58
SC CoO NRs	1.56 V	0.85 V	0.71 V	-	3000 cycles	-	53
3DOM $\text{Co}_3\text{O}_4$	1.7 V (21.17 mA $\text{cm}^{-2}$ )	0.64 V	-	-	200 cycles (400 h)	0.85 V (50 mA $\text{cm}^{-2}$ )	59
$\text{Co}_3\text{O}_4/\text{N-rmGO}$	1.54 V	0.83 V	0.71 V	-	25000 s	-	17
Graphene- $\text{Co}_3\text{O}_4$ nanocomposite	1.65 V (1.5 mA $\text{cm}^{-2}$ )	0.77 V	-	-	100 h	0.97 V (80 mA $\text{g}^{-1}$ )	14
Ni-Doped CoO nanosheets	-	-	-	377 $\text{mW cm}^{-2}$	400 h (5 mA $\text{cm}^{-2}$ )	0.63 V (charge/discharge density: 2/20 mA $\text{cm}^{-2}$ )	22
Ultrathin $\text{Co}_3\text{O}_4/\text{CC}$	-	-	-	546 $\text{W h kg}^{-1}$ (2 mA $\text{cm}^{-2}$ )	-	0.92 V (2 mA $\text{cm}^{-2}$ )	26
$\text{Co}_3\text{O}_4/\text{N-rGO}$ nanosheets	1.72 V	0.79 V	0.93 V	36.1 $\text{mWh cm}^{-3}$	25 h	0.8 V (3 mA $\text{cm}^{-2}$ )	27
Ultrathin CoOx layers	1.6 V	0.896 V	0.704 V	300 $\text{W g}_{\text{cat}}^{-1}$	10 h	0.57 V (6 mA $\text{cm}^{-2}$ )	28
NC- $\text{Co}_3\text{O}_4/\text{CC}$	1.588 V	0.87 V	0.718 V	82.0 $\text{mW cm}^{-3}$ (227 mA $\text{cm}^{-3}$ )	210 h	-	39
CoO-NSC	1.7 V	0.83 V	0.86 V	65 $\text{mW cm}^{-2}$	35 h	0.88 V	45