Supporting Information

Integrating Single Atoms with Nanoparticles Catalysts for Efficient Electrochemical Energy Conversion

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Table S1. Performance of SA/NPCs in different electrocatalytic reactions.

Catalysts	Single atoms	Nano particles	Performance	Type	Electrolyte (M)	Ref.
Fe/NC	FeN_4	Fe	$E_{1/2}$ = 0.90 V $E_{1/2}$ = 0.71 V	ORR	KOH (1.0) H_2SO_4 (1.0)	1
Fe-N-HMCTs	FeN_x	Fe_3C	$E_{1/2}$ = 0.872 V $E_{1/2}$ = 0.71 V	ORR	KOH (0.1) H_2SO_4 (0.5)	2
Fe SAs/NPs@NC	Fe	Fe	$E_{1/2}$ = 0.898 V	ORR	KOH (0.1)	3
Pt_3Co/FeN_4-C	FeN_4	Pt_3Co	$E_{1/2}$ = 0.90 V	ORR	$HClO_4$ (0.1)	4
Pt-Fe-N-C	Pt/Fe	PtFe	$E_{1/2}$ = 0.909 V	ORR	$HClO_4$ (0.1)	5
Fe/Meso-NC-1000	Fe	Fe	$E_{1/2}$ = 0.885 V	ORR	KOH (0.1)	6
FeN_3-Pd@NC NB	FeN_3	Pd	$E_{1/2}$ = 0.926 V	ORR	KOH (0.1)	7
FeSA-FeNC@NSC	Fe	Fe	$E_{1/2}$ = 0.90 V	ORR	KOH (0.1)	8

Catalysts	Single atoms	Nano particles	Performance	Type	Electrolyte (M)	Ref.
Co-SAs/SNPs@NC	Co	Co	$E_{1/2}$ = 0.898 V	ORR	KOH (0.1)	9
Cu_1Co_p-N-C	Cu	Co	$E_{1/2}$ = 0.87 V	ORR	KOH (0.1)	10
Co_3Fe_7@Co/Fe-SAC	CoFe	Co_3Fe_7	$E_{1/2}$ = 0.84 V	ORR	KOH (0.1)	11
$Fe_{NPs}/MnFe_{SAs}$-NC	Mn/Fe	Fe	$E_{1/2}$ = 0.91 V	ORR	KOH (0.1)	12
Fe_3O_4@FeNC	Fe	Fe_3O_4	$E_{1/2}$ = 0.89 V	ORR	KOH (0.1)	13
FeSA/FeAC-NC 900	Fe	Fe	$E_{1/2}$ = 0.90 V $E_{1/2}$ = 0.80 V	ORR	KOH (0.1) $HClO_4$ (0.1)	14
nPtCo/NC	CoN_4	Pt_3Co	$E_{1/2}$ = 0.89 V	ORR	$HClO_4$ (0.1)	15

Catalysts	Single atoms	Nano particles	Performance	Type	Electrolyte (M)	Ref.
Co-NCS-2	Co	Co	$E_{1/2}$ = 0.90 V	ORR	KOH (0.1)	16
RuCo@NC	Co-N_x	RuCo	$E_{j=10}$ = 1.46 V	OER	KOH (1.0)	17
Ni SAs/Fe-NiOOH	NiC_4	Fe-NiOOH	$E_{j=10}$ = 1.499 V	OER	KOH (1.0)	18
Co_nIr_1/N-C	Ir	Co	$E_{j=10}$ = 1.492 V	OER	KOH (1.0)	19
Cu/Rh(SAs)+ Cu_2Rh(NPs)/G	CuRu	Cu_2Rh	η_{10} = 8 mV	HER	H_2SO_4 (0.5)	20
Ru/Co@OG	Co	Ru	η_{10} = 13 mV	HER	KOH (1.0)	21
Ru@Co-SAs/N-C	Co	Ru	η_{10} = 7 mV η_{10} = 57 mV	HER	KOH (1.0) H_2SO_4 (0.5)	22
Ru/Fe-N-C	Ru-N_4 Fe-N-C	Ru	η_{10} = 9 mV	HER	KOH (1.0)	23
Ni SA/NP-NCF-800	Ni-N_4	Ni	η_{10} = 137.3 mV	HER	KOH (1.0)	24
Ru_{NP}-Ru_{SA}@CFN-	Ru	Ru	η_{10} = 33 mV	HER	KOH (1.0)	25

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Ru_{NP}@RuN_x-OFC/NC	Ru	Ru	η_{10} = 19 mV η_{10} = 10 mV	HER	KOH (1.0) H_2SO_4 (0.5)	26
CoSe/Co-N-C	Co	CoCe	η_{10} = 71 mV η_{10} = 63 mV η_{10} = 128 mV	HER	KOH (1.0) H_2SO_4 (0.5) PBS (1.0)	27
Ni SAs-Pd@NC	Ni	Pd	$E_{1/2}$ = 0.84 V $E_{j=10}$ = 1.61 V	ORR OER	KOH (0.1)	28

Catalysts	Single atoms	Nano particles	Performance	Type	Electrolyte (M)	Ref.
Co_{SA}&$Co_{NP\text{-}10}$	Co	Co	$E_{1/2}$ = 0.86 V $E_{j=10}$ = 1.62 V	ORR OER	KOH (0.1)	29
Co@NCNT/Co-SA@NCMT	Co	Co	$E_{1/2}$ = 0.870 V $E_{j=10}$ = 1.6 V	ORR OER	KOH (1.0)	30
Co@N-C/PCNF	Co	Co	$E_{1/2}$ = 0.85 V $E_{j=10}$ = 1.519 V	ORR OER	KOH (0.1) KOH (1.0)	31
CNT@CoSA-Co/NCP	Co	Co	$E_{1/2}$ = 0.87 V $E_{j = 10}$ = 1.61 V	ORR OER	KOH (0.1) KOH (1.0)	32
CoNP-CoSA@DSCB	Co	Co	$E_{1/2}$ = 0.886V $E_{j=10}$ = 1.571 V	ORR OER	KOH (0.1) KOH (1.0)	33
Co-Co_3O_4@NAC	Co	Co_3O_4	$E_{1/2}$ = 0.795 V $E_{j=10}$ = 1.61 V	ORR OER	KOH (0.1)	34
RuCo@Co-N-C	Co	RuCo	$E_{1/2}$ = 0.90 V $E_{j=10}$ = 1.55 V	ORR OER	KOH (0.1) KOH (1.0)	35

CoNi/Co-N@HNC	Co	CoNi	$E_{1/2}$ = 0.86 V $E_{j=10}$ = 1.59 V	ORR OER	KOH (0.1)	36
NiFe@C@Co CNFs	Co	NiFe	$E_{1/2}$ = 0.87 V $E_{j=10}$ = 1.57 V	ORR OER	KOH (0.1) KOH (1.0)	37
SD-Fe-N/C	Fe	Fe	$E_{1/2}$ = 0.852 V $E_{j=10}$ = 1.565 V	ORR OER	KOH (0.1)	38
Fe-N-C/Fe_3C-op	Fe	Fe_3C	$E_{1/2}$ = 0.911 V $E_{j=10}$ = 1.579 V	ORR OER	KOH (0.1) KOH (1.0)	39

Catalysts	Single atoms	Nano particles	Performance	Type	Electrolyte (M)	Ref.
FePc‖CNTs‖NiCo/CP	Fe	NiCo	$E_{1/2}$ = 0.89 V $E_{j=10}$ = 1.58 V	ORR OER	KOH (0.1)	40
H-CoFe@NCNF	Fe	$Co_{5.47}N$	$E_{1/2}$ = 0.77 V $E_{j=10}$ = 1.68 V	ORR OER	KOH (0.1)	41
FePc‖$NiFe_2O_4$/G	Fe	$NiFe_2O_4$	$E_{1/2}$ = 0.85 V $E_{j=10}$ = 1.57 V	ORR OER	KOH (0.1)	42
FeCo NPs/NC	FeCo	FeCo	$E_{1/2}$ = 0.82 V $E_{j=10}$ = 1.49 V	ORR OER	KOH (0.1) KOH (1.0)	43
SA&NP-FeCo-NTS	FeN_4 CoN_4	FeCo	$E_{1/2}$ = 0.87 V $E_{j=10}$ = 1.58 V	ORR OER	KOH (0.1) KOH (1.0)	44
Fe/Ni-NC‖FeNi@G	FeNi	FeNi	$E_{1/2}$ = 0.885 V $E_{j=10}$ = 1.503 V	ORR OER	KOH (0.1) KOH (1.0)	45
Ni, Fe-DSAs/NCs	NiFe	NiFe	$E_{1/2}$ = 0.895V $E_{j = 10}$ = 1.612 V	ORR OER	KOH (0.1)	4

metal/NG	AuPtIr	AuPtIr	$E_{1/2}$ = 0.855 V $E_{j=10}$ = 1.493 V	ORR OER	KOH (0.1) KOH (1.0)	46
$Ni_{SA}Fe_{SA}$-Ni_xFe/CNT	NiFe	NiFe	$E_{j=10}$ = 1.457 V η_{10} = 64 mV	OER HER	KOH (1.0)	47
CoRu-MoS_2	Co	Ru	$E_{j=10}$ = 1.538 V η_{10} = 52 mV	OER HER	KOH (1.0)	48
CoNG/Ru	Co	Ru	$E_{j = 10}$ = 1.58 V η_{10} = 15 mV	OER HER	KOH (1.0)	49

Catalysts	Single atoms	Nano particles	Performance	Type	Electrolyte (M)	Ref.
Mo-CoP/Co-N-C	Co	Mo-CoP	$E_{j = 10}$ = 1.431 V η_{10} = 45 mV	OER HER	KOH (1.0)	50
Cu_{1+n}/BDNC	Cu	Cu	$E_{j=10}$ = 1.43 V η_{10} = 216 mV	OER HER	KOH (1.0)	51
Au-Fe_1NC/NF	Fe	Au	$E_{j=10}$ = 1.476 V η_{10} = 35.6 mV	OER HER	KOH (1.0)	52
FeCoSe@NCNSs	Fe	CoSe	$E_{j=10}$ = 1.55 V η_{10} = 99 mV	OER HER	KOH (1.0)	53
Ir-SA@Fe@NCNT	Ir	Fe	$E_{j=10}$ = 1.48 V η_{10} = 26 mV	OER HER	H_2SO_4 (0.5)	54
CoNC	Co	Co	$E_{j=10}$ = 1.459 V η_{10} = 36 mV $E_{1/2}$ = 0.858 V	OER HER ORR	KOH (1.0) KOH (1.0) KOH (0.1)	55

CoSA + Co_9S_8/HCNT	Co	Co_9S_8	$E_{j=10}$ = 1.56 V	OER	KOH (0.1)	56
			η_{10} = 250 mV	HER	KOH (1.0)	
			$E_{1/2}$ = 0.855 V	ORR	KOH (0.1)	

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