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Template assisted Synthesis of Ni, N co-doped Porous Carbon from Ni Incorporated ZIF-8 Frameworks for Electrocatalytic Oxygen Reduction Reaction

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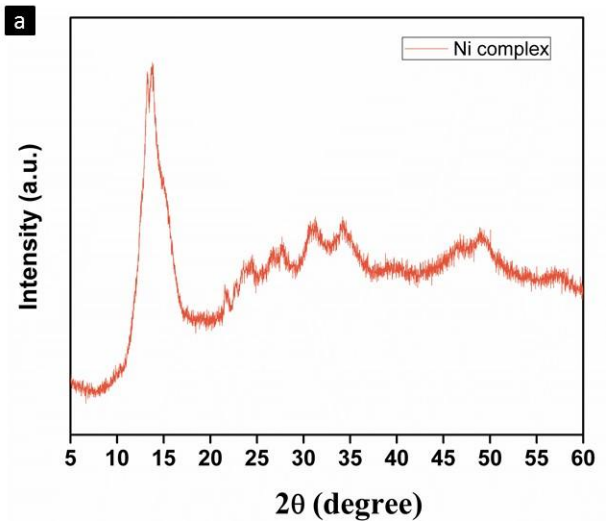

Fig. S1. PXRD pattern of Ni-methylimidazolate complex

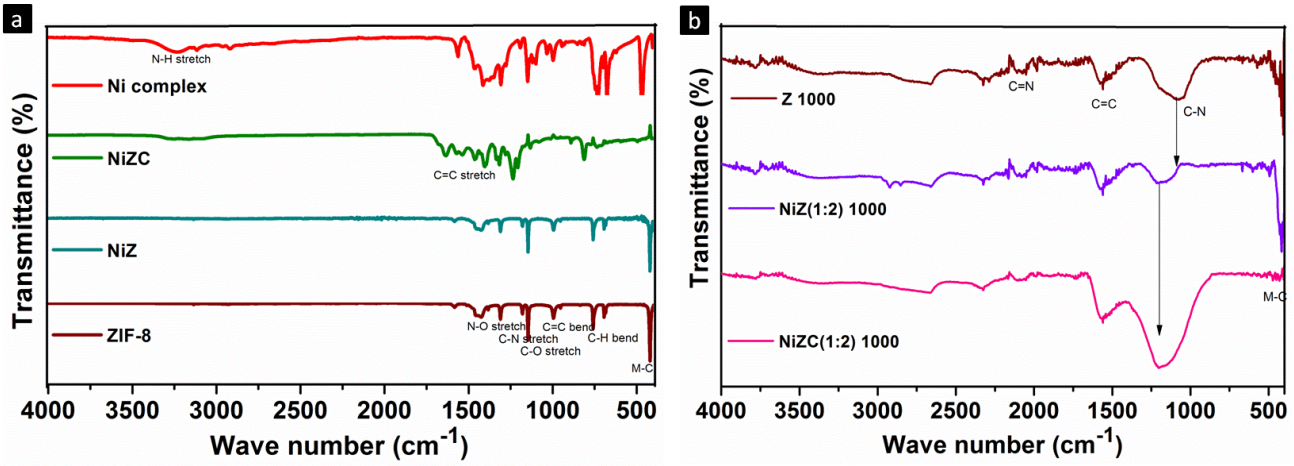

Fig. S2. FT-IR spectra of a) ZIF-8, NiZ, NiZC and Ni-Imidazolate complex b) Carbonised ZIF-8, NiZ and NiZC at 1000 °C

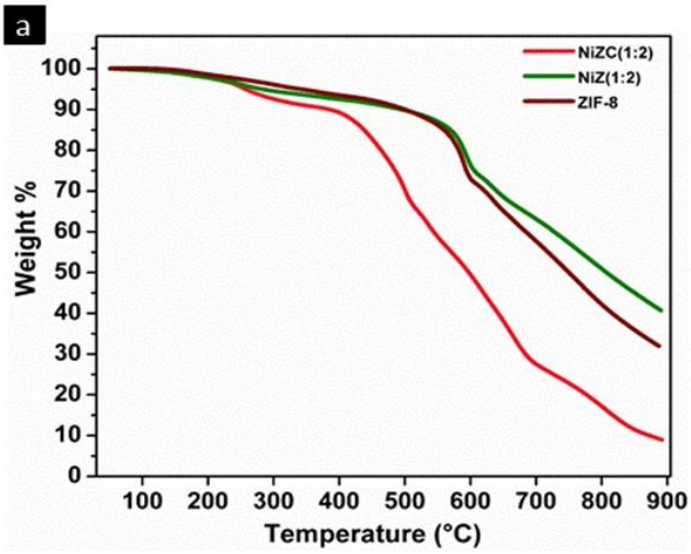

Fig. S3. TGA curves of ZIF-8, NiZ(1:2) and NiZC(1:2)

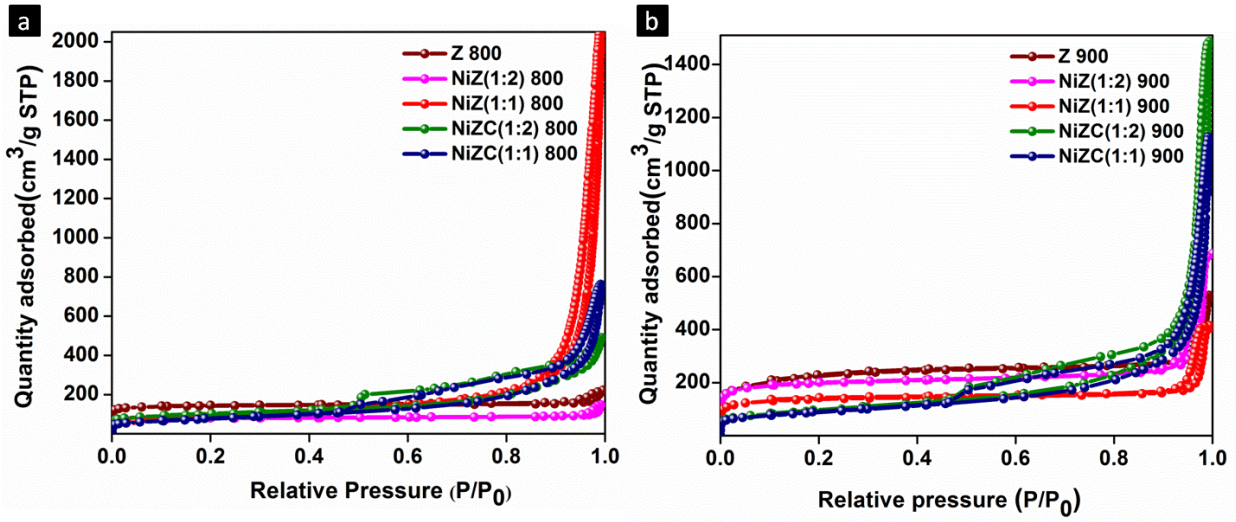

Fig. S4. N_2 adsorption- desorption isotherms of carbon samples obtained at a) 800 °C and b) 900 °C

Table S1. Surface areas and pore volumes of samples after carbonization at 800 °C and 900 °C

Sample	After carbonization					
	800 °C			900 °C		
	S_{BET} (m^2/g)	V_{total} (cm^3/g)	V_{micro} (cm^3/g)	S_{BET} (m^2/g)	V_{total} (cm^3/g)	V_{micro} (cm^3/g)
Z (ZIF-8)	453	0.35	0.20	751	0.82	0.27
NiZ(1:2)	252	0.23	0.11	644	1.06	0.26
NiZ(1:1)	339	3.2	0.1	449	0.45	0.09
NiZC(1:2)	338	0.75	0.12	337	2.29	0.1
NiZC(1:1)	271	1.18	0.08	314	1.74	0.1

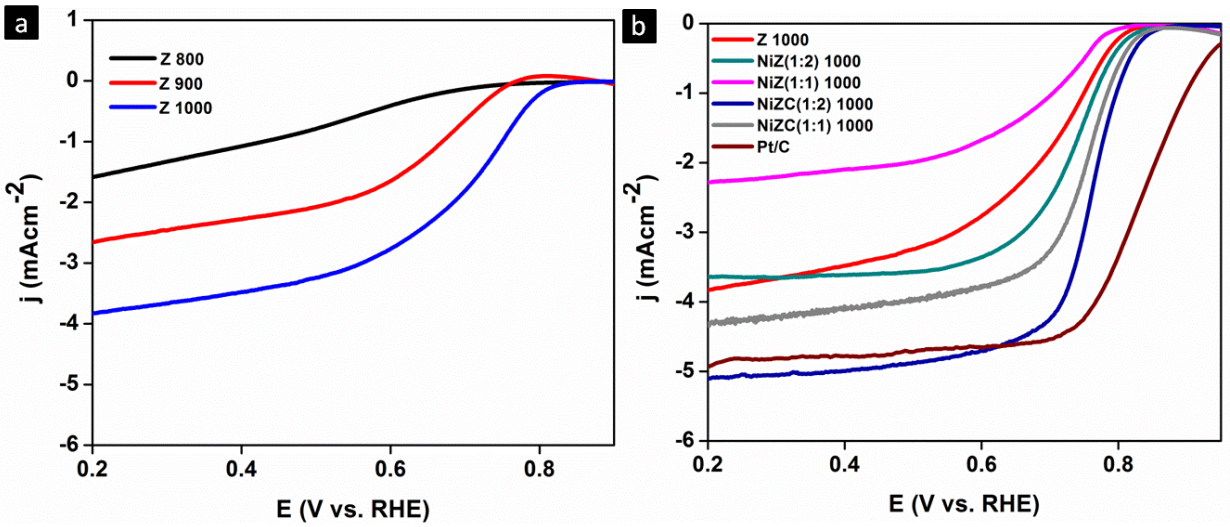

Fig. S5. a) LSV curves of ZIF-8 derived carbon samples obtained after carbonisation at different temperatures b) Compared LSV curves of carbon samples obtained after carbonisation at 1000 °C with Pt/C in O_2 saturated 0.1 M KOH solution under 1600 rpm

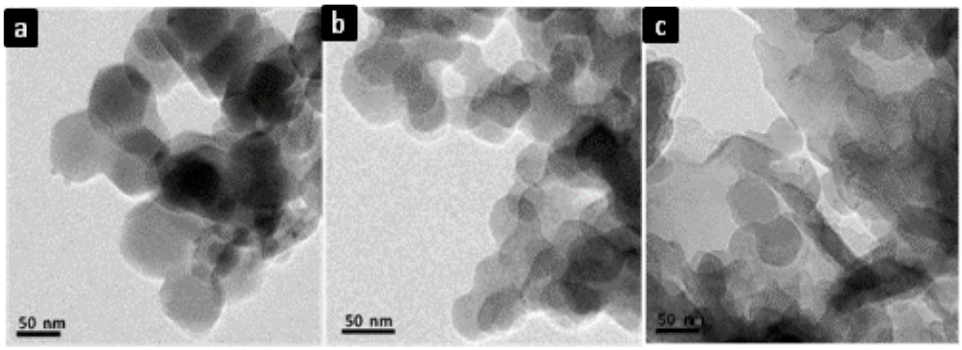

Fig. S6. TEM image of a) ZIF-8, b) NiZ (1:2) and c) NiZC (1:2) samples

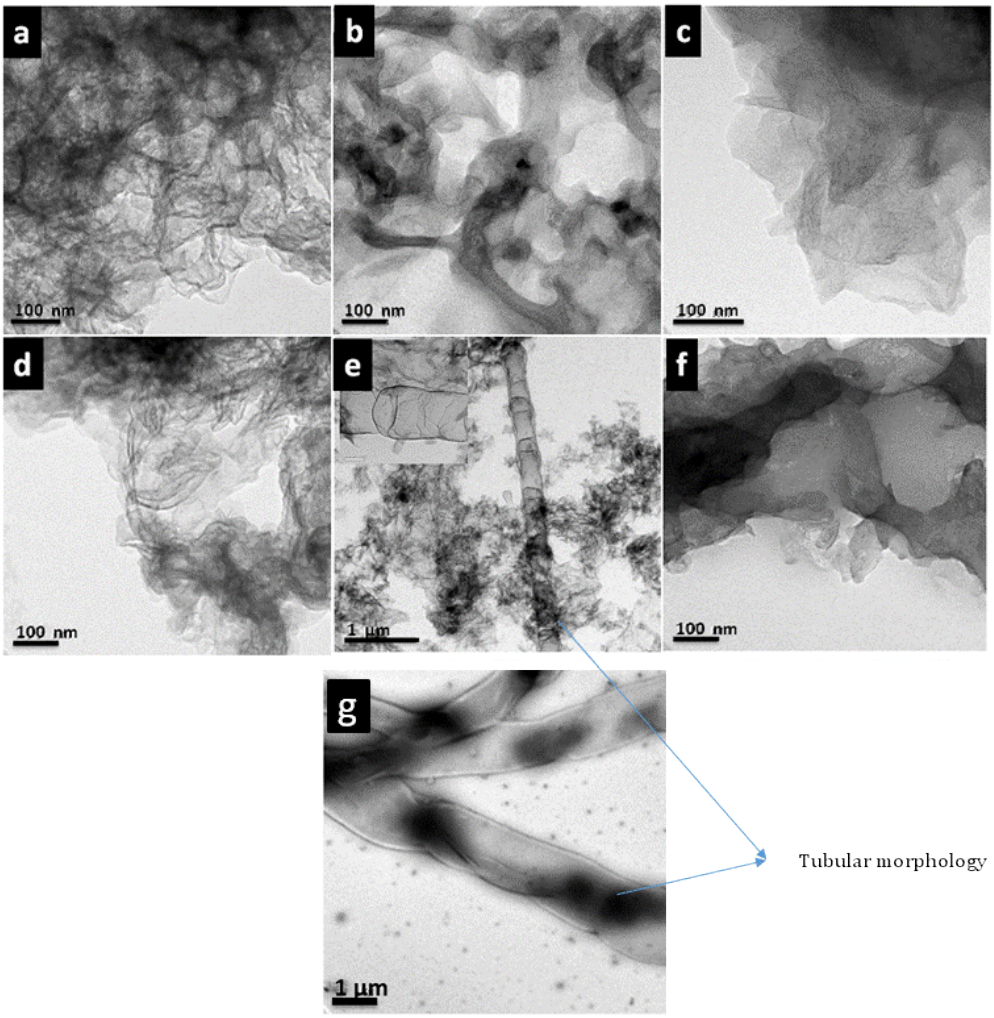

Fig. S7. TEM images of ; a) NiZC(1:2) 800, b) NiZC(1:2) 900, c) NiZC(1:2) 1000, d) NiZC(1:1) 800, e) NiZC(1:1) 900 f) NiZC(1:1) 1000 and g) NiZ(1:1) 800 with various morphologies

Table S2. Distribution of various elements in samples obtained from SEM-EDS data

Sample name	Elemental distribution (Atomic %)			
	C	N	Ni	Zn
NiZ(1:2)	62.02	32.85	0.04	5.09
NiZC(1:2)	40.63	58.11	0.01	1.25
Z 1000	79.01	20.26	-------	-------
NiZ(1:2) 1000	80.07	19.71	0.22	-------
NiZC(1:2) 1000	71.89	27.90	0.21	-------

Table S3. Distribution of various elements in NiZC(1:2) T samples obtained from SEM-EDS data

Sample name	Elemental distribution (Atomic %)		
	C	N	Ni
NiZC(1:2) 800	51.50	48.24	0.26
NiZC(1:2) 900	67.77	31.85	0.38
NiZC(1:2) 1000	71.89	27.90	0.21

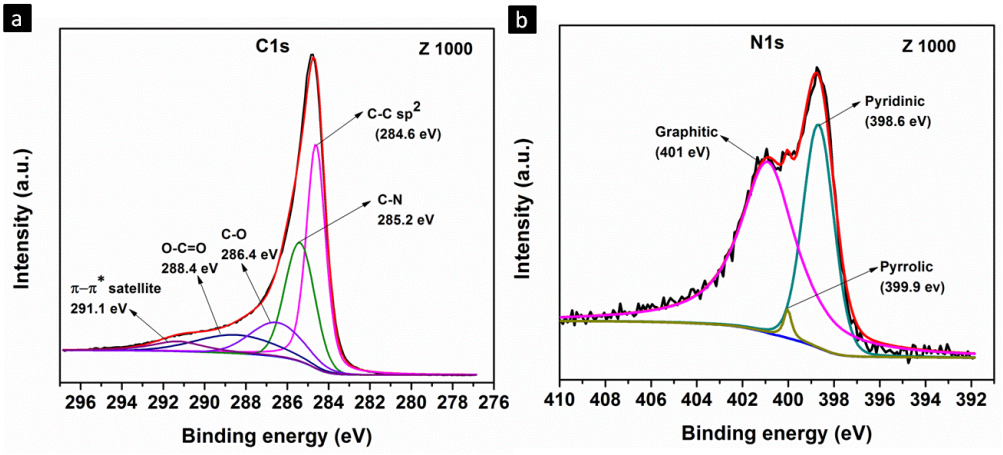

Fig. S8. XPS deconvoluted spectra a) C1s, and b) N1s of Z 1000 sample

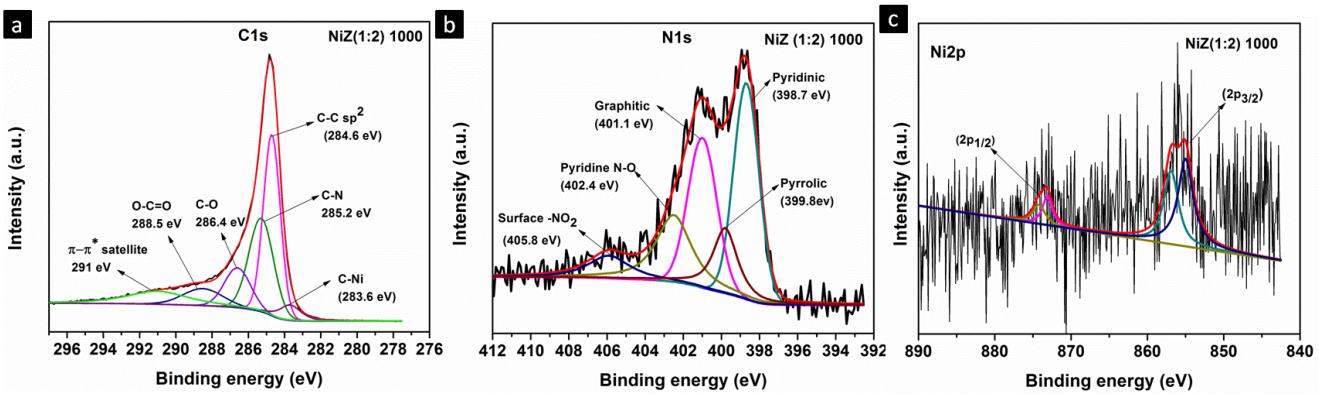

Fig. S9. XPS deconvoluted spectra of a) C1s, b) N1s, and c) Ni 2p of NiZ(1:2) 1000 sample

Table S4. Distribution of various types of nitrogen in Z 1000, NiZ(1:2) 1000 and NiZC(1:2) 1000 samples obtained from XPS deconvoluted spectrum

Sample name	**N content (At %)**				
	Pyridinic	**Pyrrolic**	**Graphitic**	**Pyridinic N-O**	**-NO_2**
Z 1000	6.431	0.286	1.281	-------	-------
NiZ(1:2) 1000	1.946	0.771	1.546	1.161	0.473
NiZC(1:2) 1000	4.743	0.43	2.571	1.454	------

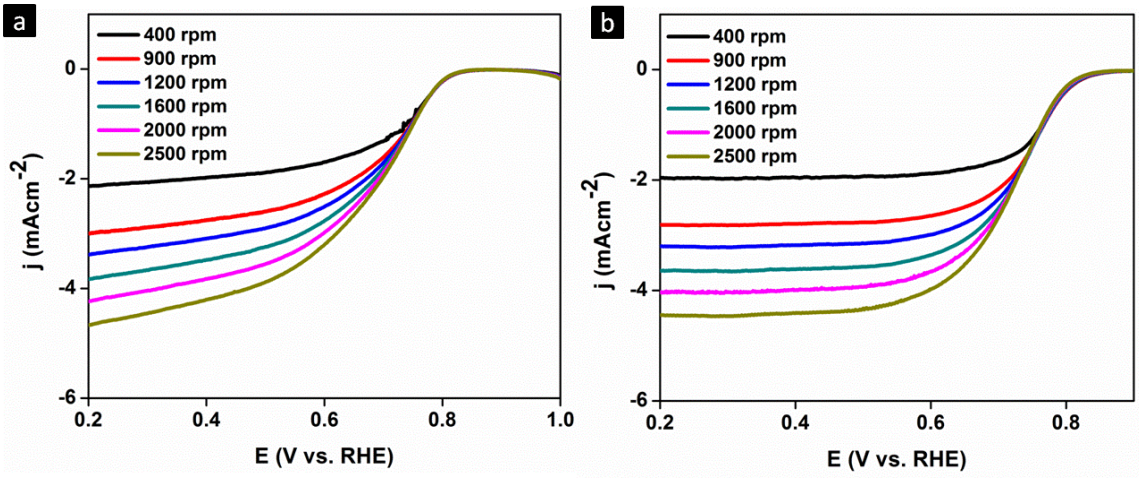

Fig. S10. LSV curves of a) Z 1000 and b) NiZ(1:2) 1000 under different rotation rates in O_2 saturated 0.1 M KOH solution.

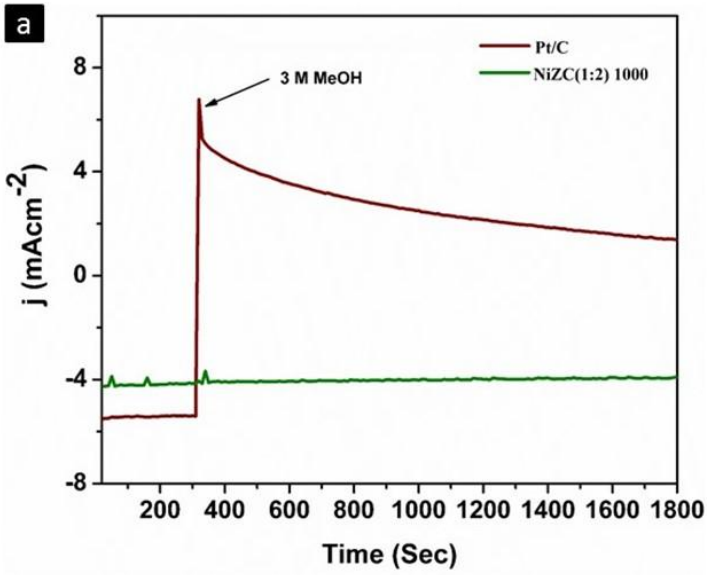

Fig. S11. Methanol tolerance curves of NiZC(1:2) and Pt/C

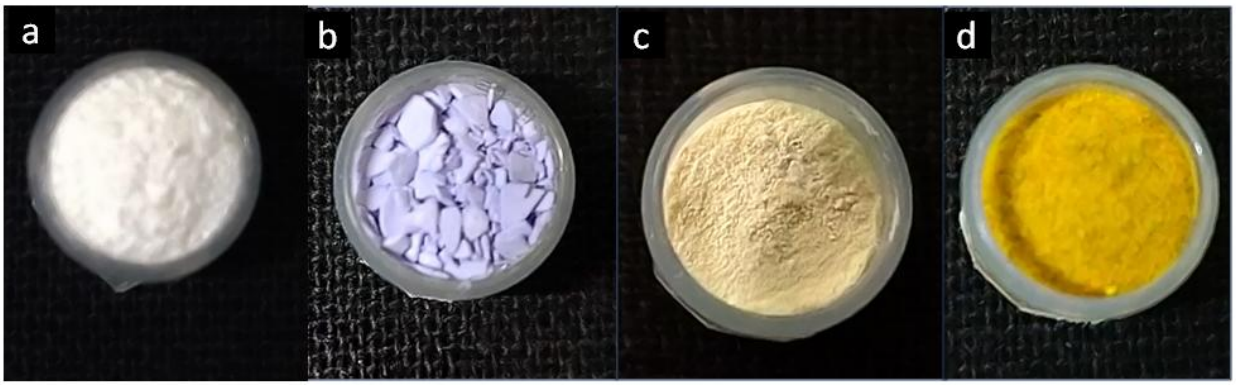

Fig. S12. Photographs of a) ZIF-8 , b) NiZ , c) NiZC and d) Ni-methylimidazolate complex powder samples

Table S5. Comparison of ORR performance of Ni incorporated catalysts with recent literatures

Sample name	Onset	Half wave	Current desity (mA cm^{-2})	Electron transfer number	reference
Ni@N-CNCs	0.04 V (vs Ag/AgCl)	-0.19 V(Vs Ag/AgCl)	-4.8	4.0	[71]
$Ni_3(HITP)_2$ framework	0.82 V (vs. RHE),o.1 M aq. KOH	---------	−2.5	--------	[72]
NCNTs/ E-NNPs	0.96 V (vs. RHE), 0.1 M KOH	0.86V (vs. RHE)	-3.8	3.7	[73]
Ni-NC700	0.86 V (vs. RHE), 0.1 M KOH	0.75 V (vs. RHE), 0.1 M KOH	-2.2	------	[27]
Ni/ rGO	0.80 V (vs. RHE), 0.1 M KOH	O.60V	-4.6	≈2.8	[74]
Ni-GT-750-A	0.89 V (vs. RHE,.1 M KOH	------	-3.90	---------	[28]
NiZC(1:2) 1000	0.86 V (vs. RHE),.1 M KOH	0.76 V	-5.2	3.8	[Present work]