Supporting Information

Extremely efficient and stable hydrogen evolution by a Pt/NiO$_x$ composite film deposited on a nickel foam using a mixed metal-imidazole casting method

Zaki N. Zahran,[a,b*], Yuta Tsubonouchi,[a] Debraj Chandra[a], Tomoki Kanazawa,[c] Shunsuke Nozawa,[c] Eman A. Mohamed,[a] Norihisa Hoshino[a] and Masayuki Yagi,[a*]

[a]Department of Materials Science and Technology, Faculty of Engineering, Niigata University, 8050 Ikarashi-2, Niigata 9050-2181, Japan.

[b]Faculty of Science, Tanta University, Tanta 511111, Egypt.

[c] Institute of Materials Structure Science, High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba, Ibaraki, 305-0801, Japan

*Correspondence to: yagi@eng.niigata-u.ac.jp and znzahran@eng.niigata-u.ac.jp

Contents:

Table S1. Comparison of the Pt-film(w) electrode with the state-of-the-art Pt-based electrocatalysts with the excellent η^{10} values less than 200 mV for HER performances in 1.0 M KOH media (pH 14) [a].

Catalysts	Current collectors	Γ_{Pt} (mg cm^{-2})	Fabrication methods	η^{10} / η^{100} (mV)	Tafel slope (mV dec^{-1})	Stability	j_m at η = 50 mV (A cm^{-2} mg$_{Pt}^{-1}$)	Ref.
Pt-film(w)	NF	1.08	Drop casting/calcination	4.2/26.6	23	CP: η^{10} and η^{100} remained constant at ~5.0 and 27 mV for 60 h.	0.42	TW
Pt	GC	0.098	Drop casting/calcination	60/170	62	CP: η^{10} increased from 60 to 131 mV after 20 h.	0.073	S1
Pt	FTO	0.098	Drop casting/calcination	198/NA	142	CP: η^{10} increased from 150 to 230 mV after 20 h.	NA	S2
Pt_3Ni-NiS	NF	~1.0	Electrophoretic	12/73	24	CA: At η = 12 mV, j remained constant at 10 mA cm^{-2} for 192 h	0.075	S3
Pt	NF	~1.0	Electrophoretic	22/107	31	CA: At η = 22 mV, j decreased from 10 to 6 mA cm^{-2} after 48h.	0.035	S3
Pt/NiO/Ni	NF	0.092	Electrodeposition	34/110	39	CP: η^{10} increased from 34 to 55 mV after 24 h.	0.220	S4
Pt/Ni	NF	0.113	Electrodeposition	50/150	56	NA	0.090	S4
Pt-Ni_3N	Ni mesh	0.300	LSV deposition	50/110	36.5	CA: At η = 50 mV, j decreased from 10 to 8 mA cm^{-2} after 24h.	0.033	S5
PtO_2-$Ni(OH)_2$ NS	Ti	0.0755	Hydrothermal	80/280 70/250	89	CP: η^{20} remained constant at ~300 mV for 100 h.	0.093 0.132	S6
PtCo-Co	Ti mesh	0.0430	Hydrothermal/calcination	28/105	35	CA: j remained constant at 20 mA cm^{-2} for 50 h, but η was not shown.	0.51	S7
Pt(111) modified by $Ni(OH)_2$	Pt	NA	Electrodeposition	138/NA	100-130	CA: At η = 80 and 110 mV, j remained constant at 3.7 and 7.7 mA cm^{-2} for 2.25 h, respectively.	NA	S8
Pt modified by $Ni(OH)_2$	Pt	NA	Chemical deposition	~45 (η^5)/NA	75	NA	NA	S9
Pt_{SA}-$Co(OH)_2$	Ag	0.059	Cyclic voltametric deposition	29/104	35.7	CP: η^{20} remained constant at 65 mV for 50 h, but η^{100} increased from 140 to 150 after 20 h.	0.42	S10
$Pt_{13}Cu_{73}Ni_{14}$/CNF	C felt	6.653	Impregnation/galvanic displacement	67/NA	54	CA: At η = 100 mV, j decreased by 18% of its initial value after 0.28 h	0.013	S11
Pt_3Ni_2 NW-S/C	GC	0.077	Drop casting with	51/NA	NA	CP: η^5 increased from 30 to 40 after	0.120	S12

			Nafion			5h.		
Pt-Ni AS	GC	0.0170	Drop casting with Nafion	27.7/NA	27	NA	1.50	S13
Pt_3Ni/C nanoframs/$Ni(OH)_2$	GC	0.0100	Drop casting with Nafion	63 (η^5)/NA	NA	NA	0.31	S14
Pt NW/SL-$Ni(OH)_2$	GC	0.0161	Drop casting with Nafion	70 ($\eta^{2.5}$)/NA	NA	NA	0.09	S15
Pt-BP/GR	GC	0.0143	Drop casting with Nafion	21/80	46.9	NA	3.2	S16
Pt_{SA}-NiO/Ni/Ag NW	Flex. cloth	0.0054	Hydrothermal/ electrodeposition	26/85	27.1	CP: η^{20} remained constant at 40 mV for 30 h.	6.85	S17
Pt_{SA}-$MoSe_2$	GC	0.0029	Drop casting with Nafion	29/110	41	NA	5.17	S18
Pt_{SA}-N-C	GC	0.0063	Drop casting with Nafion	46/220	36.8	CP: η^{10} remained constant at 46 mV for 20 h.	1.90	S19
Pt_{SA}/AG	GC	0.0311	Drop casting with Nafion	12/NA	30.6	NA	0.80	S20
In-Pt_{SA} NW/C	GC	0.0128	Drop casting with Nafion	46/NA	32.4	CP: η^{10} remained constant at 46 mV for 5 h.	0.86	S21
Hcp-Pt-Ni/C	GC	0.0076	Drop casting with Nafion	65/NA	78	CA: At η = 65 mV, j decreased from 10 to 5 mA cm^{-2} after 1h.	1.60	S22
PtNi-O/C	GC	0.0051	Drop casting with Nafion	40/105	78.8	CP: η^{10} increased from 40 to 100 mV after 10 h.	3.92	S23
$Pt_{3.6}$Ni-S NW/C	GC	0.0153	Drop casting with Nafion	20/NA	114.8	CP: η^5 increased from 15 to 33 mV after 5 h.	2.61	S24
PtNi NP/Ni NSA	C cloth	0.0693	Drop casting with Nafion	38/NA	42	CP: η^{20} increased from 50 to 90 mV after 90 h.	NA	S25
Pt_3Ni_3 NW/C-air	GC	0.0153	Drop casting with Nafion	40/NA	NA	CP: η^5 increased from 30 to 40 mV after 3 h.	0.65	S26, 27
$Pt_1Ru_{1.54}$ NC/BP	GC	0.0148	Drop casting with Nafion	22/75	19	CP: At η = 22 mV, j decreased from 10 to 7 mA cm^{-2} after 20 h.	3.38	S28
Pt-$Co(OH)_2$	C cloth	0.3900	Electrodeposition	32/115	70	CP: η^5 increased from 32 to 90 mV after 20 h,	0.05	S29
Pt-Ni octahedra/C	GC	0.0062	Drop casting with	70/NA	59	CP: η^4 increased from 25 to 50 mV	1.81	S30

			Nafion			after 1 h,		
Pt-2D-$(NiOH)_2$/C	GC	0.00113	Drop casting with Nafion	180/NA	72	CA: At η = 100 mV, j decreased by 49% of its initial value after 5.56 h.	0.88	S31
PtNiCo alloy nanohexapod/C	GC	0.0100	Drop casting with Nafion	22(η^5)/NA	NA	NA	NA	S32

a) GC: Grassy carbon, TW: this work, NA: not available, CP: chronopotentiometry, CA: chronoamperometry, NS: nanosheet, Pt_{SA}:Pt single atom, CNF: carbon nanofiber, NW: nanowires, AS: anisotropic, SL: single layered, BP: black phosphorous, GR: graphite, N-C: nitrogen doped carbon, AG: aniline-stacked graphene, Hcp: hexagonal close-packed superstructure, NP nanoparticle, NSA: nanosheet array, air: thermally annealed in air, NC: nanocrystals, 2D: two dimensional.

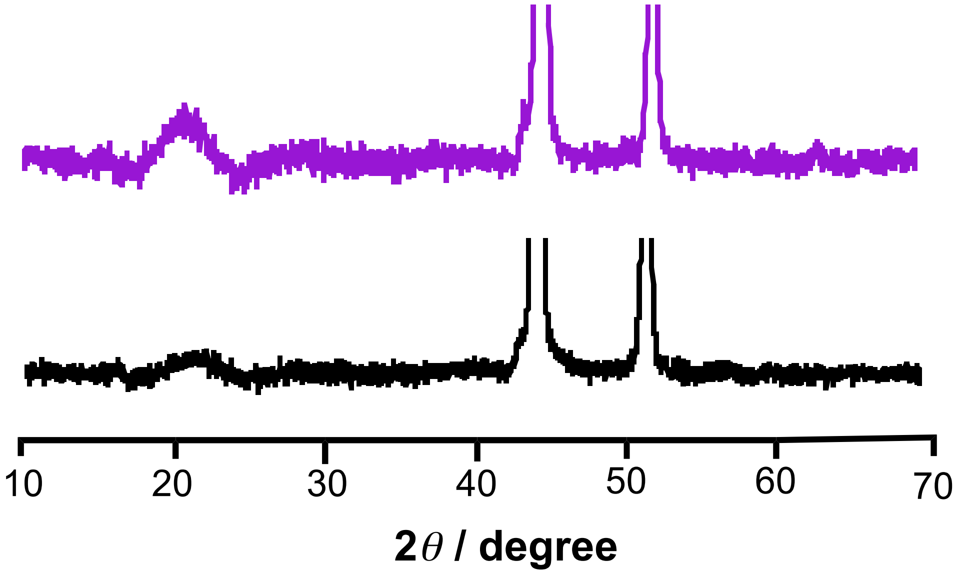

Figure S1. X-ray diffraction patterns (XRD) of the bare NF substrate before (black, below) and after (violet, above) calcination at 450 °C.

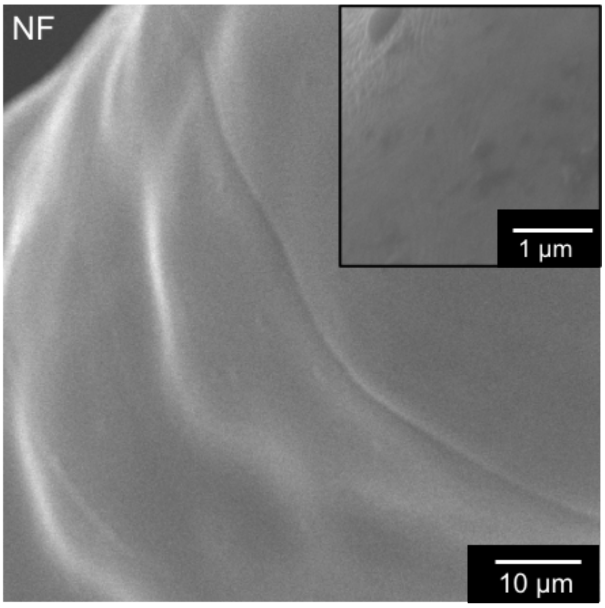

Figure S2. SEM image (top view) of the bare NF surface.

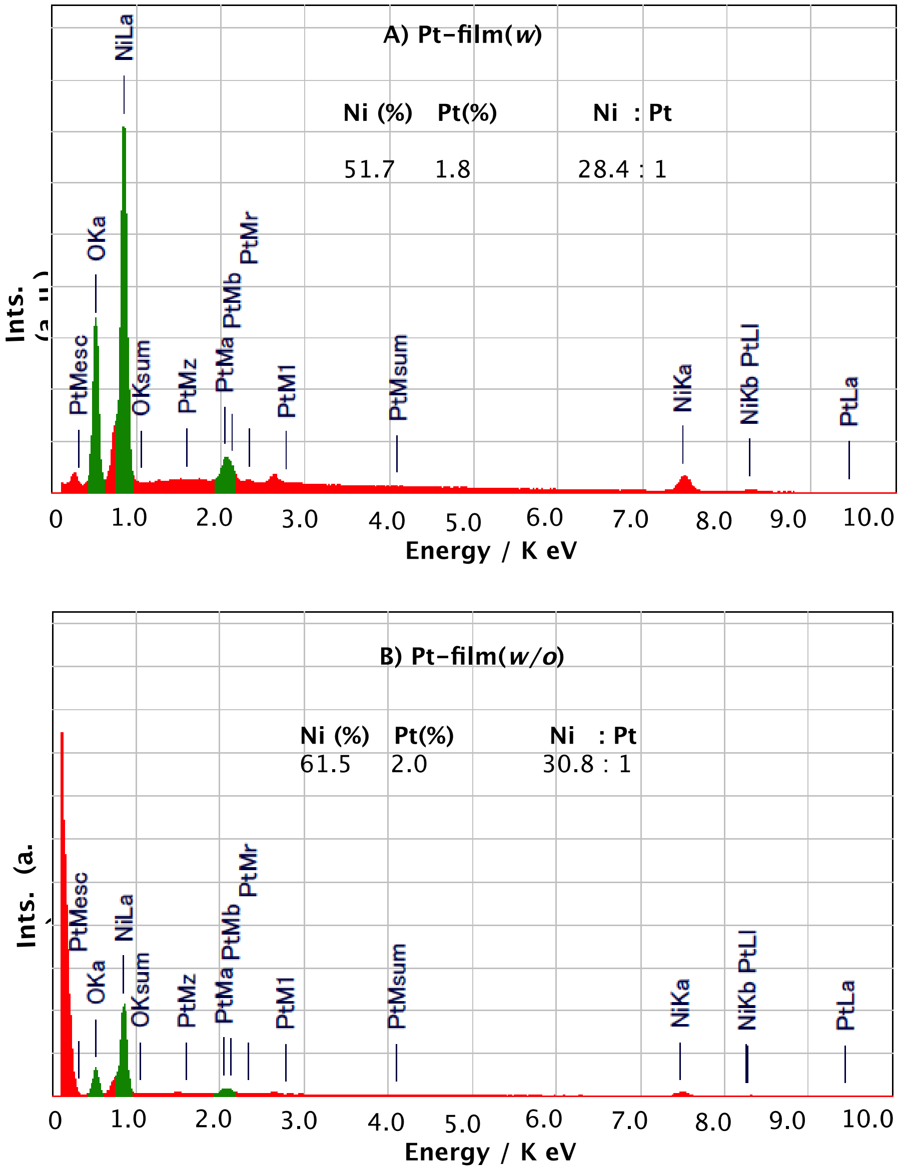

Figure S3. EDS spectra of (**A**) Pt-film(*w*) and (**B**) Pt-film(*w/o*) on the NF substrate, as measured with SEM observation.

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