Supporting Information

Au Integrated AgPt Nanorods for Oxygen Reduction Reaction in Proton Exchange Membrane Fuel Cells

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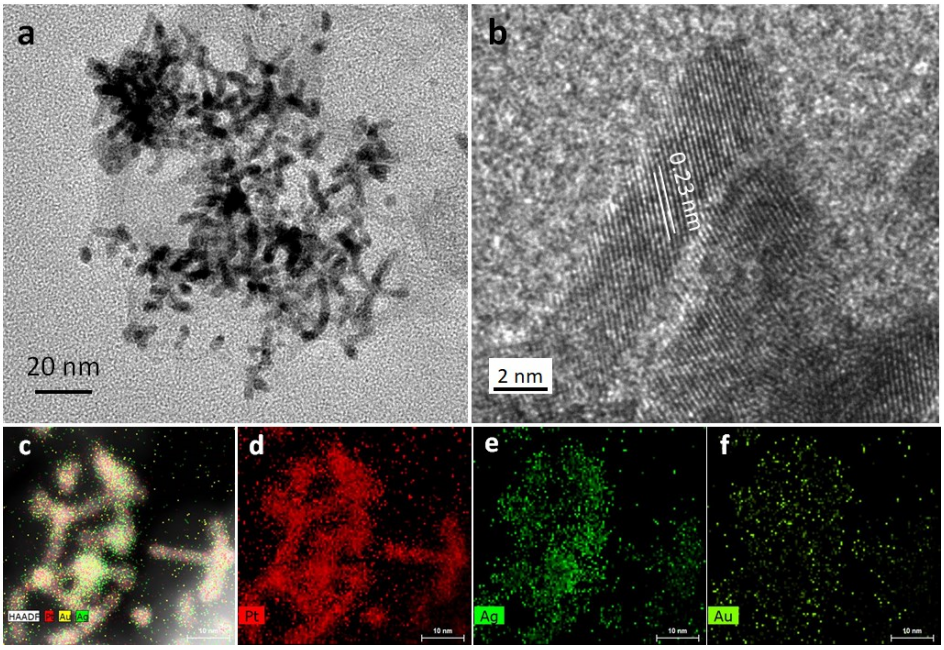

Fig. S1. a-c) TEM images of the Au-AgPt NR/C B catalyst synthesized following the reaction scheme B, and d-g) show the element mapping by EDX analysis.

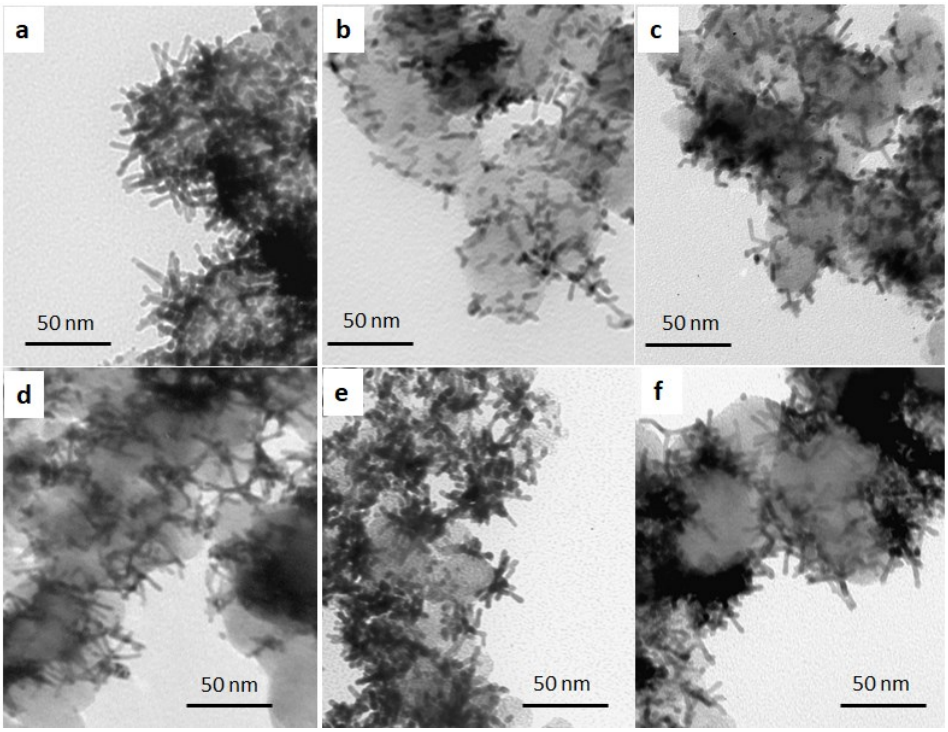

Fig. S2. TEM images of a) Pt NR/C, b) AgPt NR/C, c) Au-AgPt NR/C 2%, d) Au-AgPt NR/C 5%, e) Au-AgPt NR/C 8% and f) Au-AgPt NR/C 12% synthesized following the reaction scheme A.

Table S1. The metal content measured by TGA & ICP-MS of Au-AgPt NR/C synthesized following the reaction scheme A

Catalysts	TGA-residue / wt%	ICP-MS / wt%			ICP-MS / at%		
		Au	Ag	Pt	Au	Ag	Pt
AgPt NR/C	60.98	0	32.23	67.77	0	46.23	53.77
Au-AgPt NR/C 2%	61.27	2.30	30.07	62.53	1.92	45.63	52.45
Au-AgPt NR/C 5%	60.52	6.77	28.56	64.67	5.45	41.97	52.58
Au-AgPt NR/C 8%	62.08	9.92	25.46	62.08	8.16	38.22	53.62
Au-AgPt NR/C 12%	60.66	13.84	24.00	63.06	11.56	35.25	53.19

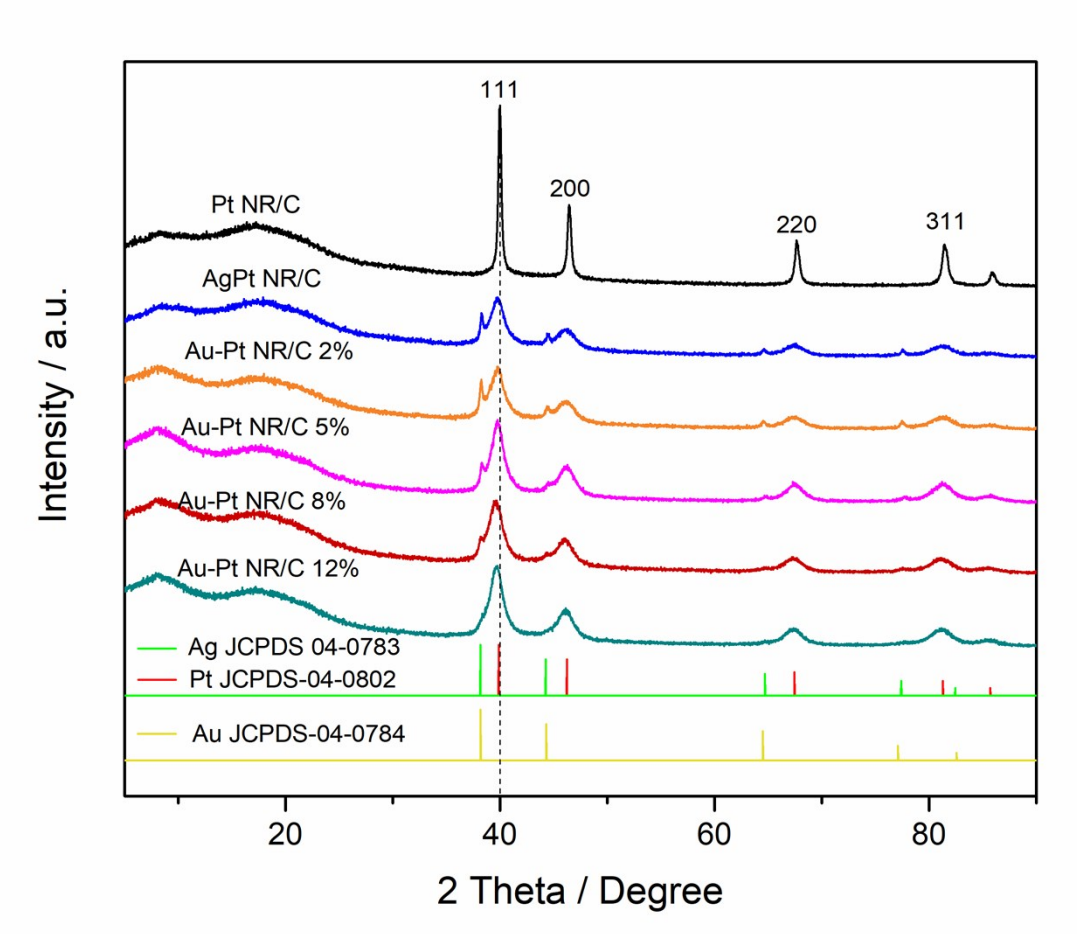

Fig. S3. XRD patterns of the Pt NR/C, AgPt NR/C and Au-AgPt NR/C catalysts with various Au contents synthesized following the reaction scheme A.

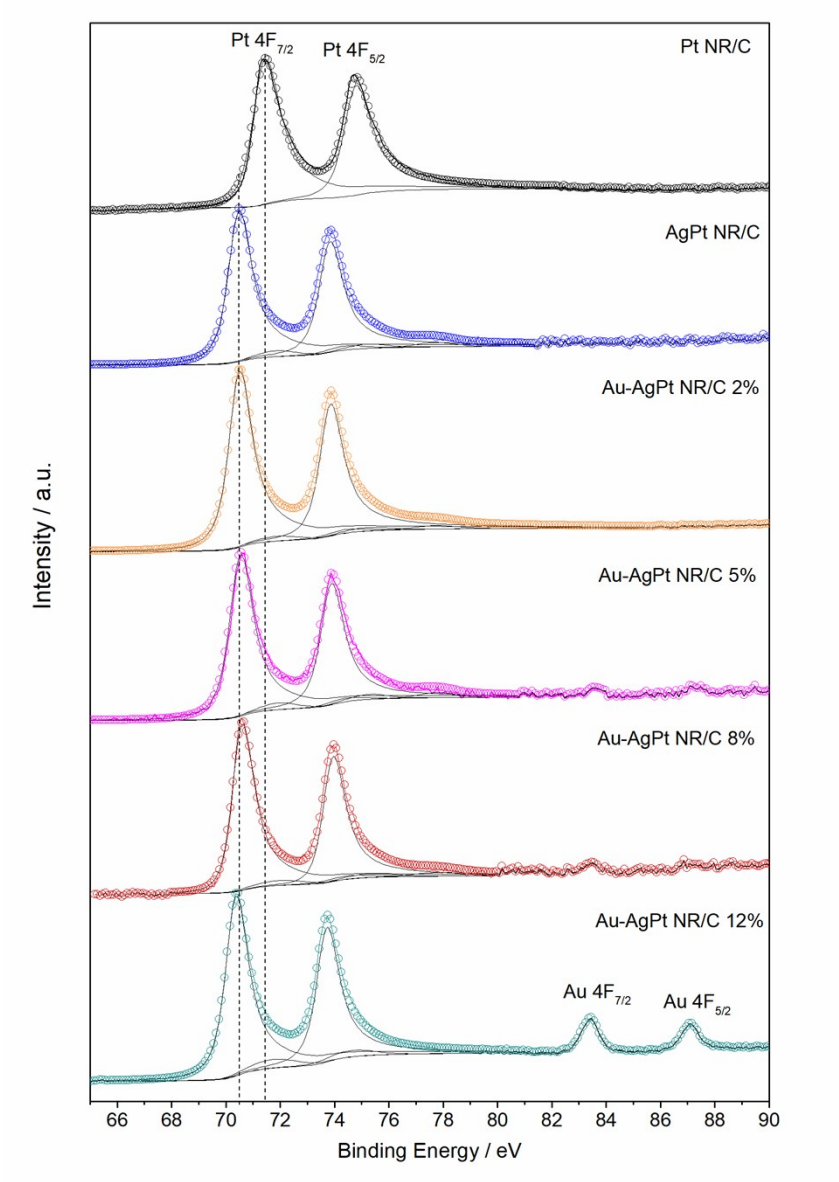

Fig. S4. High-resolution XPS spectra of the Pt 4f region generated for the Pt NR/C, AgPt NR/C and Au-AgPt NR/C catalysts with various Au contents synthesized following the reaction scheme A.

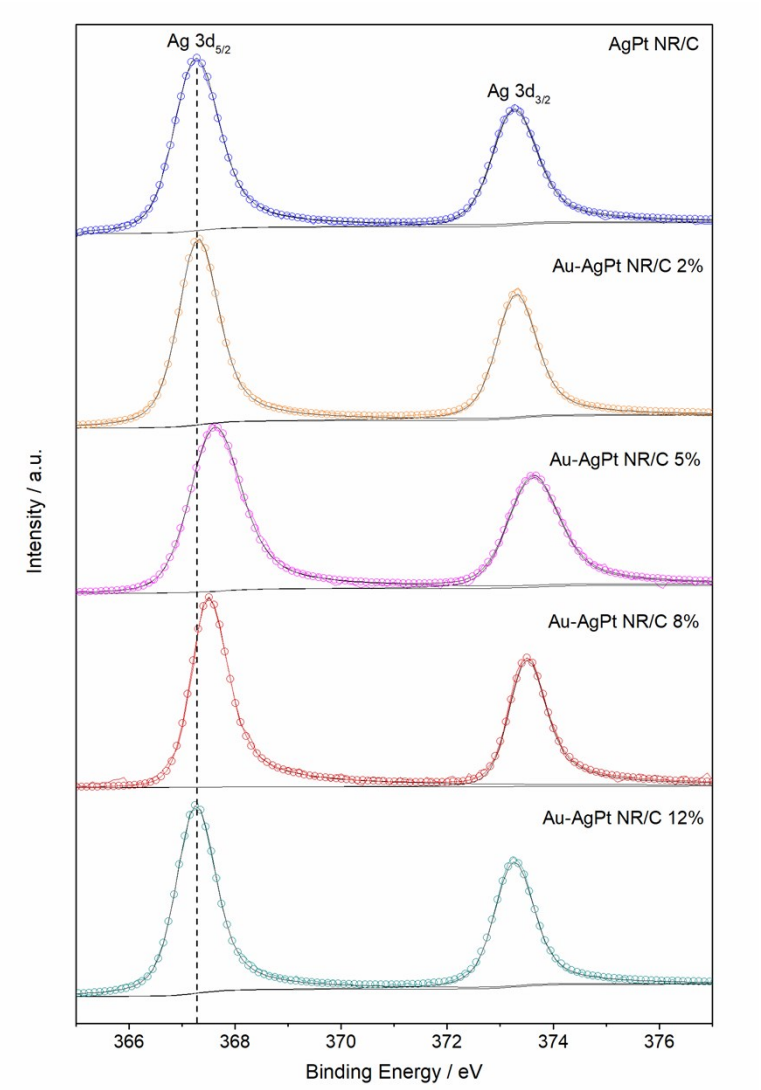

Fig. S5. High resolution XPS spectra of the Ag 3d region generated for the AgPt NR/C and Au-AgPt NR/C catalysts with various Au contents synthesized following the reaction scheme A.

Table S2. Pt and Ag states deduced from the Pt 4f and Ag 3d XPS regions

	Pt (%)			Ag (%)	
Catalyst	Pt^0	Pt^{2+}	Pt^{4+}	Ag^0	Ag^+
Pt NR/C	100	0	0	0	0
AgPt NR/C	93.28	3.66	3.05	100	0
Au-AgPt NR/C 2%	94.56	2.94	2.50	100	0
Au-AgPt NR/C 5%	93.01	4.02	2.97	100	0
Au-AgPt NR/C 8%	92.86	3.92	3.23	100	0
Au-AgPt NR/C 12%	93.88	6.12	0	100	0

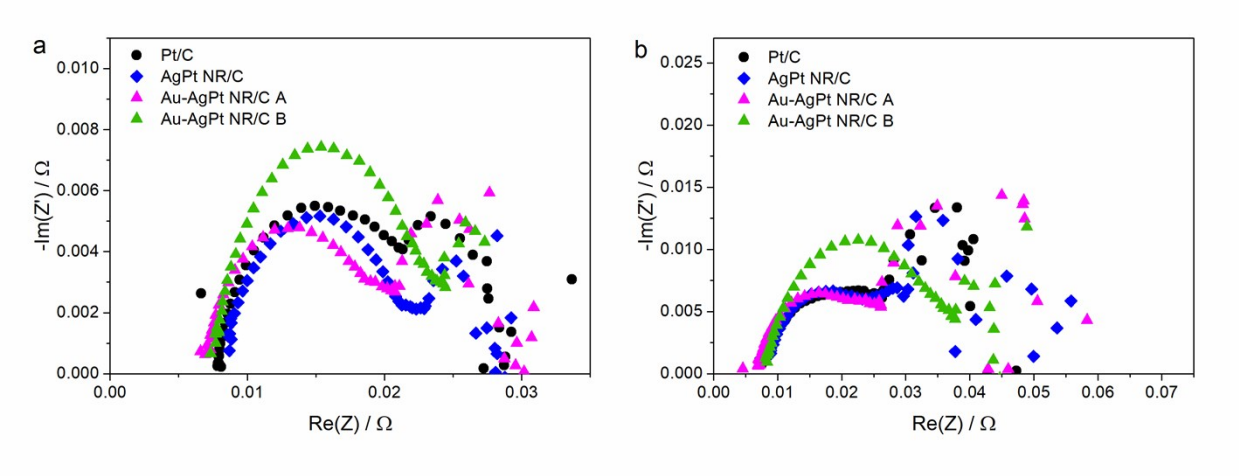

Fig. S6. EIS spectra recorded at a) 0.65 V and b) 0.5 V with an amplitude of 10 mV in the frequency range 10k–0.1 Hz.

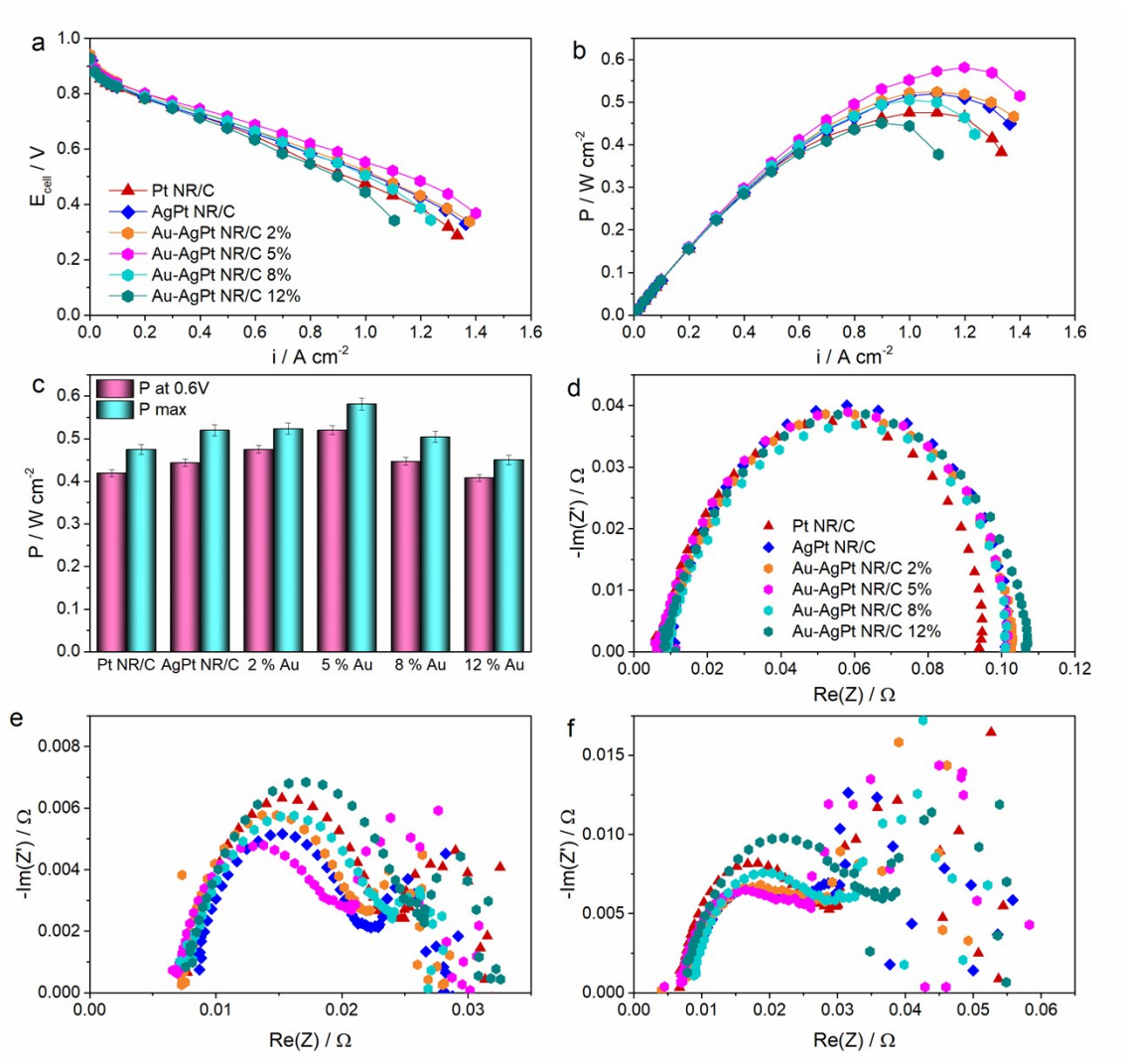

Fig. S7. Power performance comparison for the MEAs with the cathode catalysts made of varied at% Au integrated AgPt NR/C synthesized following the reaction scheme A benchmarking to Pt NR/C and AgPt NR/C; a) polarization and b) power density curves obtained at 80 °C with fully humidified H_2/air at an absolute pressure of 2.5/2.3 bar and stoichiometry of 1.3/1.5, respectively; and c) the comparison of the power densities at 0.6 V and the peak value. The recorded EIS spectra at d) 30 mA cm^{-2}, e) 0.65 V and f) 0.5 V in the frequency range 10k–0.1 Hz.

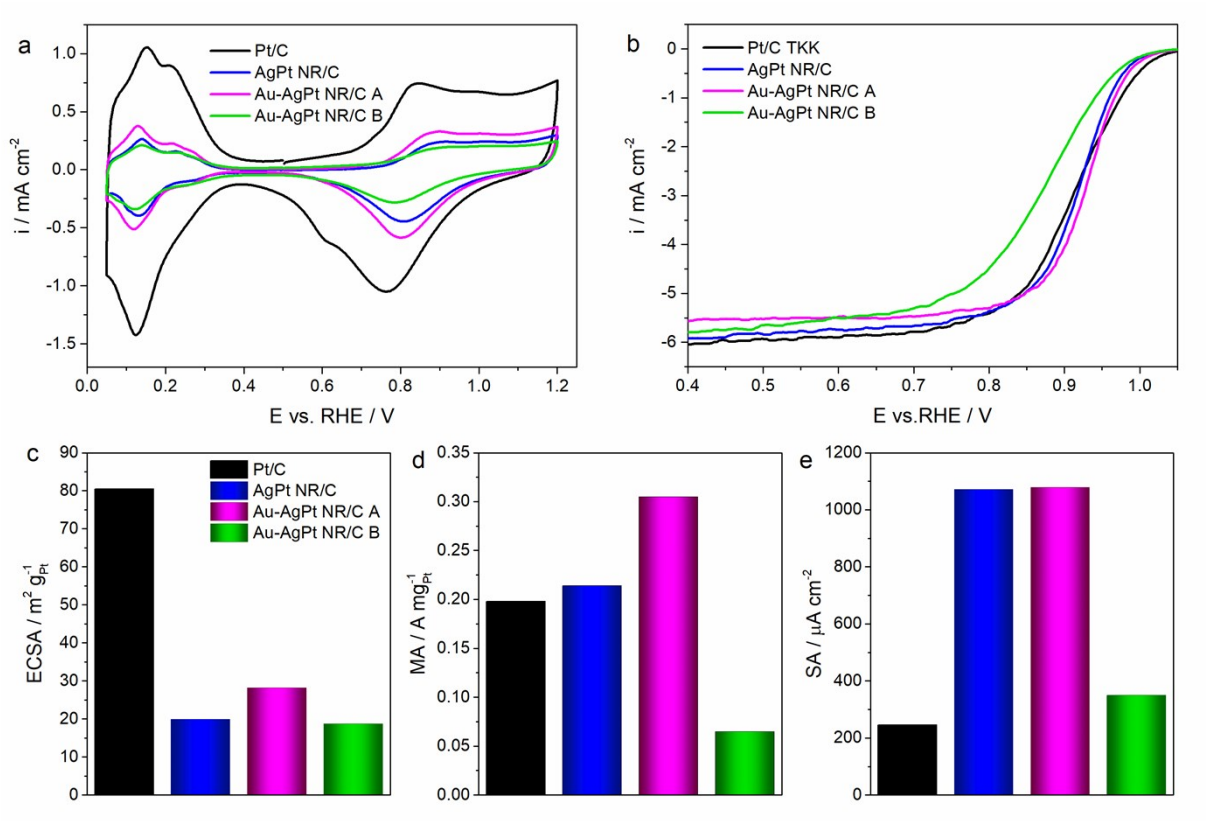

Fig. S8. Catalytic activities of the commercial Pt/C and as-prepared catalysts measured in 0.1 M $HClO_4$(aq) electrolyte using the rotating disc electrode (RDE) method; a) CV plots recorded with a scan rate of 20 mV s^{-1} in the N_2 saturated electrolyte, and b) LSV plots recorded at 1600 rpm with a scan rate of 20 mV s^{-1} in the oxygen saturated electrolyte. The corresponding c) ECSA, b) mass activity (MA) and c) specific activity (SA).

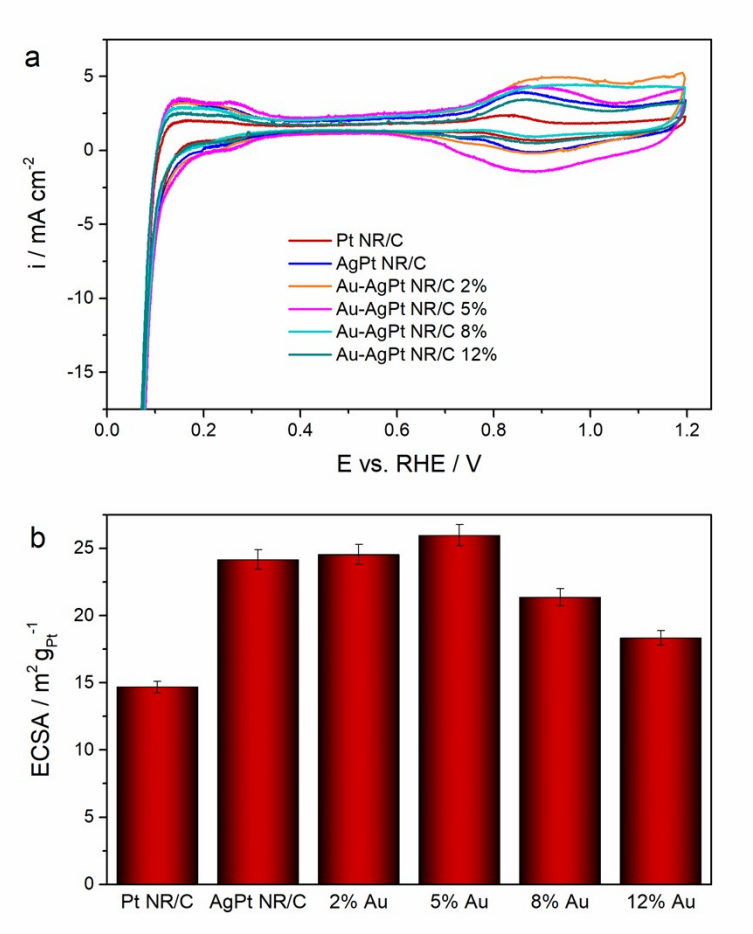

Fig. S9. a) Cathode CVs recorded between 0.05-1.2 V with a scan rate of 20 mV s^{-1} in the MEAs under H_2/N_2, and b) corresponding ECSA.

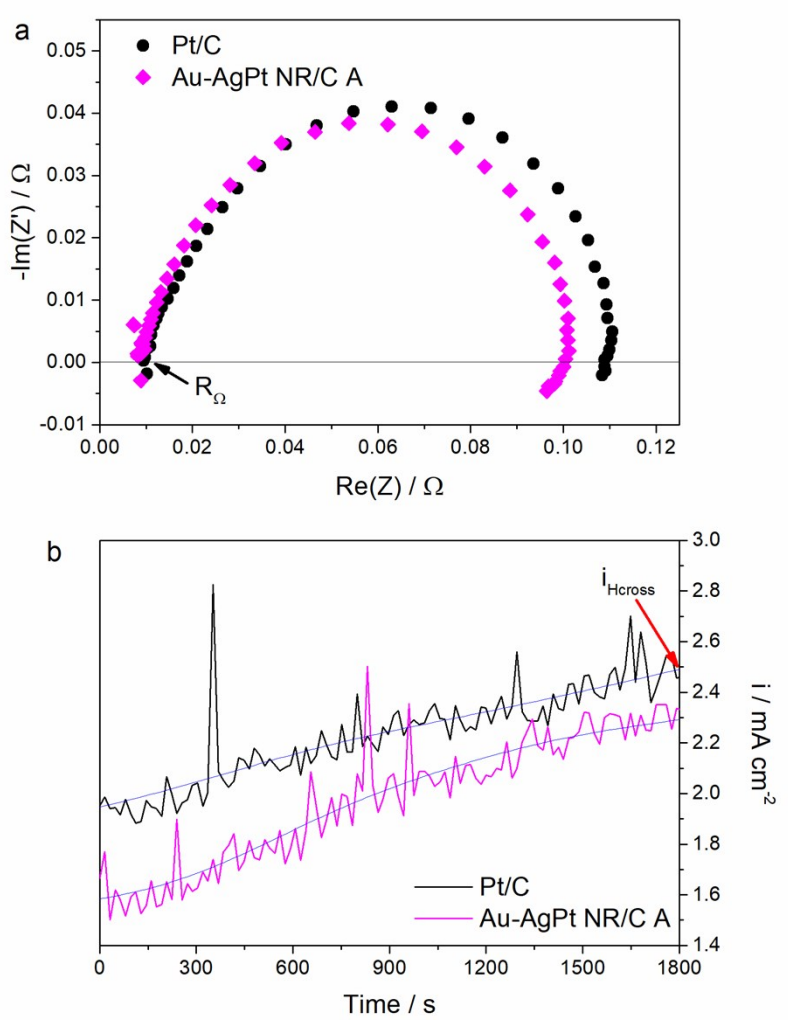

Fig. S10. a) EIS measured in H_2/O_2 at 30 mA cm^{-2} with an amplitude of 4.5 mA cm^{-2} in the frequency range of 10 kHz – 0.1 Hz; and b) H_2 - crossover current density recorded by holding at 0.5 V vs. RHE under H_2/N_2 feeds.

Table S3. The correction factors deduced from Fig. S10 and the corresponding kinetic current density at 0.9 V.

Catalyst - GDE	R_Ω / Ω	I_{HCross} / mA cm^{-2}	i_k @0.9 V / mA cm^{-2}
Pt/C	0.0094	2.49	0.013
AgPt NR/C	0.0087	2.51	0.018
Au-AgPt NR/C A	0.0083	2.28	0.022
Au-AgPt NR/C B	0.0090	2.34	0.009

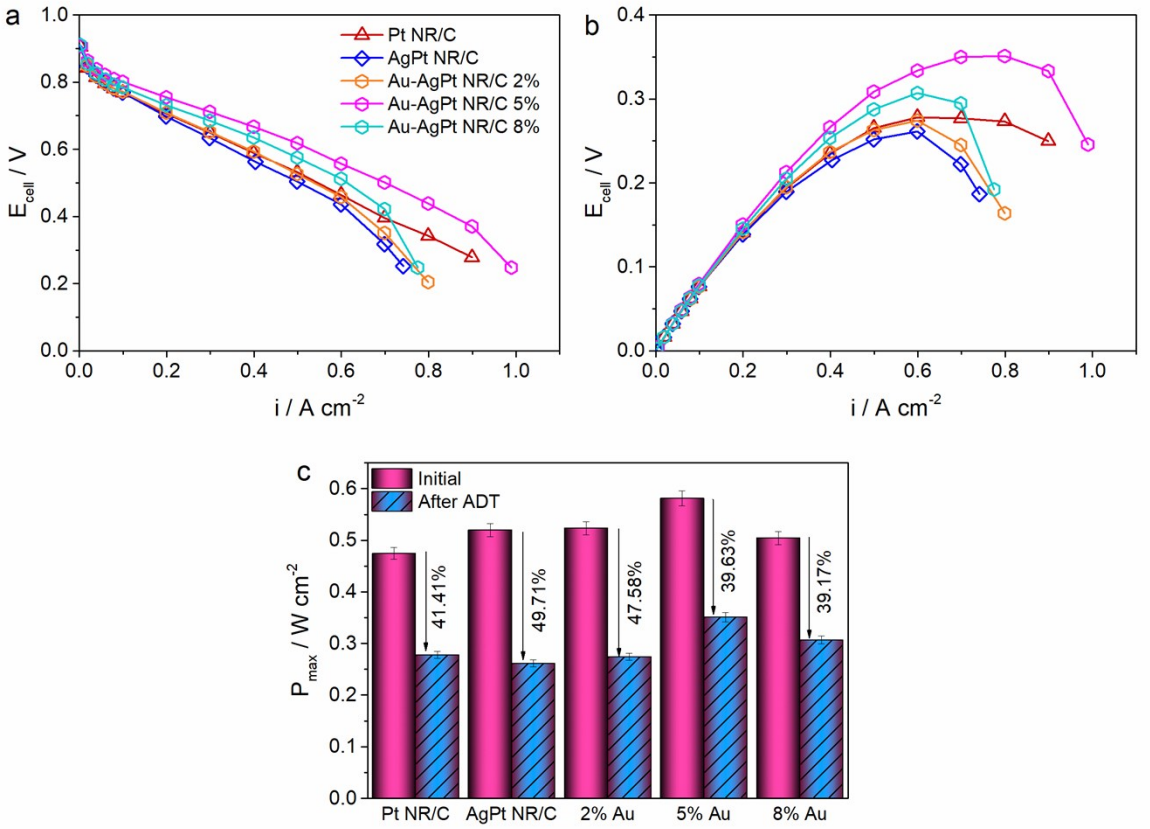

Fig. S11. a) Polarization and b) power density curves recorded after the ADT and c) corresponding peak power density comparison before and after the ADT for MEAs with the cathode catalysts made of Pt NR/C, AgPt NR/C and Au-AgPt NR/C with various Au contents synthesized following the reaction scheme A. The ADT was performed using potential sweeping between 0.6-1.2 V at a scan rate of 100 mV s^{-1} for 5000 cycles with H_2/N_2.

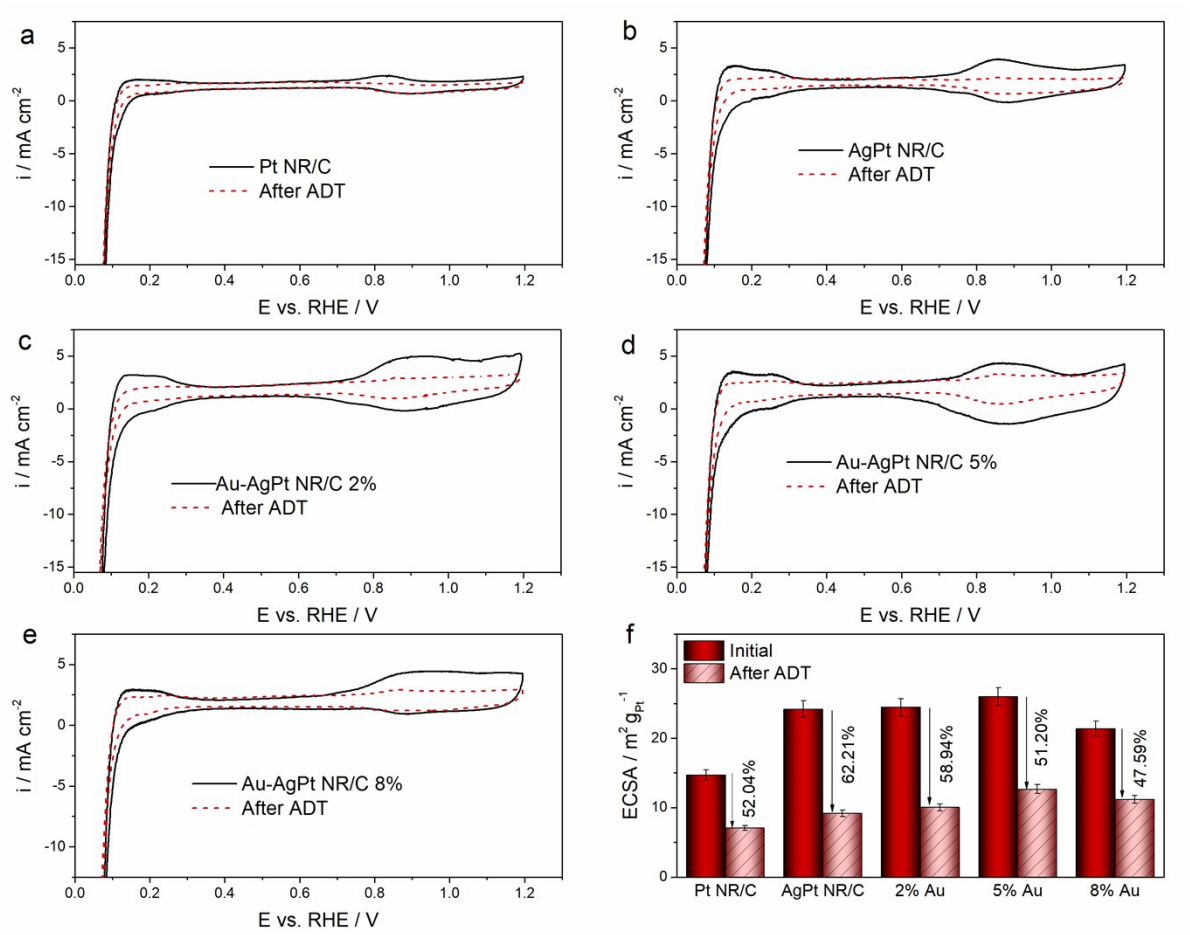

Fig. S12. Cathode CVs and the corresponding ECSA decline ratio after the ADT for MEAs with the cathode catalysts made of Pt NR/C, AgPt NR/C and Au-AgPt NR/C with various Au contents synthesized following the reaction scheme A. The ADT was performed using potential sweeping between 0.6-1.2 V at a scan rate of 100 mV s^{-1} for 5000 cycles with H_2/N_2.