Electronic Supplementary Information

Bimetallic $Pd_{96}Fe_4$ Nanodendrites Embedded in Graphitic Carbon Nanosheets as Highly Efficient Anode Electrocatalysts

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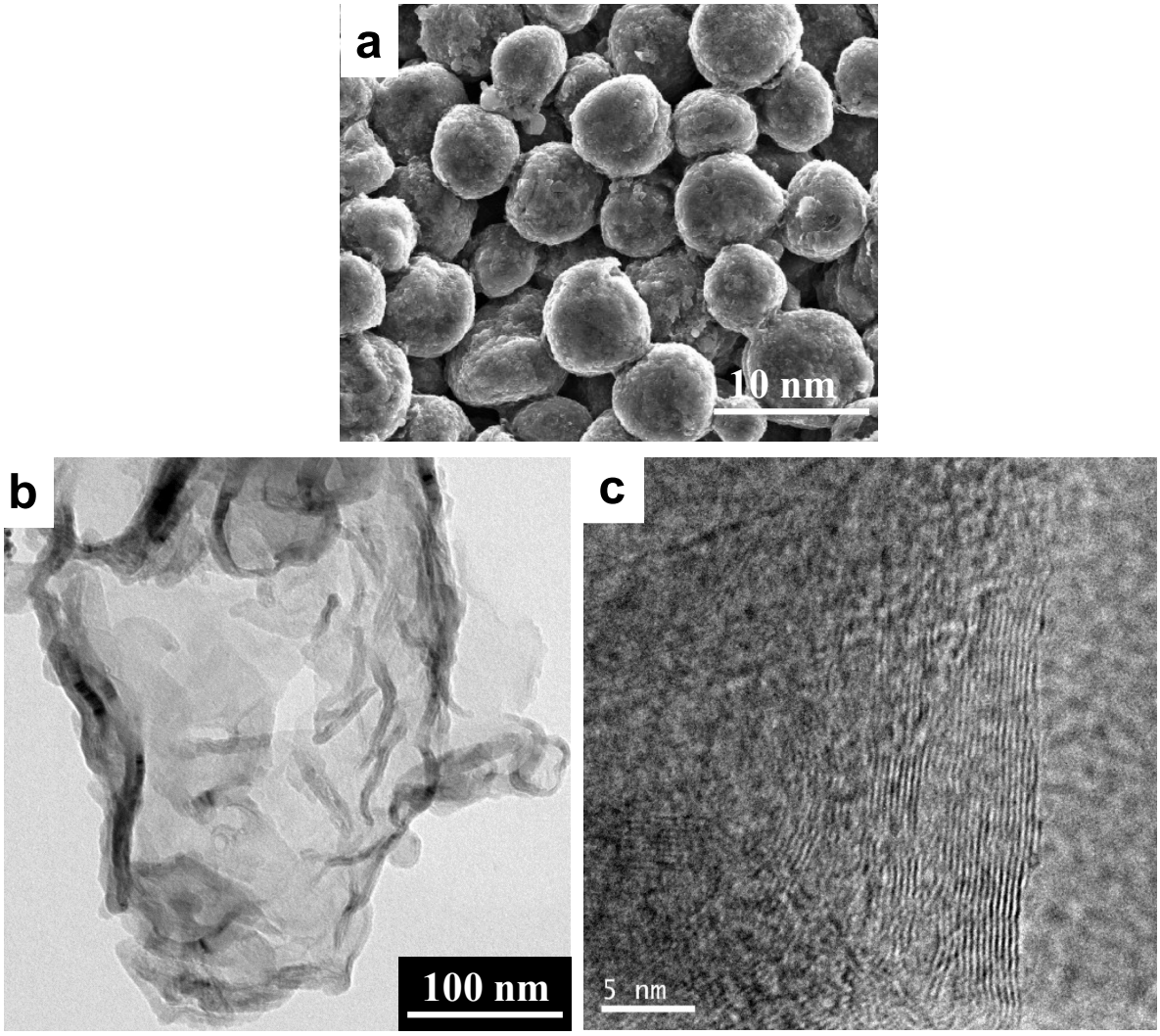

Fig.S1 (a) FESEM image of mesocarbon microbeads (MCMB). (b) TEM and (c) HRTEM image of graphitic carbon nanosheets derived after radiolysis of MCMB solution.

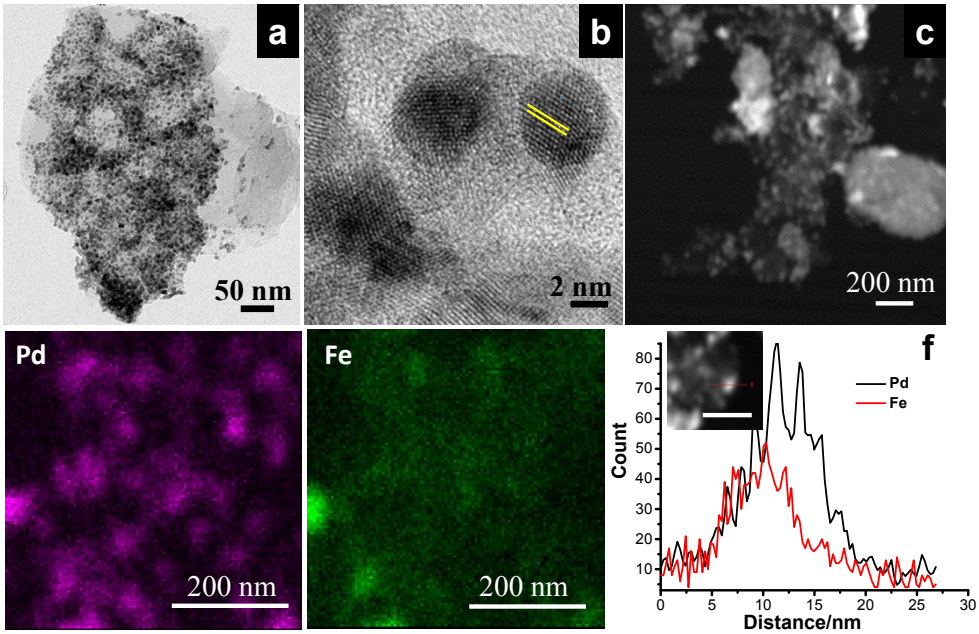

Fig.S2 (a) TEM, (b) HRTEM, (c) HAADF-STEM images, and (d, e) elemental mapping and (f) EDS line scanning profiles of $Pd_{77}Fe_{23}$/GCN nanohybrids.

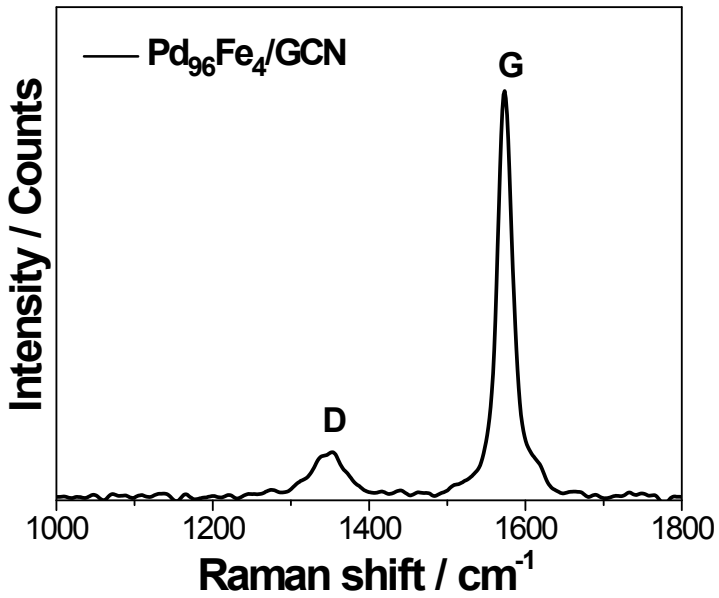

Fig.S3 A typical Raman spectrum of $Pd_{96}Fe_4$/GNC nanohybrid.

Table S1 Elemental compositions of Pd-Fe contained nanoalloys measured by ICP-AES.

Metal loaded on GCN	ICP-AES		Metal composition in solution		Metal content by ICP-AES
	Atomic content (at.%)		(Atomic, at.%)		Weight (%)
	Pd	Fe	Pd	Fe	
Pd	100	-	-	100	9±1%
Fe	-	100	100	-	1.5±0.35%
$Pd_{96}Fe_4$	96±2.1	4±1.5	90	10	4±0.15%
$Pd_{91}Fe_9$	91±3.2	9±1.8	85	15	3.4±.28%
$Pd_{85}Fe_{15}$	85±3.7	15±2.8	75	25	1.9±0.5%
$Pd_{77}Fe_{23}$	77±4.8	23±2.1	50	50	1.45±0.12%

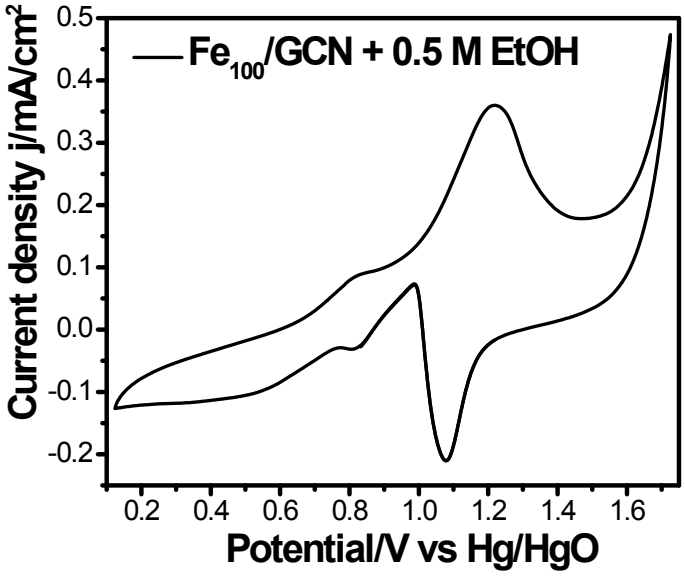

Fig.S4 Cyclic voltammetric runs associated with the electrocatalytic oxidation of 0.5 M EtOH by Fe_{100}/GCN in 1 M KOH. The reference electrode was Hg/HgO electrode. The scan rate was 50 mVs^{-1}.

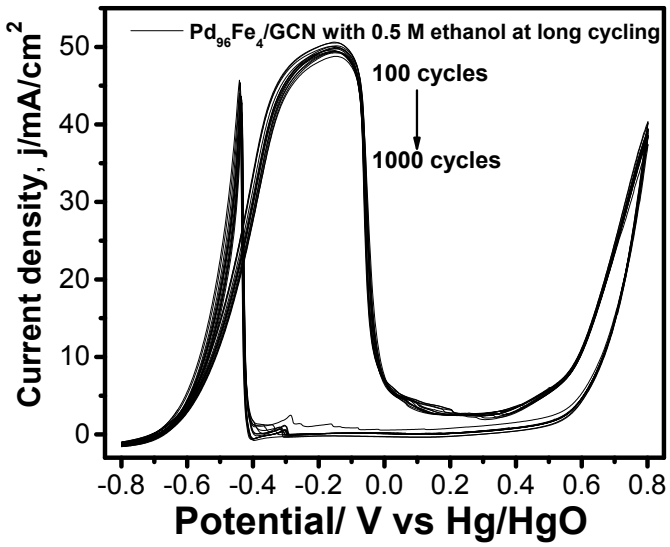

Fig.S5 (a) Long cycling study of $Pd_{96}Fe_4$/GCN electrodes in a solution of 1M KOH and 0.5 M ethanol at scan rate of 50 mV Sec^{-1}.

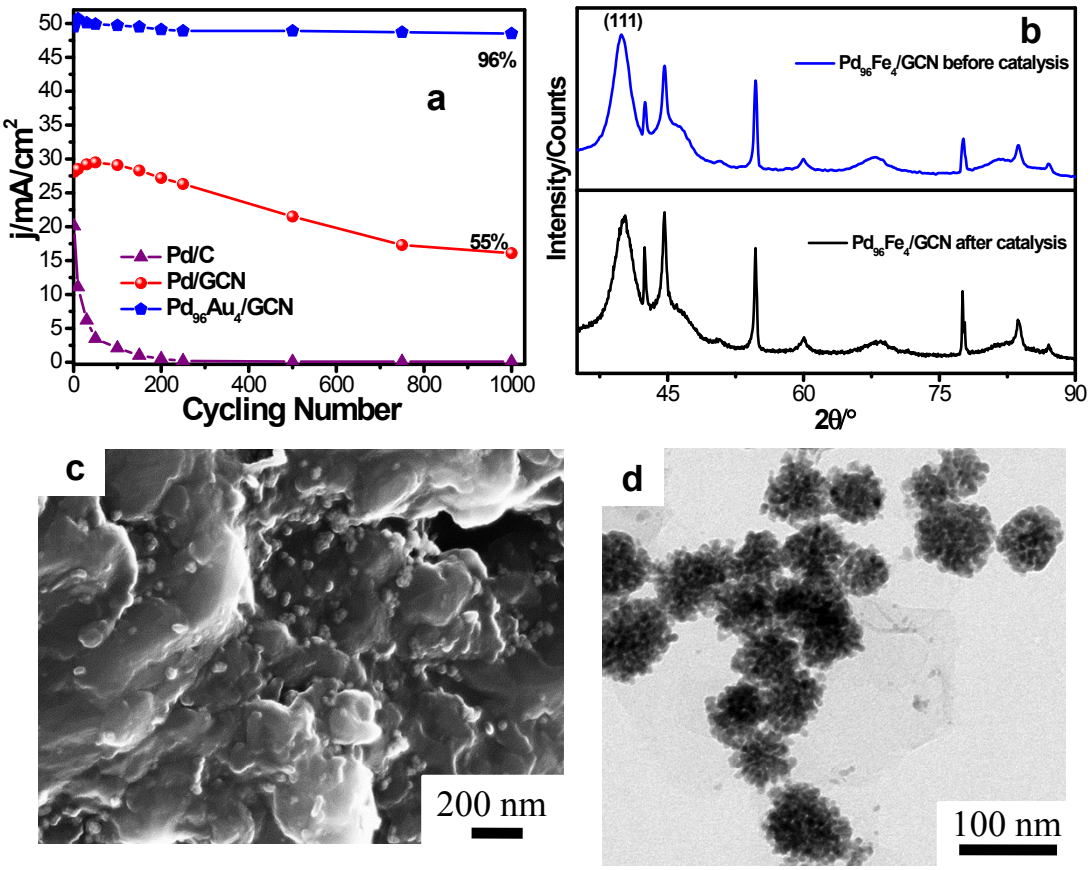

Fig.S6 (a) Long cycling study of Pd/C, Pd/GCN, and $Pd_{96}Fe_4$/GCN electrodes in a solution of 1M KOH and 0.5 M ethanol at scan rate of 50 mV Sec^{-1}. (b) XRD, (c) FESEM (d) TEM images of $Pd_{96}Fe_4$/GCN electrodes after 1000 cycling of ethanol oxidation.

Table S2 Comparison of the electrochemical performance of Pd electrocatalysts for the ethanol oxidation.

Electrode	E_{onset}, mV/RHE	j_f, $mA.cm^{-2}$	j_f, $mA.cm^{-2}.mg^{-1}$	Specific Current, j_f, $mA.mg^{-1}$	Reference
Pd black catalyst	–306	0.65	-	-	1
Pd/Graphene	–356	0.56	-	-	2
Pd/CNT	–320	-	364	-	3
Pd/C	–436	-	63	-	4
Pd/C	–335	-	42	-	5
Pd/Ppy	–384	7.05	4147	248.70	6
Pd/Graphene/Nafion	–376	14.22	5925	355.5	7
Pd/Nafion	–346	8.55	1745	104.7	7
Pd nanoplates/Nafion	–376	4.05	1500	90	8
Pd nanowires/Nafion	–420	-	1327	-	9
Pd/CNT	–426	-	3540	-	10
PtPdNPs/GNs	-	22.4	-	-	11
Ni@PbPt/Graphene	-	-	-	281	12
Pt−Pd (1:3)/RGO	-	-	-	1486.7	13
Pt–Cu/RGO	-	-	-	1114.7	14
PtPd NFs-RGO	-	-	-	600	15
PdCo NTAs/CFC	-	-	-	1491	16
Pd/PANI/Pd	-	-	-	310	17
Pd–PEDOT/GE	-	-	-	458.5	18
Pd–PEDOT	-	-	-	285.1	18
PtPd/PPy/PtPd nanotube	-	3.1	-	-	19
$Pd_{89}Pt_{11}$/PPy	–356	15.8	5197	782	20
$Pd_{54}Au_{46}$/PPy	–426	10.35	5280	792	20
$Pd_{96}Fe_4$/GCN	–486	49.8	11008	1100	This work

Table S3 Effect of catalysts for the oxidation of methanol, ethylene glycol, tri-ethylene glycol, glycerol.

Fuel	**Current density (mA/cm^2)**				
	Pd_{100}/GCN	$Pd_{96}Fe_4$/GCN	$Pd_{91}Fe_9$/GCN	$Pd_{85}Fe_{15}$/GCN	$Pd_{77}Fe_{23}$/GCN
Ethanol	30.2	49.87	32.4	24.1	18.5
Methanol	1.87	5.38	4.7	4.4	4.023
Ethylene Glycol	12.8	22.63	7.9	7.8	3.48
Tri-Ethylene Glycol	0.88	1.29	0.84	0.33	0.13
Glycerol	2.75	8.37	7.08	7.70	4.3

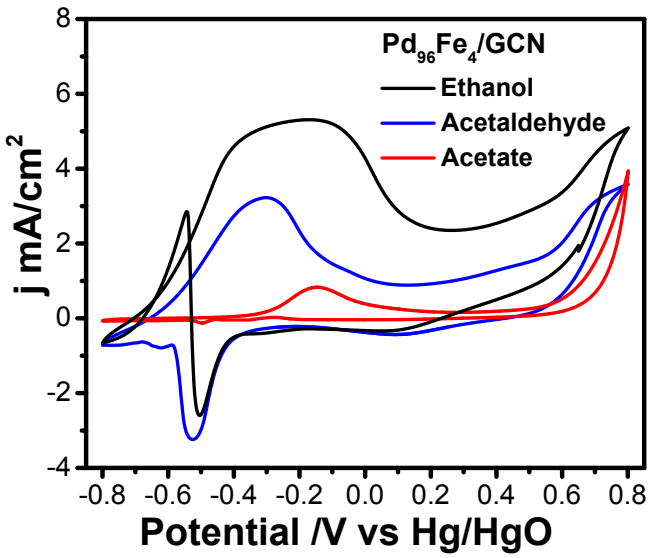

Fig.S7 Cyclic voltammograms for $Pd_{96}Fe_4$/GCN catalyst for CH_3CH_2OH, CH_3CHO, and CH_3COONa solutions fuels each of concentration 100 mM in 0.5 M aqueous KOH at a scan rate of 50 mV Sec^{-1}.

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