Electronic Supplementary Material (ESI) for Catalysis Science & Technology.

Supporting information

An efficient and durable novel catalyst support with superior electron donation property and fuel diffusivity for direct methanol fuel cell

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Raman spectra of pure CNT, POCNT, PECNT, and nitrogen doped PECNT are shown in Figure S1(A) For all the samples, the peak around 1563 cm^{-1} corresponds to G-band which is the characteristic peak for all graphitic carbon materials arising due to E2g symmetry phonon mode. Also, another peak around 1340 cm^{-1} corresponds to the D-band. All the parameters are tabulated in Table S1.

Thermogravimetric analysis curves of the support material and the catalyst are shown in Figure S1 (B). Total metal loading of around 37 wt. % is confirmed from the curve.

The specific surface area (SSA) and porosity of MWNT and PECNT are shown in Figure S2. All the parameters related to the SSA measurement and pore volume are tabulated in Table S2.

HRTEM images of PtRu loaded PECNT shows that in spite of uniform particle distribution, the preferential anchoring sites are the straight edges of the PECNT arising due to partially unzipping few outer layer of MWNT (Figure S1). The preferential anchoring sites have been highlighted with boxes.

The HOMO-LUMO spatial distributions of various N doped PECNT are presented in Figure. S2

The data points in region II and III were fitted according to the Randles equivalent circuit shown in Figure. S3 in order to have the complete idea about the components consists of. The high-frequency intercept in the real Z axis resistance gives rise to R_1, which signifies the ohmic resistance corresponds to all electrical connection and the electrolyte resistance is calculated to be 5.1 ohm. CPE1 and R2 along with CPE2 and R3 are the high-frequency and low-frequency constant phase element and charge transfer resistance respectively. L1 and C1 are the inductance and capacitance respectively. The equivalent circuit for region III was shown in Figure. S3

Figure Caption:

Figure S1. (A) Raman spectra of (a) pure CNT, (b) POCNT (c) PECNT and (d) N doped PECNT. (B) TGA curve of NPECNT and PtRu loaded NPECNT.

Figure S2. (A) Nitrogen adsorption-desorption isotherm of (a) pure CNT and (b) PECNT. Pore-size distribution plot of (B) pure CNT and (C) PECNT.

Figure S3. (a) and (b) HRTEM images of PtRu decorated partially exfoliated multiwalled carbon nanotubes.

Figure S4. HOMO-LUMO spatial distribution of various N doped PECNT.

Figure S5. (Left) Cyclic voltammogram of PtRu/NPECNT in 1(M) H_2SO_4 + 1(M) MeOH electrolyte, recorded at a scan rate of100 mv s^{-1}. (Right) Randles equivalent circuit for region II and region III.

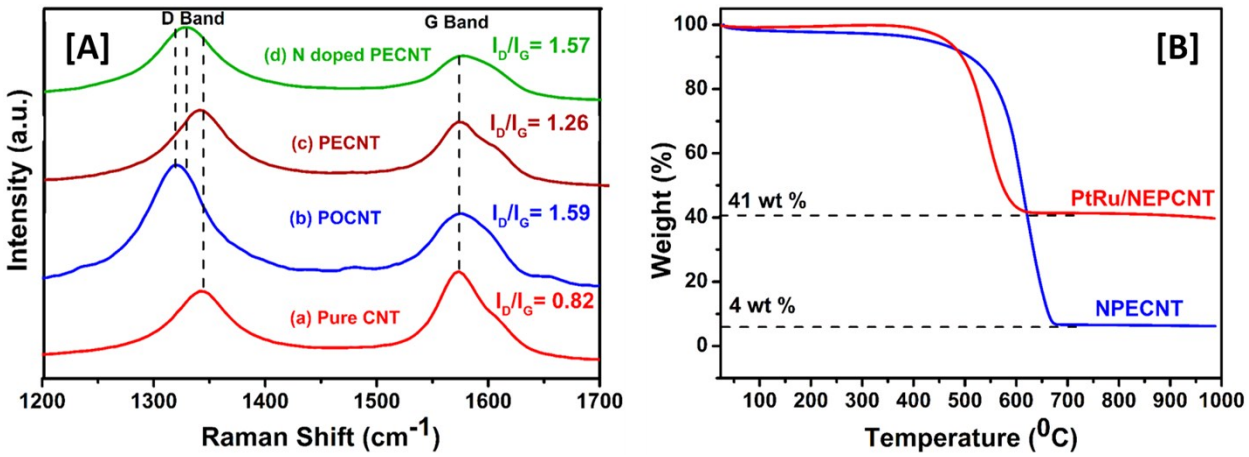

Figure S1. (A) Raman spectra of (a) pure CNT, (b) POCNT (c) PECNT and (d) N doped PECNT. (B) TGA curve of NPECNT and PtRu loaded NPECNT.

Table S1. G band, D band and I_D/I_G ratio of MWNT, POCNT, PECNT and NPECNT.

Samples	**G-Band position (cm^{-1})**	**D-Band position (cm^{-1})**	**Shift (cm^{-1})**	**I_D/I_G**
Pure CNT	1573	1343	--	0.82
POCNT	1573	1319	21	1.59
PECNT	1573	1340	--	1.26
N doped PECNT	1573	1328	12	1.57

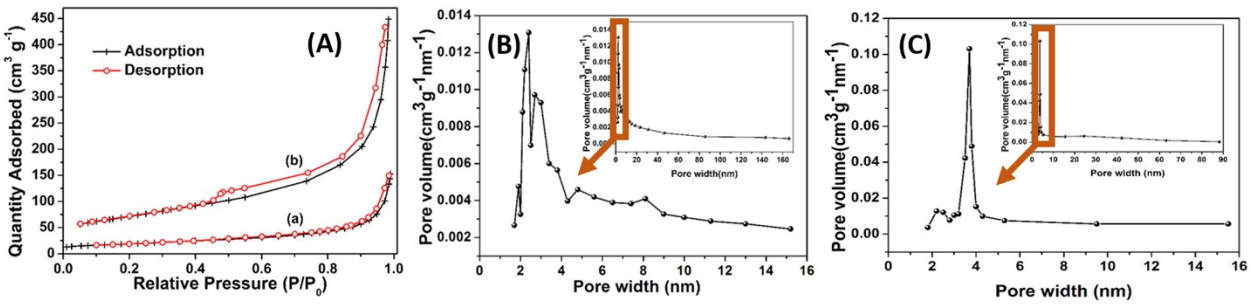

Figure S2. (A) Nitrogen adsorption-desorption isotherm of (a) pure CNT and (b) PECNT. Pore-size distribution plot of (B) pure CNT and (C) PECNT.

Table S2: Parameters of BET surface area and BJH pore size distribution analysis.

Sample	BET Surface Area (m^2 g^{-1})	BJH Pore Size (nm)	Maximum incremental pore volume (cm^3 g^{-1} nm^{-1})
Purified CNT	66.80	2.3,2.7	0.104
PCNT	141.42	3.7	0.013

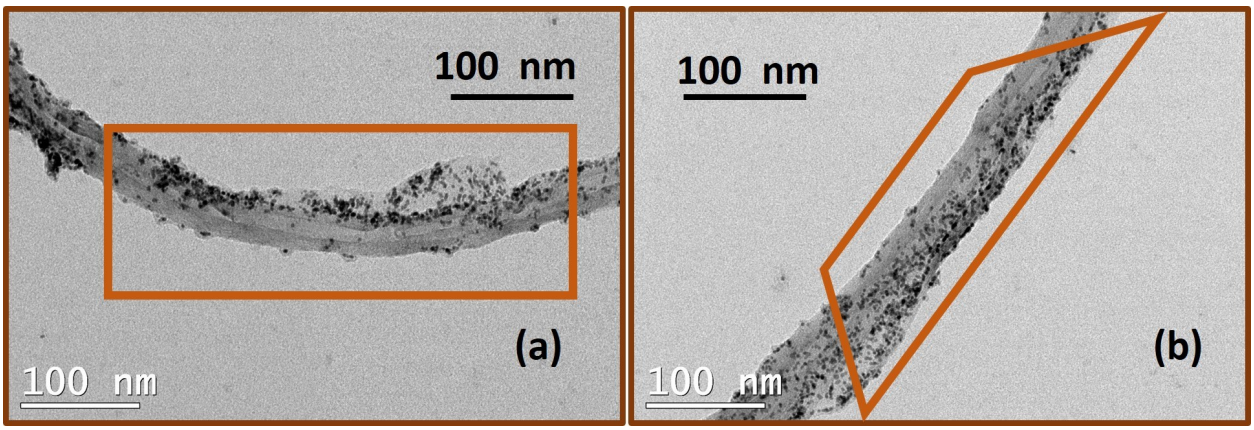

Figure S3. (a) and (b) HRTEM images of PtRu decorated partially exfoliated multiwalled carbon nanotubes.

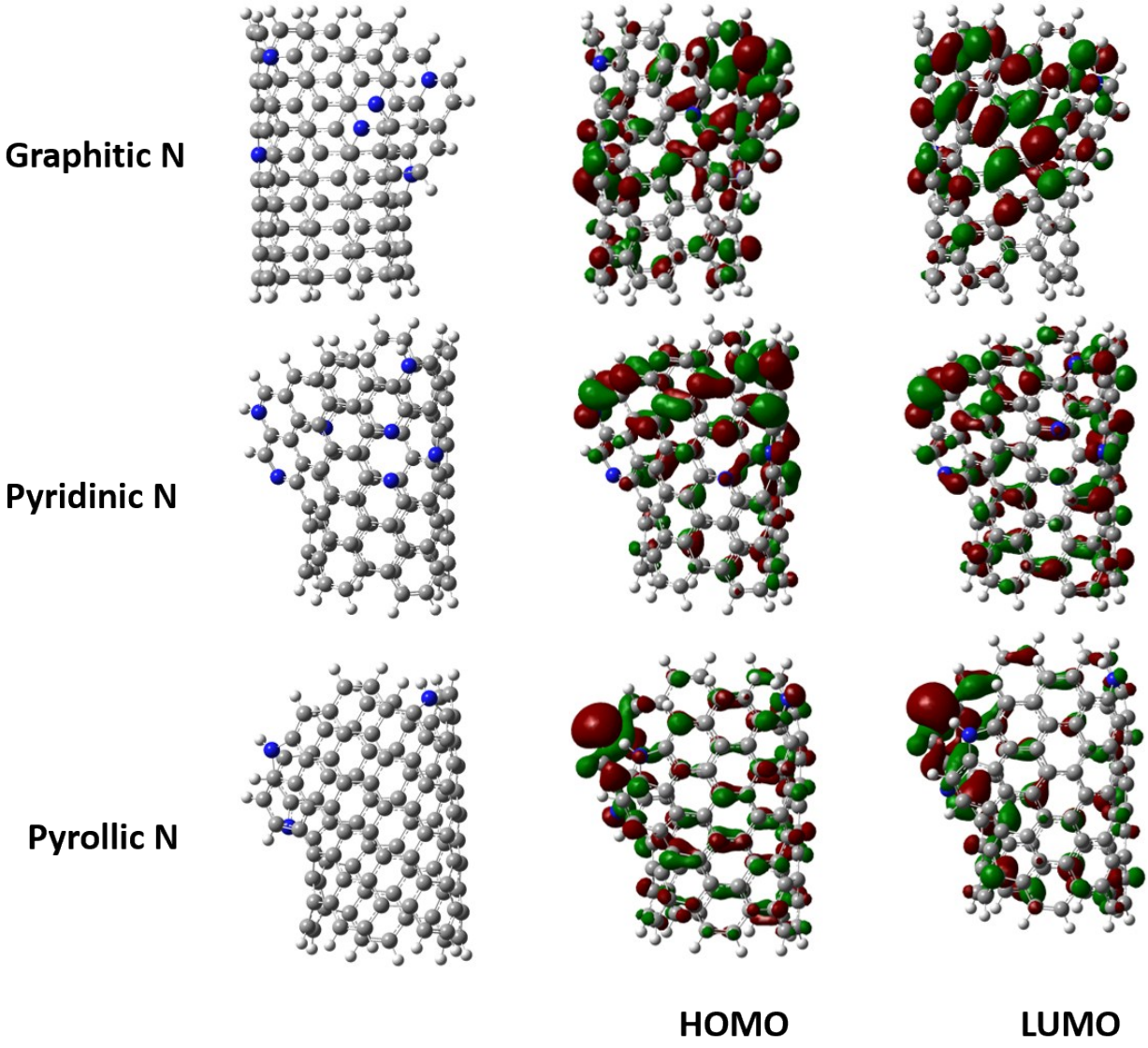

Figure S4. HOMO-LUMO spatial distribution of various N doped PECNT

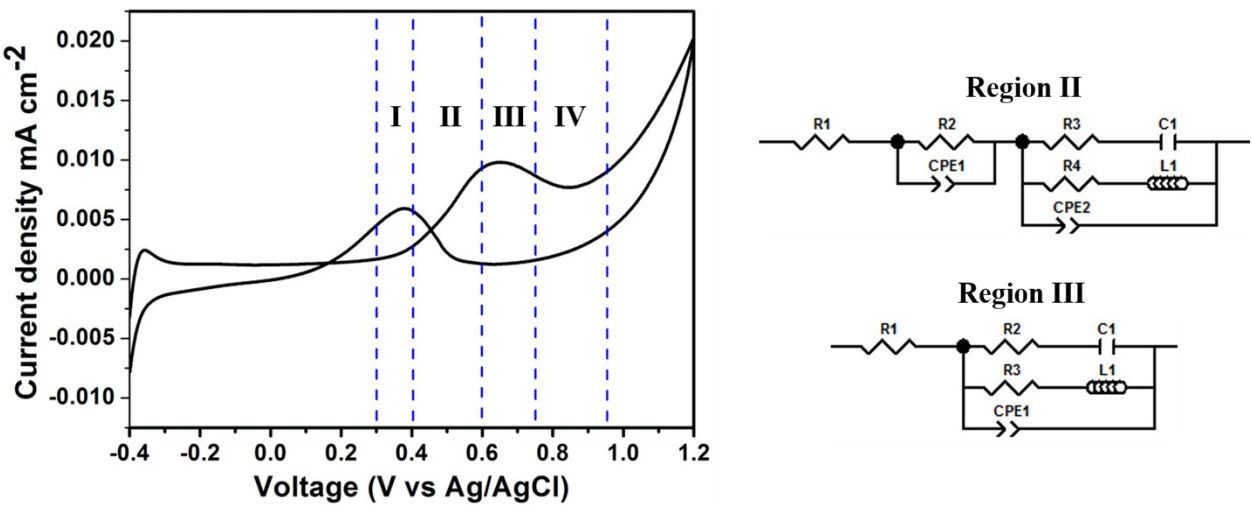

Figure S5. (Left) Cyclic voltammogram of PtRu/NPECNT in 1(M) H_2SO_4 + 1(M) MeOH electrolyte, recorded at a scan rate of 100 mv s^{-1}. (Right) Randles equivalent circuit for region II and region III