Supplementary information

Article

Comparative Study of the Structural Features and Electrochemical Properties of Nitrogen-Containing Multi-Walled Carbon Nanotubes after Ion-Beam Irradiation and Hydrochloric Acid Treatment

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Abbreviations and parameters

N-MWCNTs – nitrogen-containing multi-walled carbon nanotubes
PE – photoemission
φ – ion beam fluence value
hν – exciting photon energy

TEM data

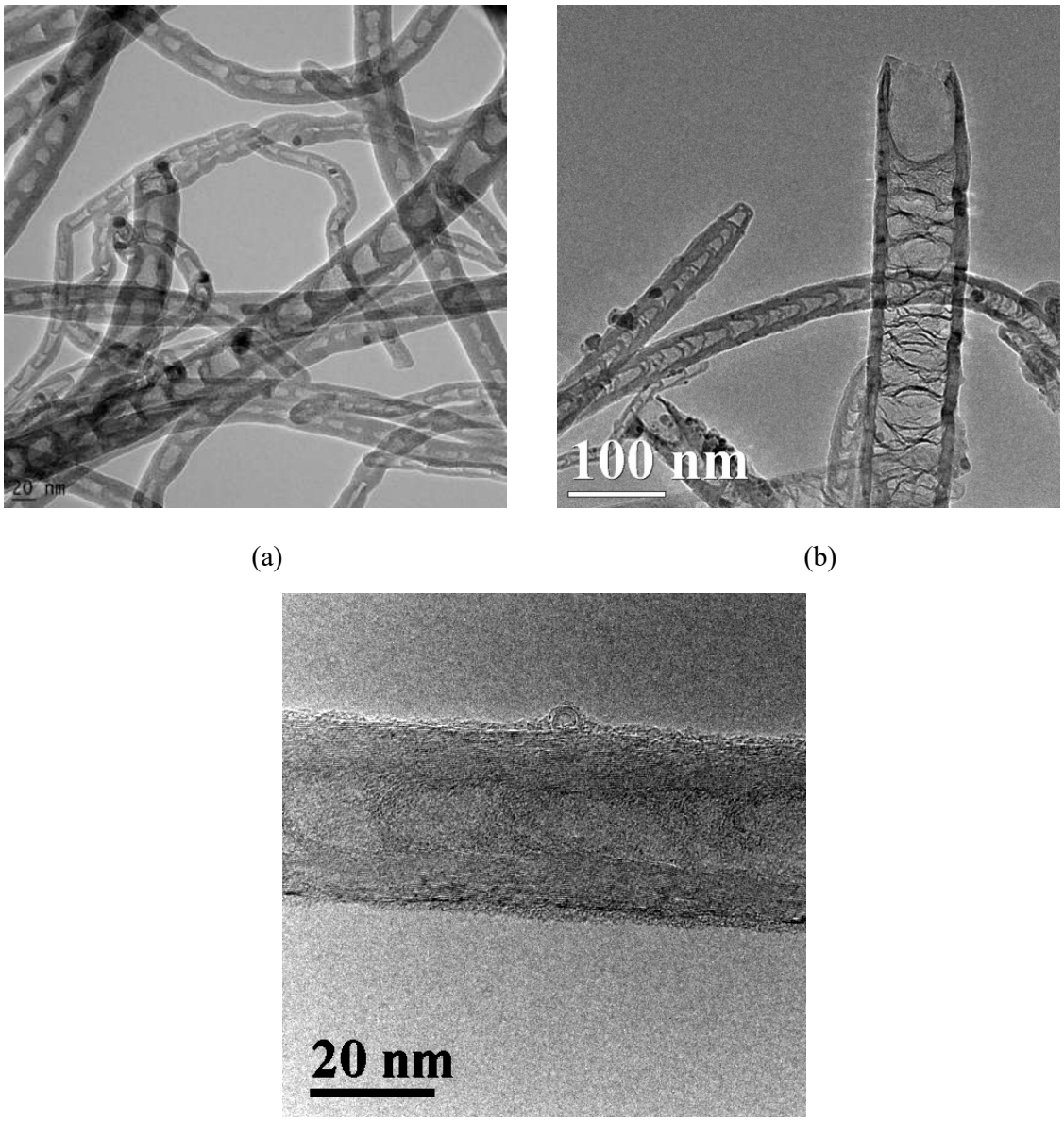

Figure S1. TEM images of as-prepared N-MWCNTs (**a**) and after treatment in HCl (**b**) as well as after irradiation by ion beam with $\varphi_2=5.5 \times 10^{16}$ ion·cm^{-2} (**c**).

Raman spectroscopy

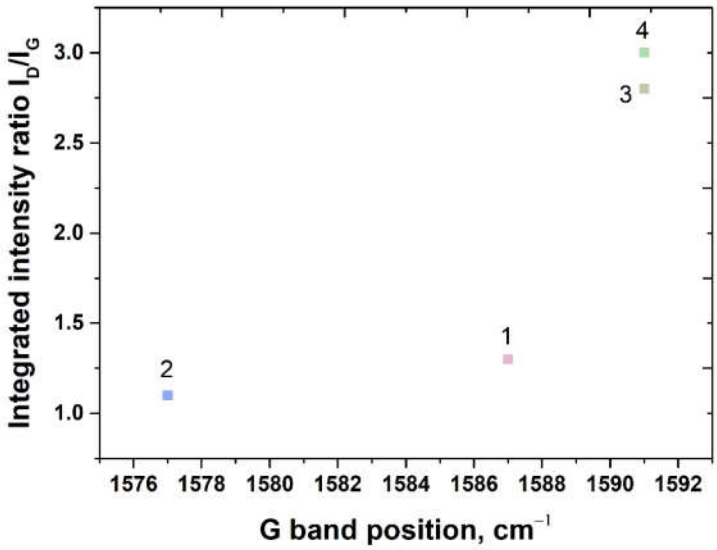

Figure S2. The G band position vs. I_D/I_G ratio for N-MWCNTs before and after treatments: 1 – initial; 2 – after HCl; 3 – after irradiation by ion beam with $\varphi_1=1.2 \times 10^{16}$ ion·cm^{-2}; 4 – after irradiation by ion beam with $\varphi_2=5.5 \times 10^{16}$ ion·cm^{-2}.

X-ray photoelectron spectroscopy

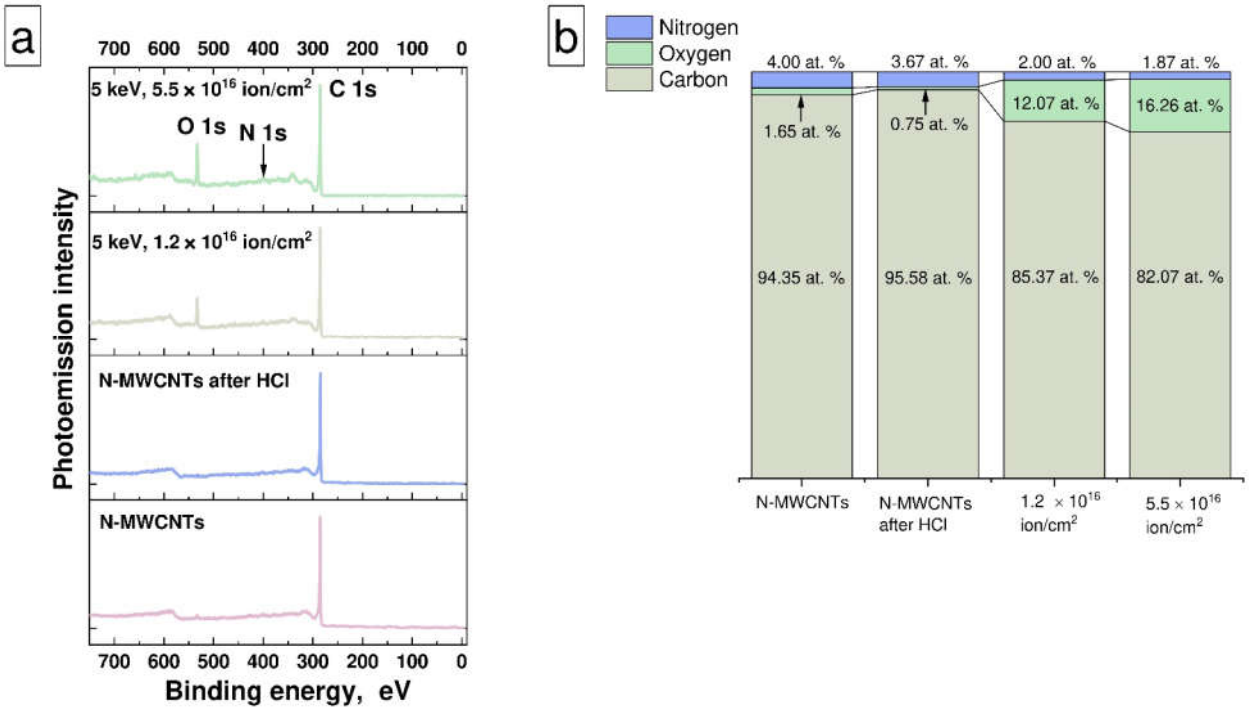

Figure S3. (**a**) Survey PE spectra of N-MWCNTs before and after treatments (hν=850 eV);.(**b**) diagram of atomic concentration from XPS survey spectra for samples.

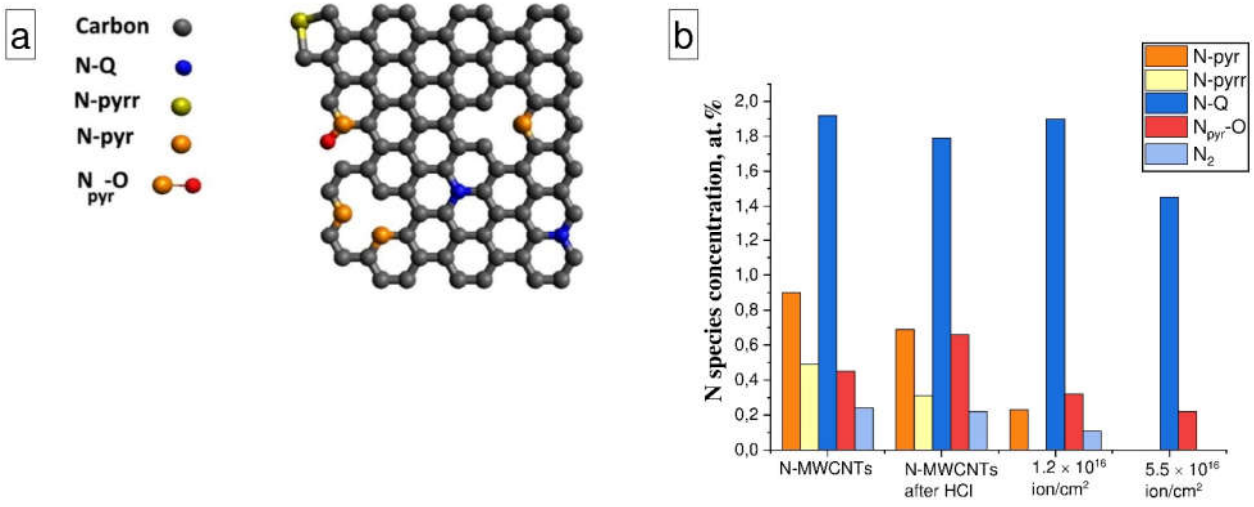

Figure S4. (**a**) Types of nitrogen inclusions in the hexagonal lattice of graphene; (**b**) the distribution of the concentrations of various nitrogen inclusions in N-MWCNTs before and after various treatments.

Electrochemical data obtained in 1M H_2SO_4 electrolyte

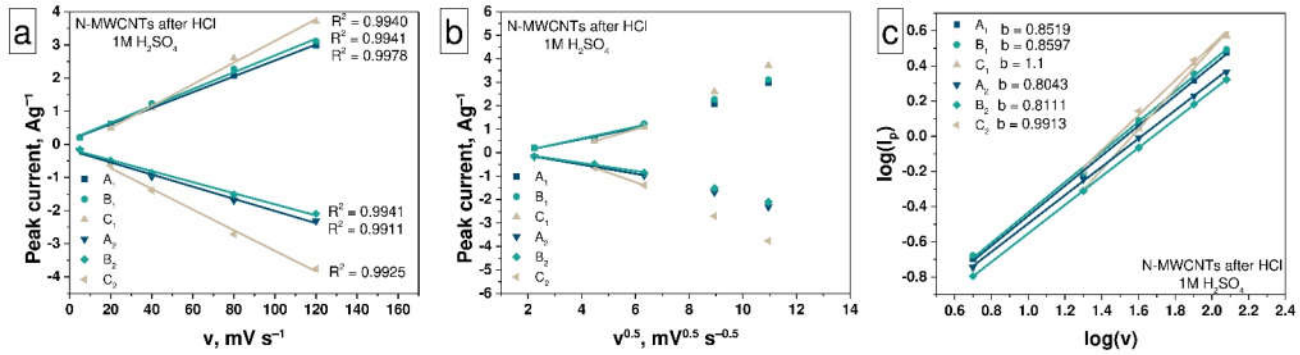

Figure S5. (**a**) Scan rate and (**b**) square root of scan rate vs peak current and (**c**) log of scan rate vs log of peak current plots for N-MWCNTs after HCl.

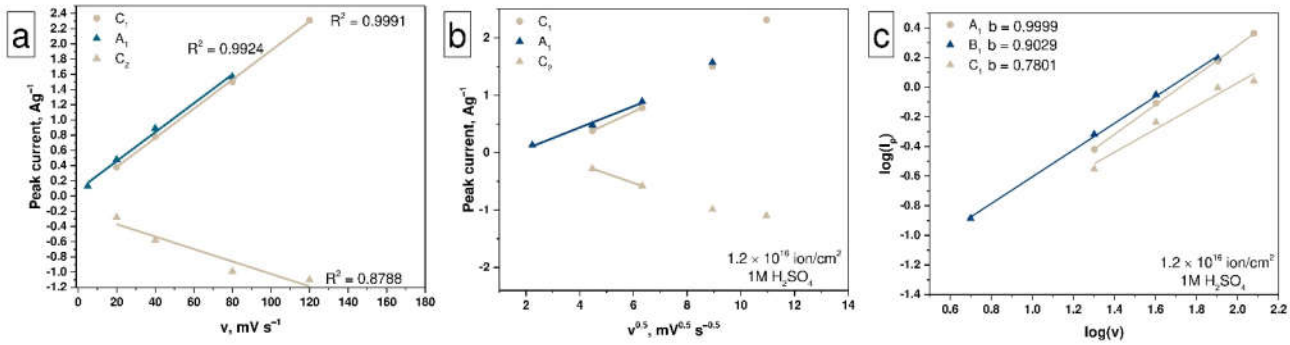

Figure S6. (**a**) Scan rate and (**b**) square root of scan rate vs peak current and (**c**) log of scan rate vs log of peak current plots for N-MWCNTs irradiated by ion beam with φ_1=1.2 × 10^{16} ion·cm^{-2}.

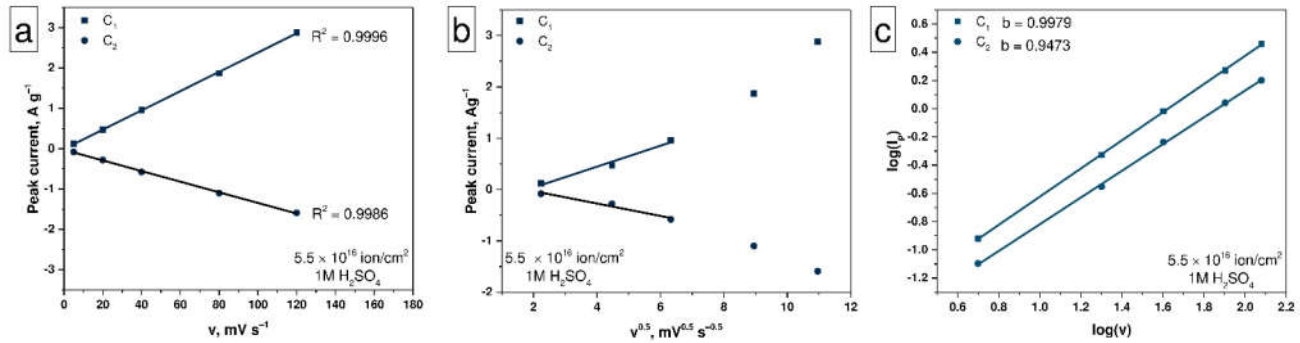

Figure S7. (**a**) Scan rate and (**b**) square root of scan rate vs peak current and (**c**) log of scan rate vs. log of peak current plots for N-MWCNTs irradiated by ion beam with φ_2=5.5 × 10^{16} ion·cm^{-2}.

Electrochemical and Raman data

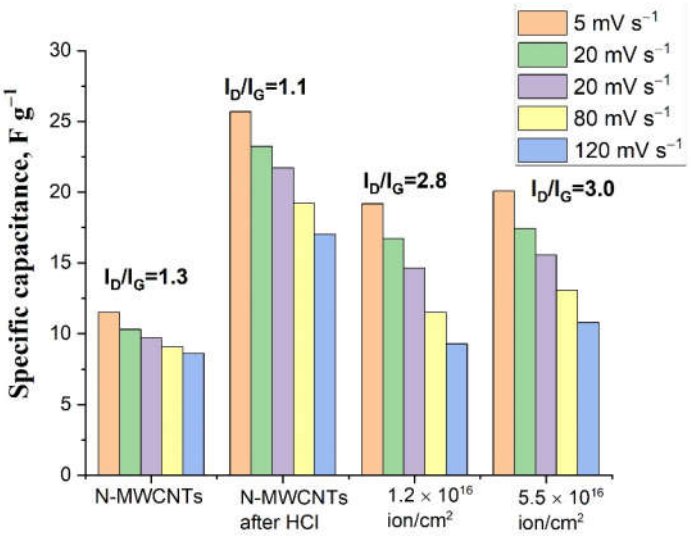

Figure S8. The diagram of the specific capacitance of nanotubes vs. their degree of defectiveness from the data of electrochemical measurements and Raman studies.