

Introduction

The increasing demand for efficient and sustainable energy storage has driven interest in advanced electrode materials for supercapacitors, particularly for flexible and wearable applications. MXenes, as 2D materials, offer excellent electrical conductivity, hydrophilicity, and tunable surface chemistry. While Ti₃C₂T_x is widely studied, Nb₂C MXene shows promising properties, including larger interlayer spacing and enhanced ion transport. However, restacking of MXene layers limits their performance. In this work, Nb₂C MXene was functionalized with three organosilanes (γ -methacryloxypropyltrimethoxysilane (Acrylate silane), 2-[methoxy(polyethyleneoxy)6-9propyl]trimethoxysilane (PEG silane) and 3-aminopropyl trimethoxysilane (Amino silane)) to improve its electrochemical properties. Structural and electrochemical analyses revealed that Nb₂C exhibits higher capacitance than Ti₃C₂T_x, with amino silane providing the most significant enhancement. These results demonstrate that surface functionalization is an effective strategy for improving MXene-based electrodes for flexible supercapacitor applications.

SEM

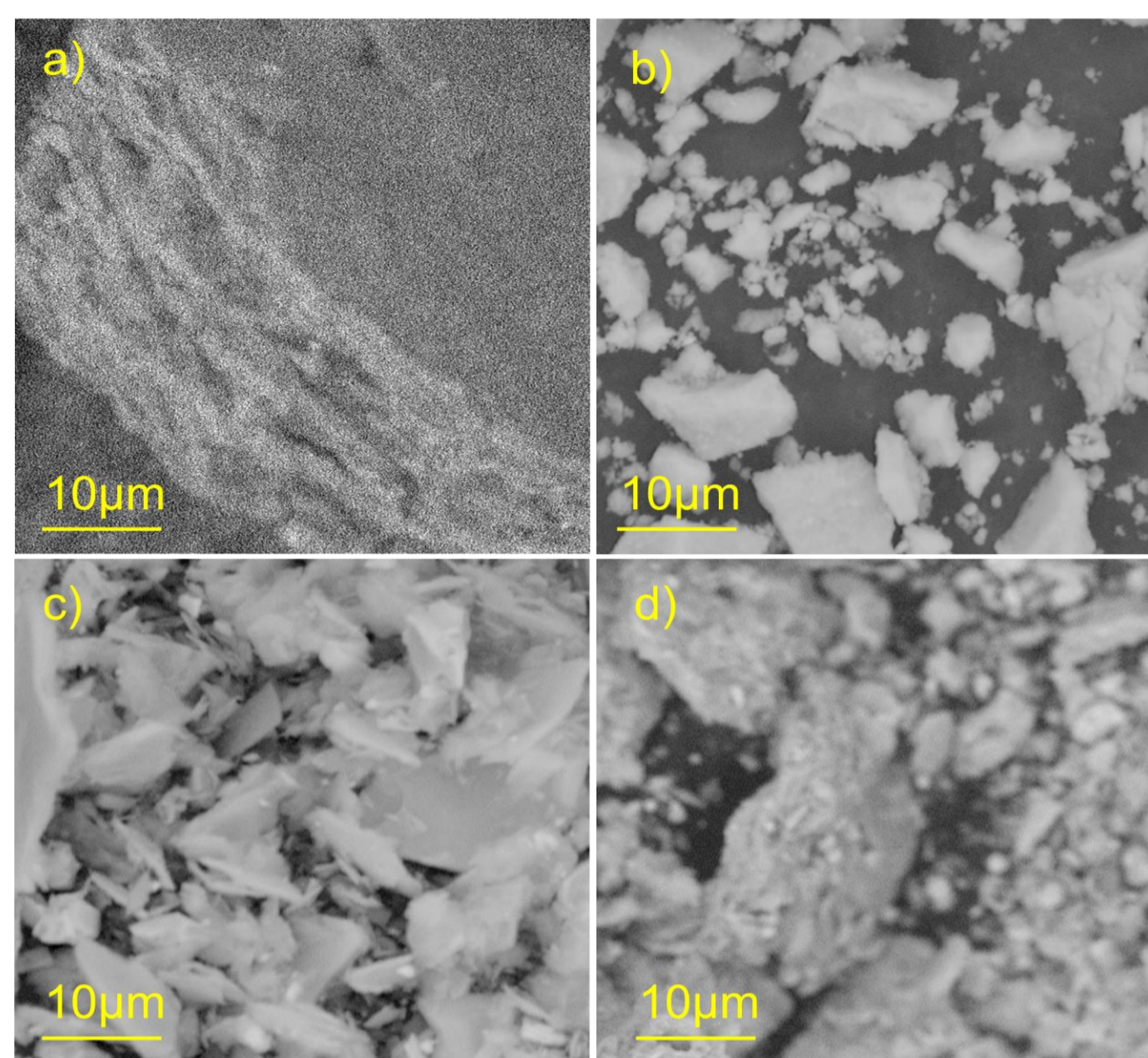


Figure 1 – SEM micrographs: a) pure Nb₂C, b) amino Nb₂C, c) PEG Nb₂C, d) acrylate Nb₂C MXenes.

Water contact angle

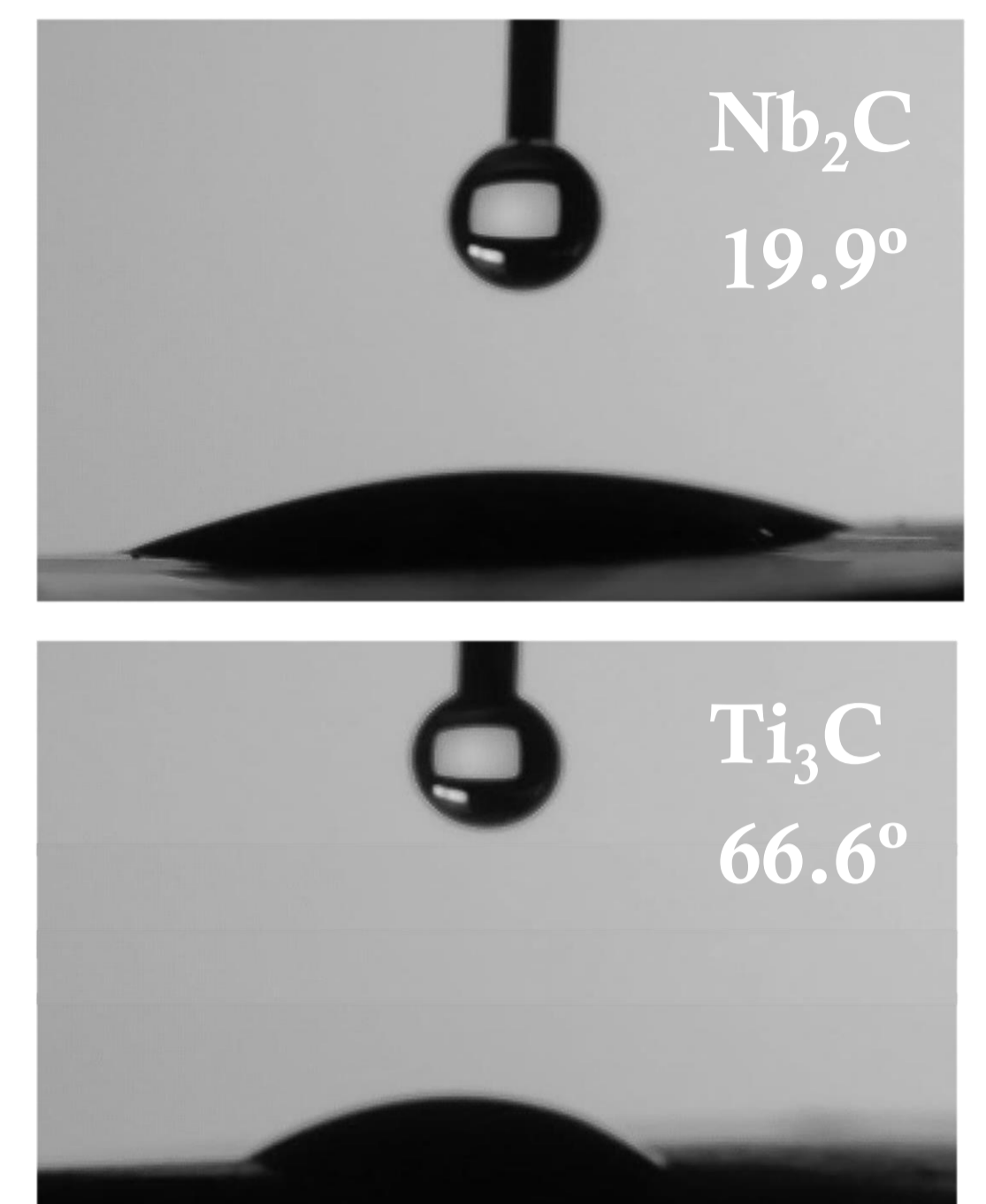


Figure 2 – Water contact angle measurements for Nb₂C and Ti₃C₂.

FTIR

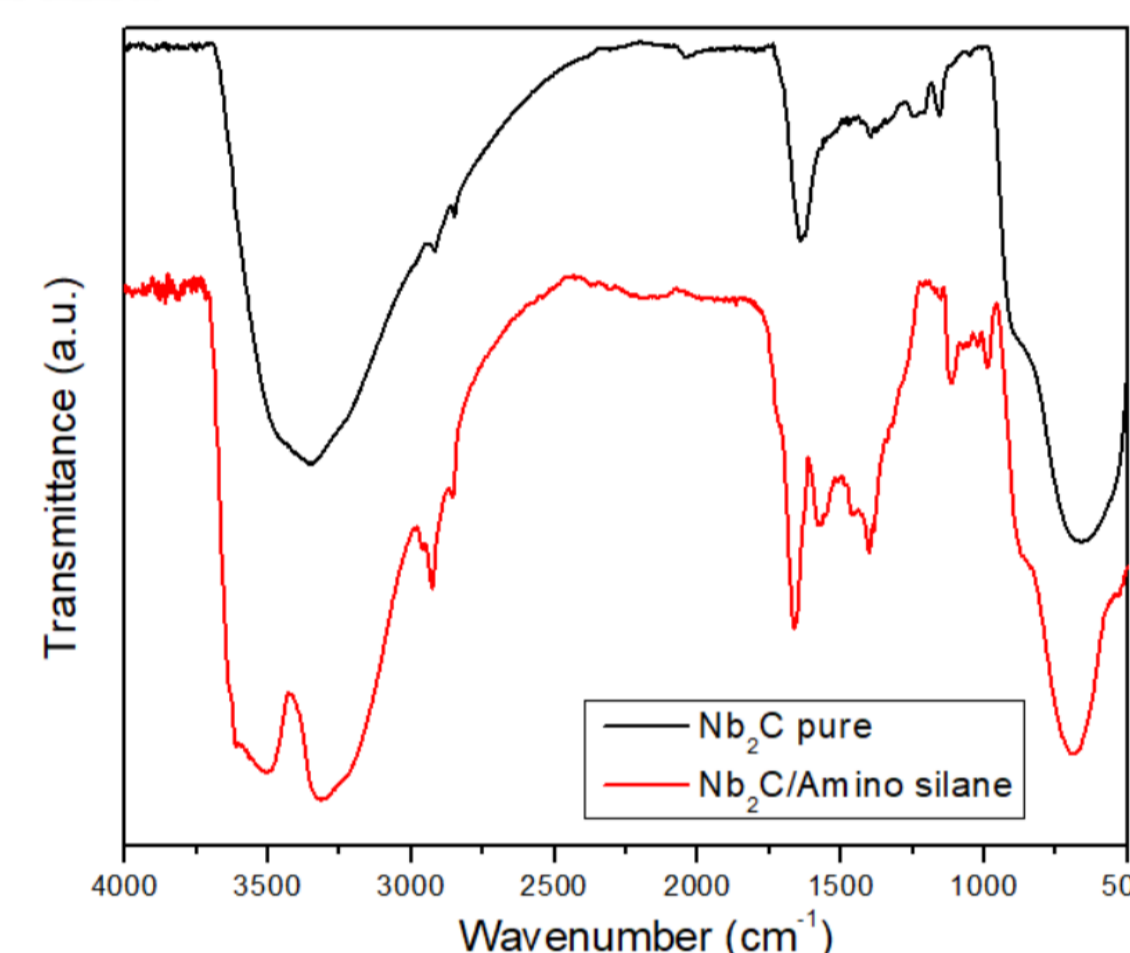


Figure 3 - FTIR spectra of pure and amino silane functionalized Nb₂C MXenes.

XRD

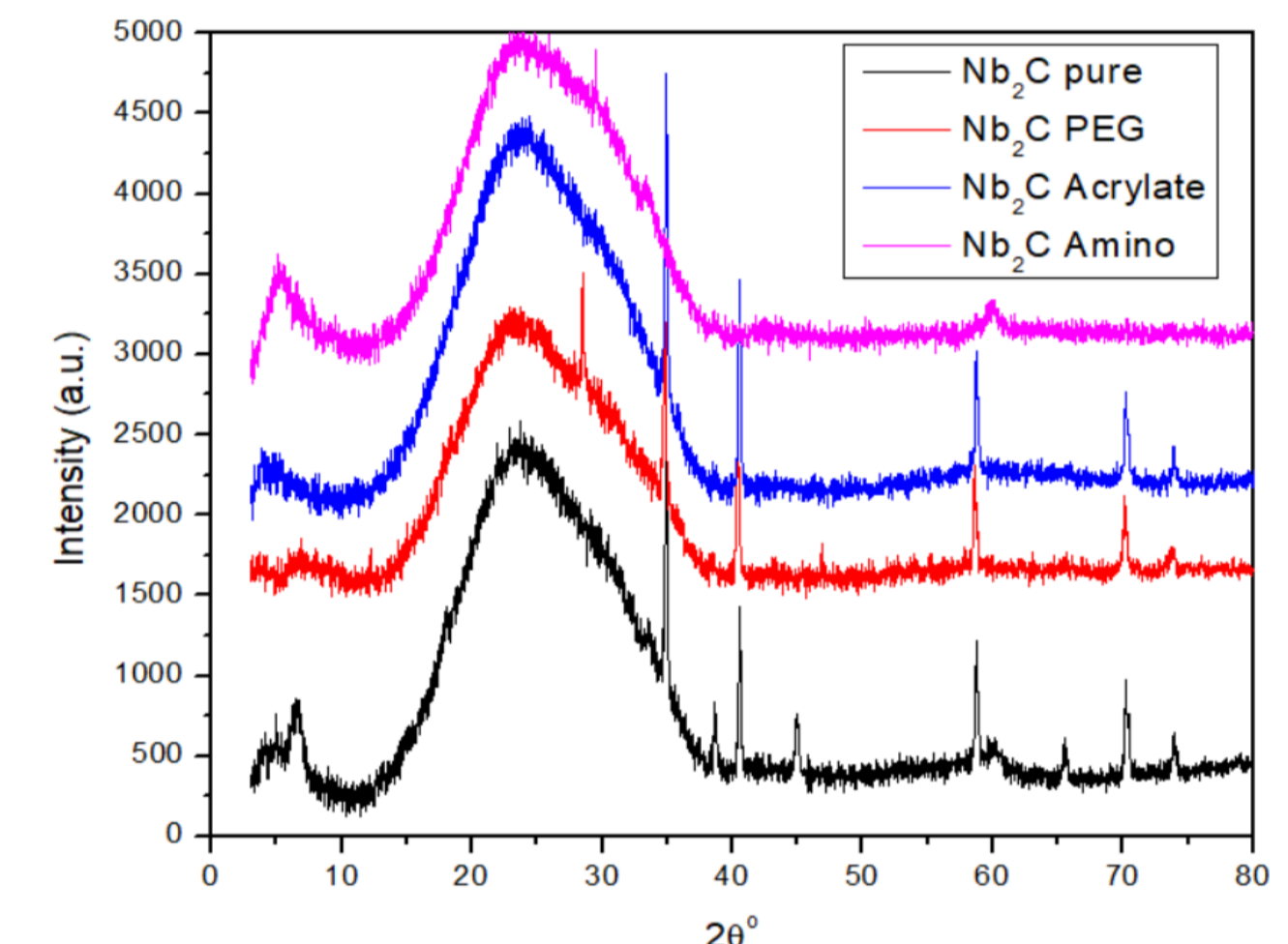
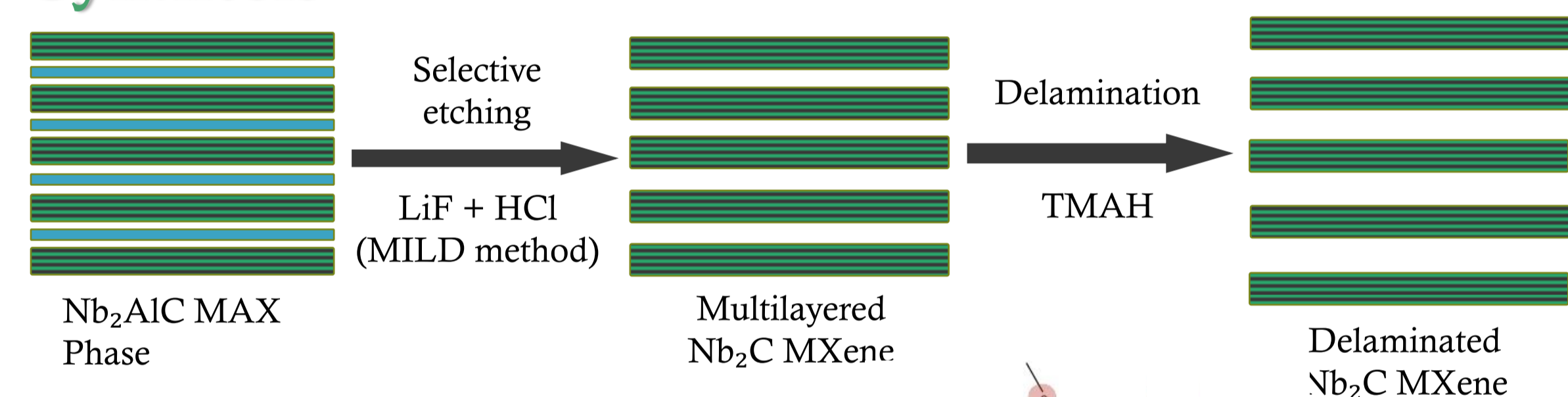


Figure 4 – XRD spectra for pure and functionalized Nb₂C MXene.

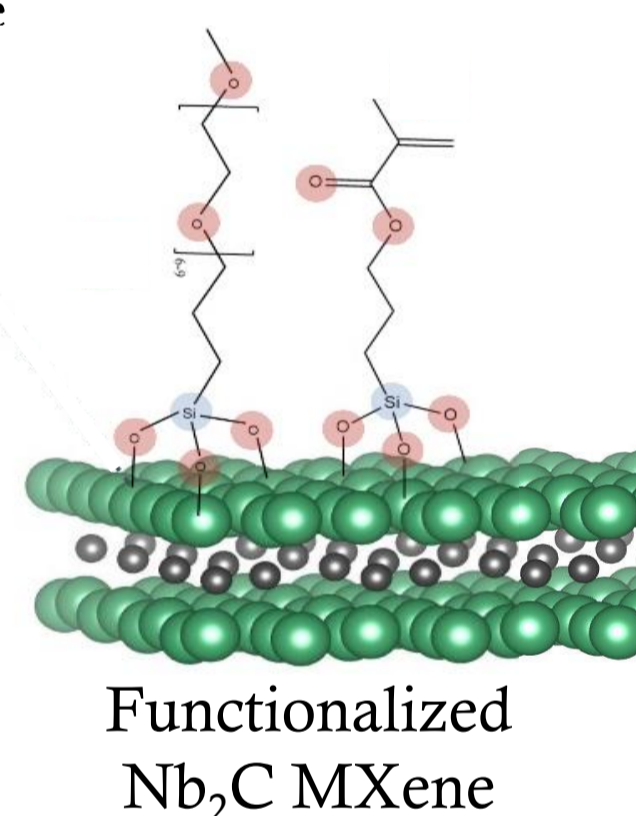
Results and discussion

Synthesis

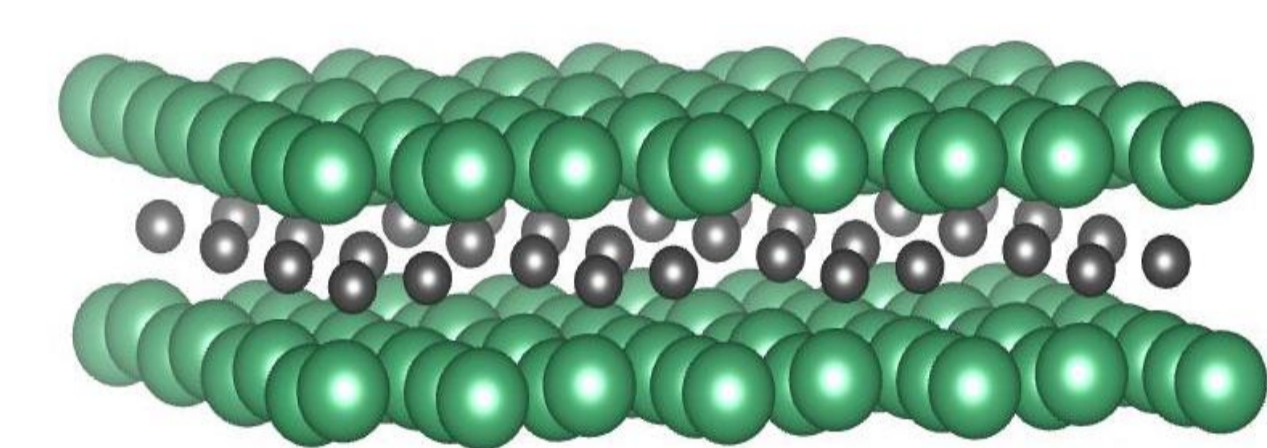


Functionalization

Acrylate,
PEG,
Amino
Silane

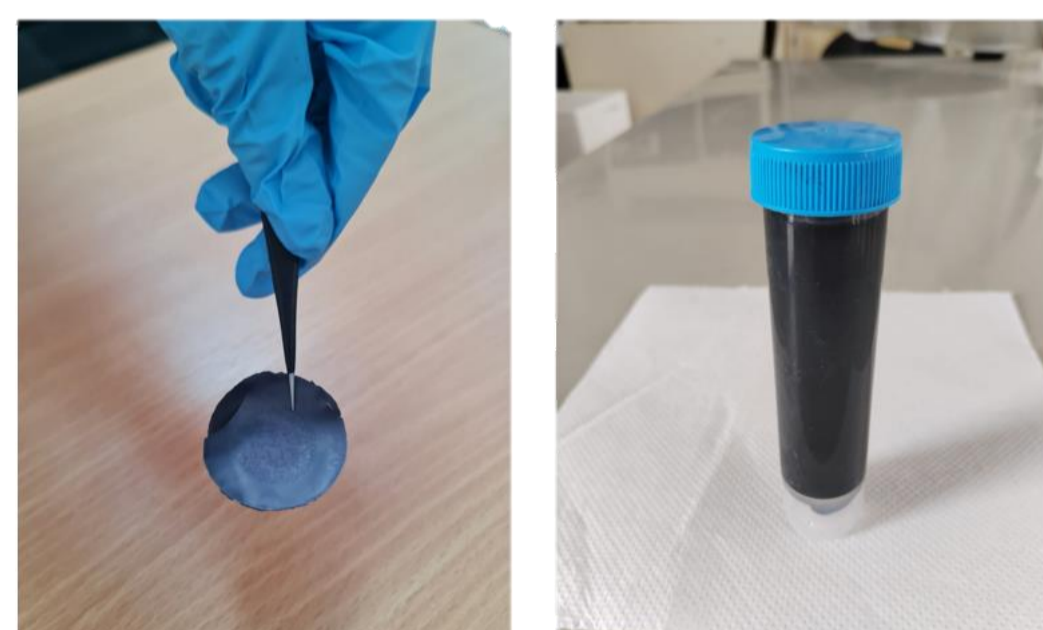


Structure



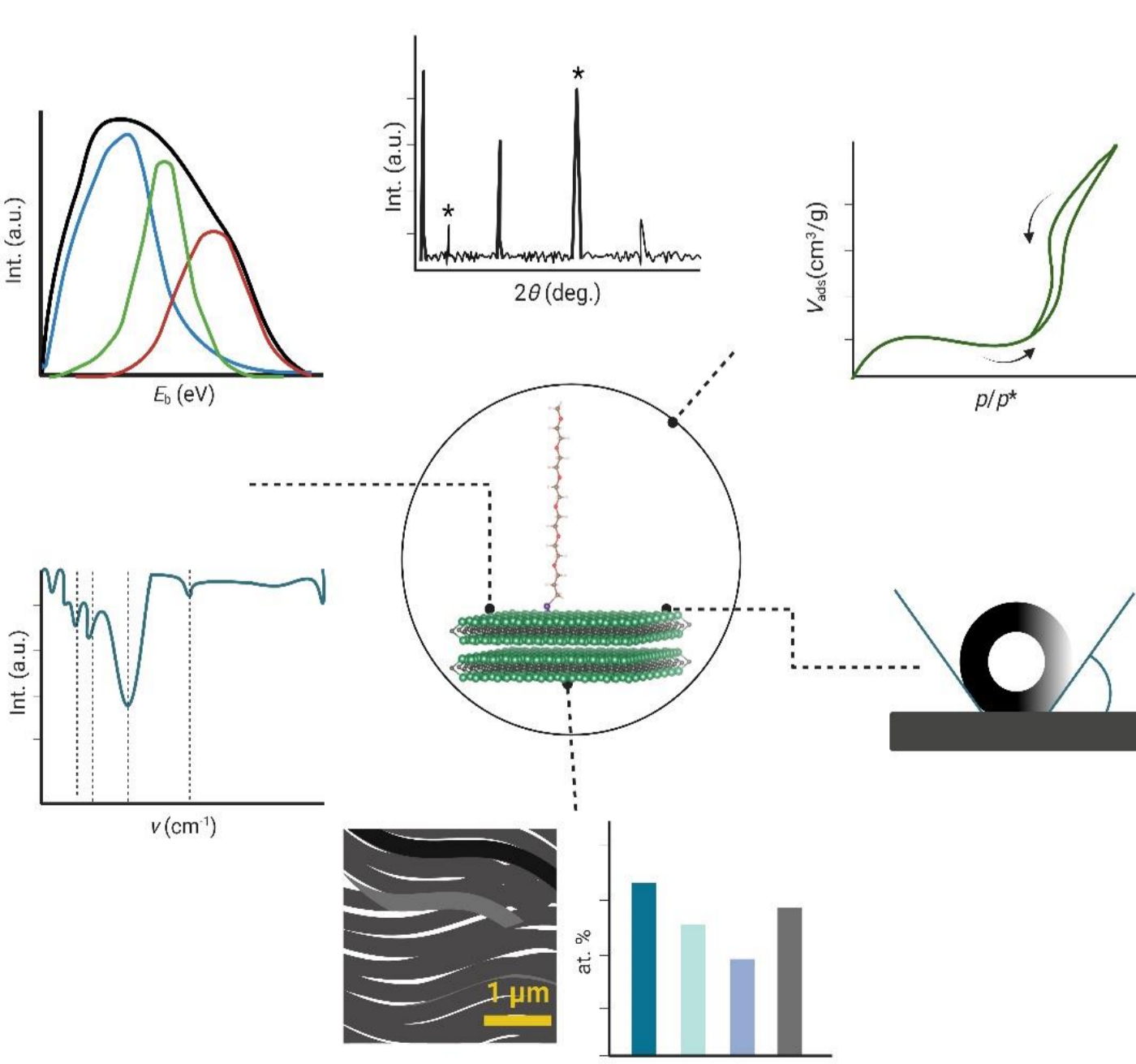
Schematic representation of Nb₂C MXene

Photographs



Photographs of freestanding MXene film and DI water dispersion

Characterization



References



Cyclic voltammetry

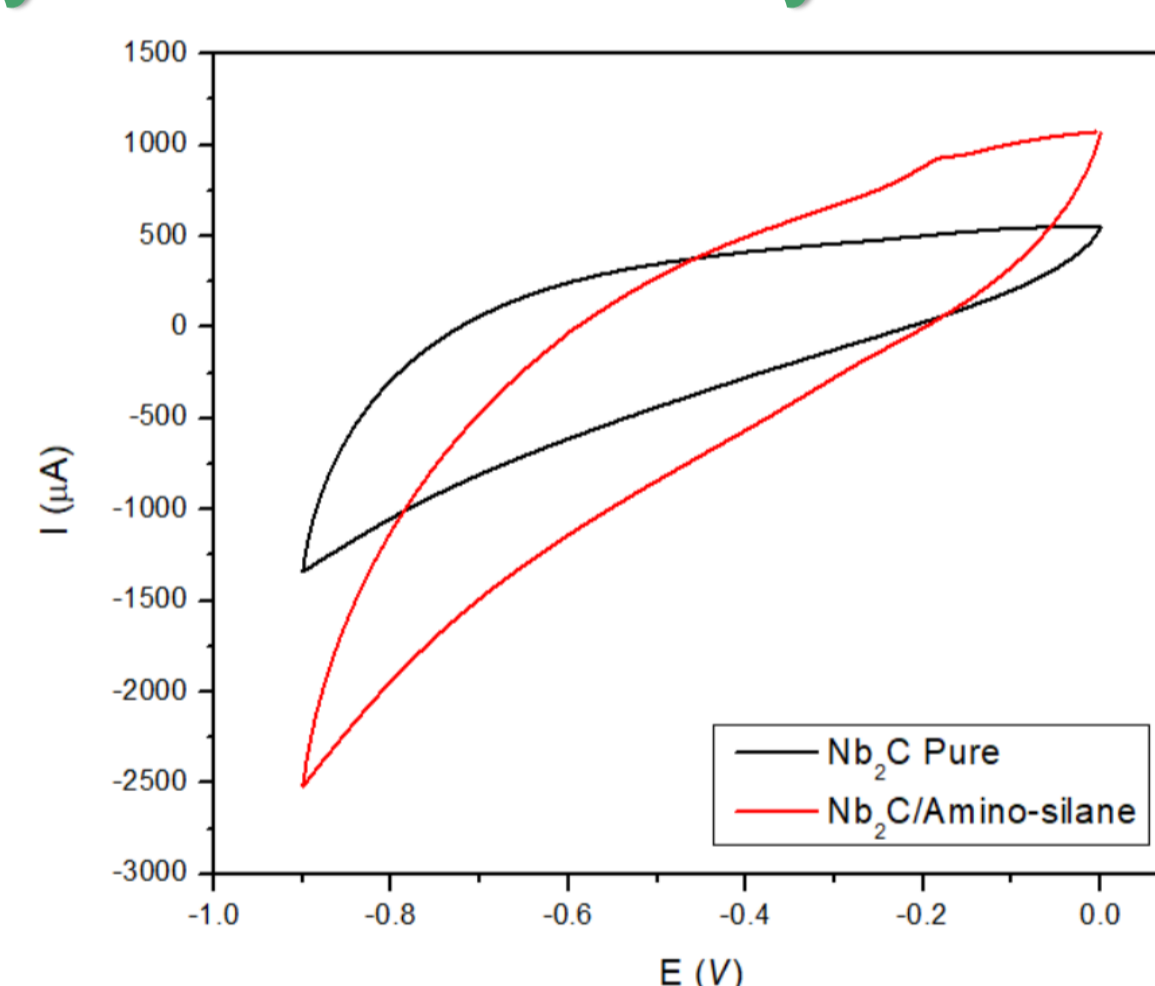


Figure 5 - Cyclic voltammograms of pure Nb₂C and amino silane Nb₂C MXene on a 5 mV/s scanning speed.

Table 1 – Specific capacitance values for pure Nb₂C and Ti₃C₂ MXenes at different scanning speeds.

Scan rate, (mV/s)	Specific capacitance, (F/g)	
	Nb ₂ C	Ti ₃ C ₂
100	9.516	11.63
50	15.67	17.17
10	52.42	45.37
5	92.67	68.09

Conclusion

Nb₂C MXene was successfully synthesized using the MILD method and functionalized with PEG, acrylate, and amino silanes for supercapacitor applications. FTIR confirmed successful surface functionalization, while SEM revealed a more delaminated structure than pristine Nb₂C, indicating reduced restacking and improved surface accessibility. Cyclic voltammetry showed that functionalization significantly affects capacitive behavior. Amino silane-functionalized Nb₂C exhibited the highest specific capacitance, attributed to improved electrolyte interaction and increased active sites. The presented results highlight the key role of surface functionalization in enhancing electrochemical performance and show that Nb₂C MXene exhibits competitive behavior compared to Ti₃C₂ under the studied conditions, demonstrating organosilane functionalization as an effective strategy for advanced flexible supercapacitor electrodes.

Acknowledgment: