When MXenes Meet Photon-Counting Spectral CT: Quantitative Imaging of Ti-Based 2D Nanomaterials

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MXenes are an emergent family of 2D transition-metal carbides and nitrides whose high electron density, tunable surface chemistry, and colloidal stability make them attractive candidates for nanomedicine and theranostics. In parallel, spectral photon-counting spectral CT (SPCCT) has matured to provide energy-resolved X-ray detection and material-specific image reconstruction. Here, we bring these advances together by synthesizing titanium-based MXene nanomaterials and demonstrating their sensitive detection and quantitative imaging using PCCT. Aqueous dispersions of Ti-based MXenes ($Ti_3C_2T_x$) were prepared and characterized for size, composition, and stability, then imaged in phantoms across multiple energy thresholds spanning the diagnostic X-ray spectrum, with $Ti_3C_2T_x$ scanned at a series of known concentrations. Ti-prior spectral quantification approach that leverages energy-binned attenuation prior knowledge was used to do material decomposition to estimate MXene concentration maps. The resulting images show robust MXene contrast across energy bins, clear separability, and accurate concentration estimates over a practical range relevant to nano-theranostic dosing. Together, these findings establish PCCT as a powerful platform for label-free, element-aware readouts of Ti-based MXenes, enabling quantitative tracking, dose optimization, and therapy monitoring. This proof-of-concept positions MXene–SPCCT imaging as a versatile foundation for next-generation nanomedicine workflows that integrate delivery, diagnosis, and response assessment.

Keywords: MXene; titanium-based nanomaterials; spectral photon-counting spectral CT; material decomposition; quantitative imaging; theranostics; nanomedicine.

References

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Figures

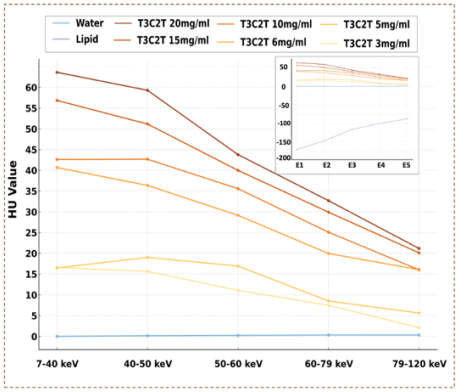

Figure 1: Spectral Curve Analysis Across Energy Windows in SPCCT of Mexene