

# Minimal Fluorine, MXimum Catalysis: Fluoride-free Synthesis of MXenes for Electrochemical Ammonia Production from Nitrate

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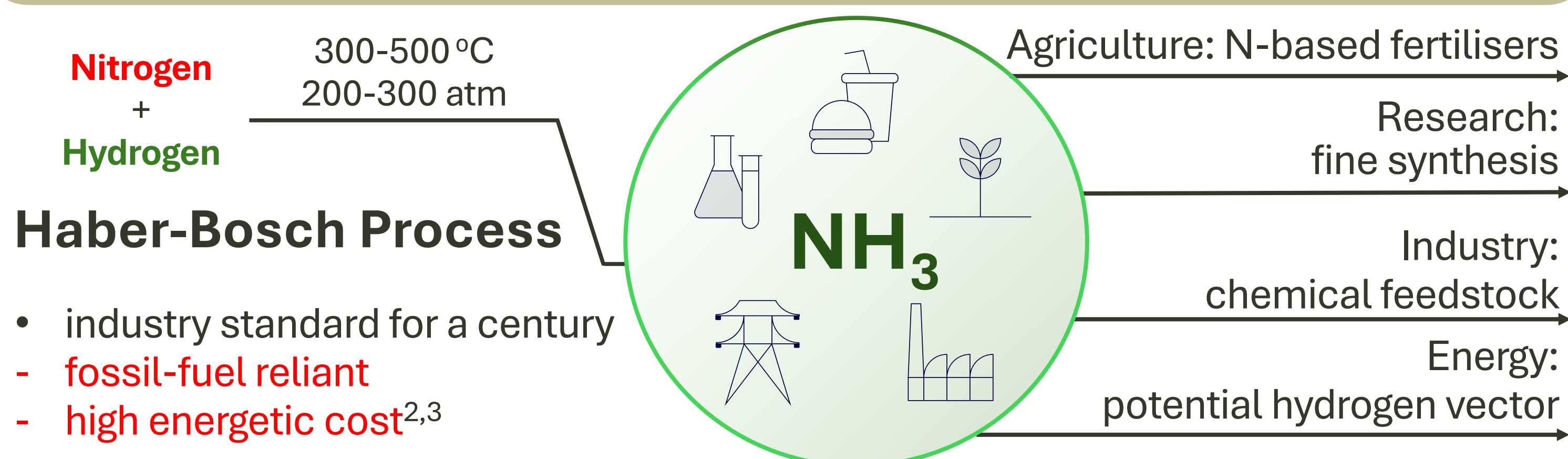


## Key Questions

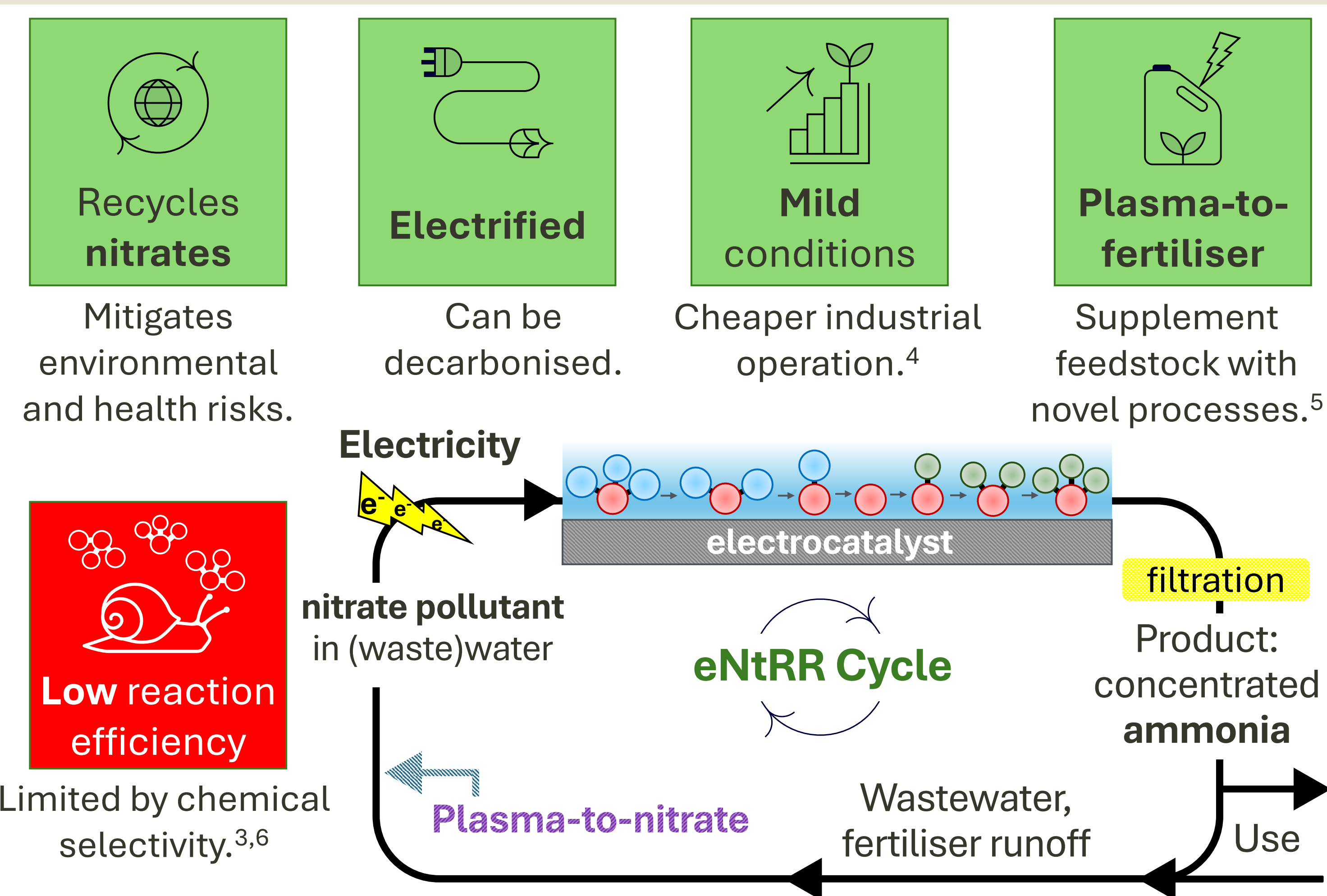
- Can harmful waste, such as nitrates (or NO<sub>x</sub>), be transformed into valuable chemicals?
- Is electrochemical ammonia (NH<sub>3</sub>) synthesis a sustainable and viable alternative to the Haber-Bosch Process?
- Can synthesis of novel materials (MXenes) be streamlined for safer and more efficient procedures?

## Electrochemical Ammonia Synthesis

- The global ammonia industry was valued at USD 86.9 bn in 2025, with 4.22% predicted annual growth.<sup>1</sup>

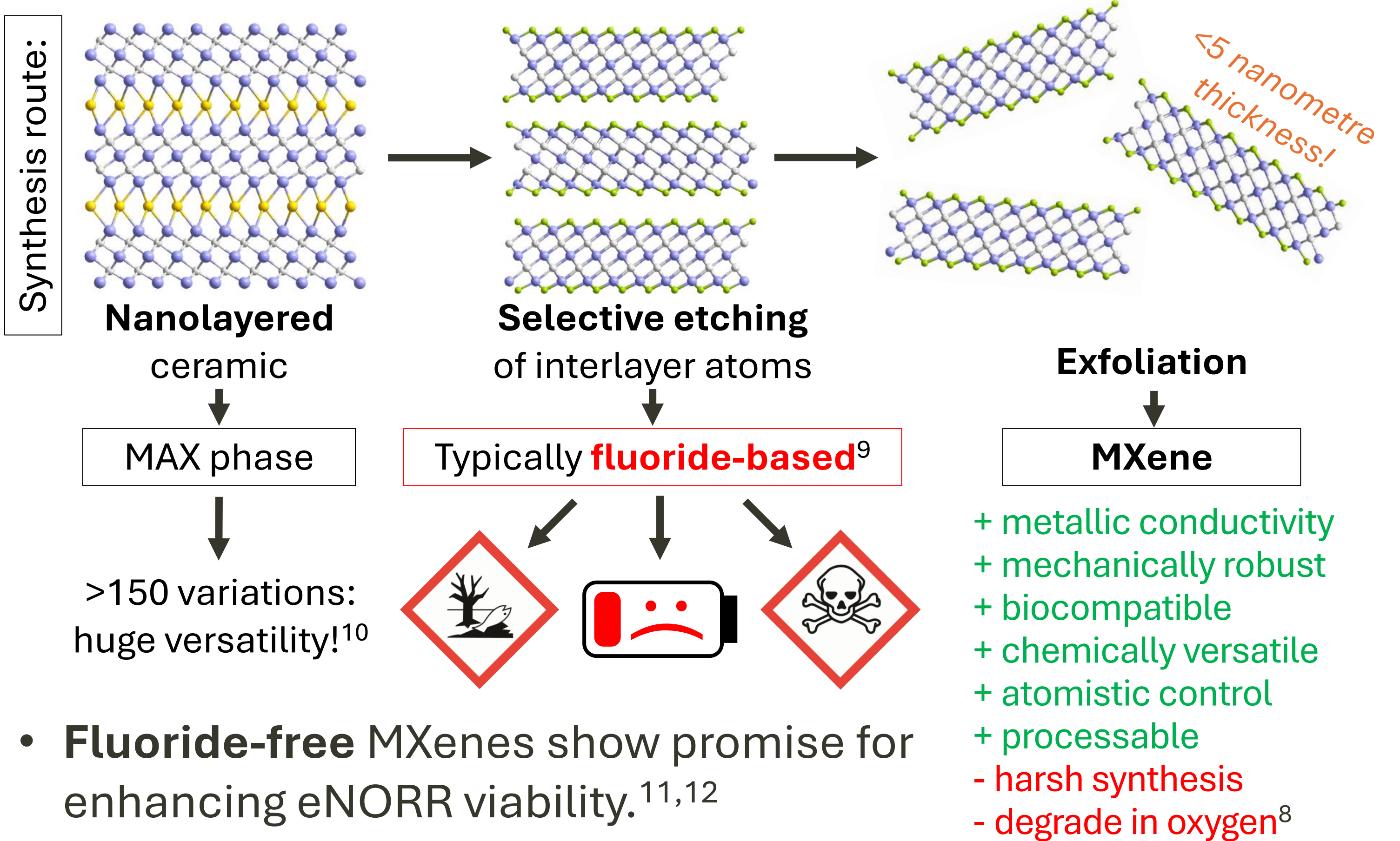


## eNtRR (Electrochemical Nitrate Reduction Reaction)



## MXenes: 2D nanoscale metal carbide/nitrides

- Electrocatalysts improve electrochemical reaction efficiency.
- Potential MXene applications include electrocatalysis, battery materials, heat/radiation shielding, sensing, and more.<sup>7,8</sup>

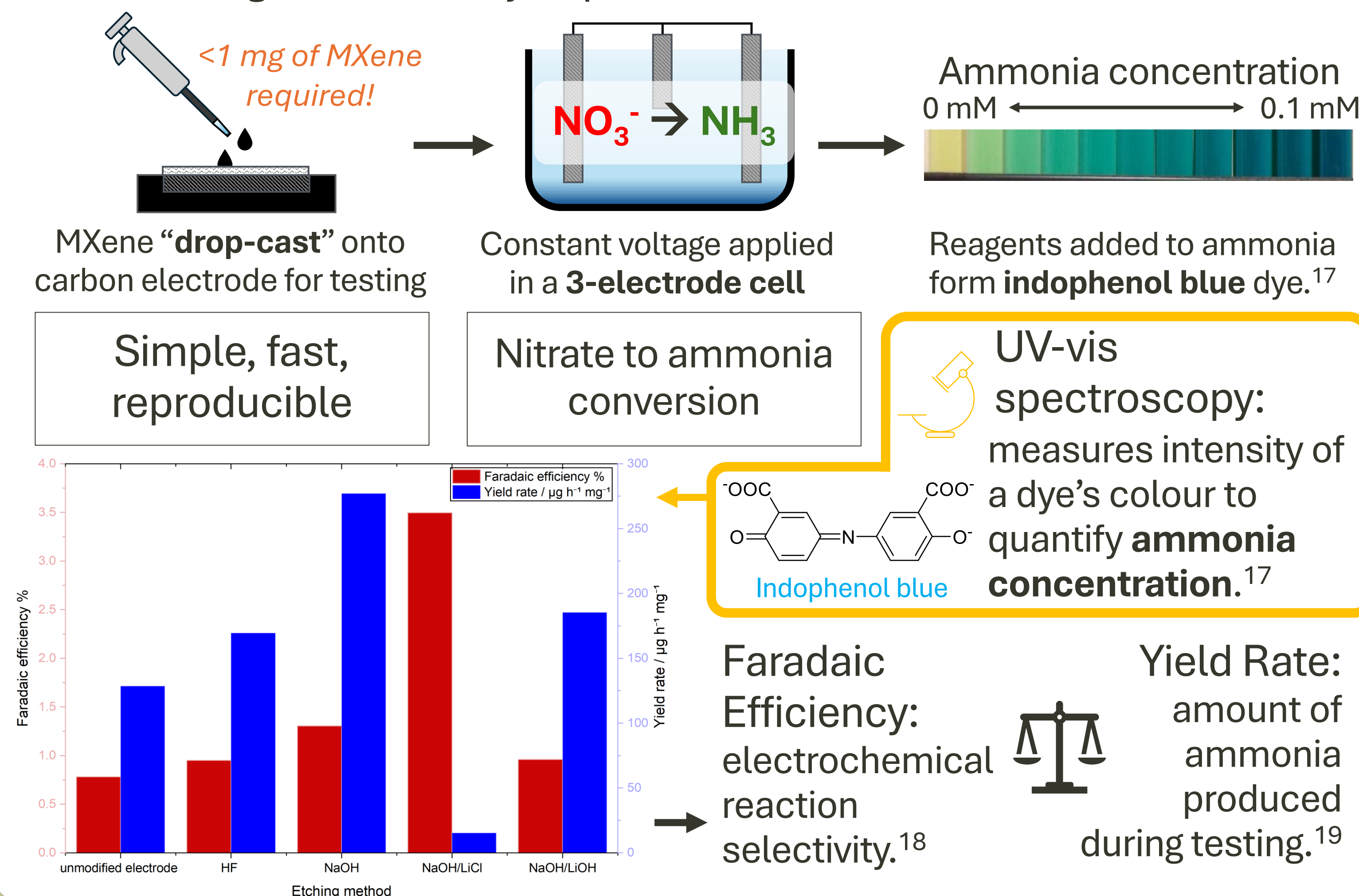


Safe, simple, and sustainable process for high quality MXenes needed!

## Applying Fluoride-Free MXenes in eNtRR

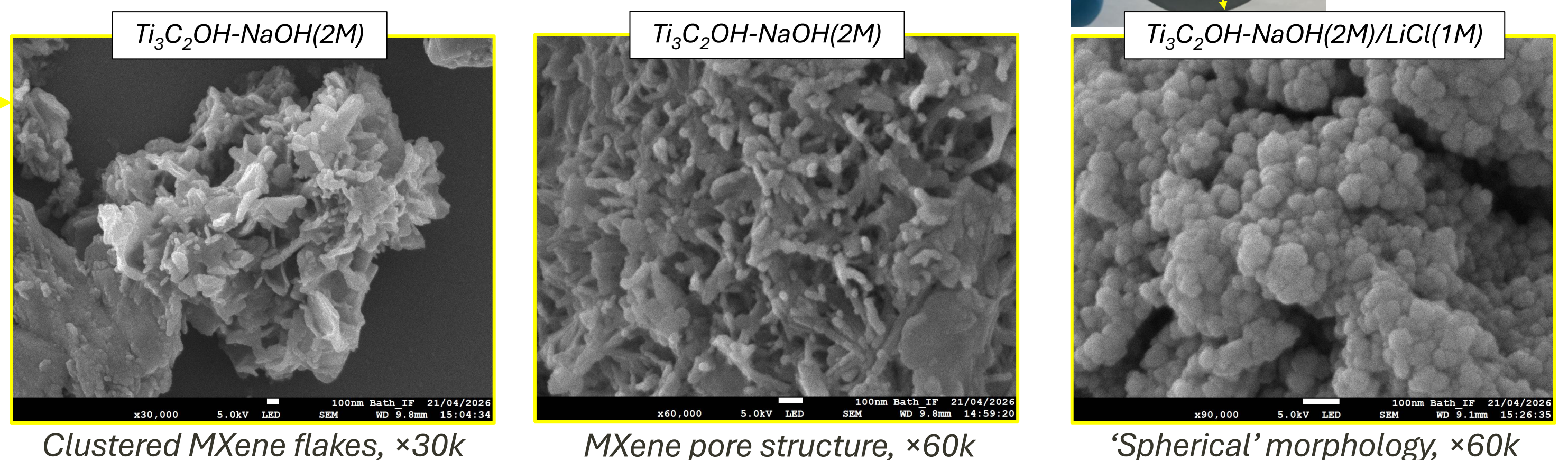
- Etching method: Low concentration, one-pot, Hydrothermal<sup>13,14</sup>
- Mild conditions
  - Whole synthesis in one reactor
  - Water based
  - + cheaper and safer
  - + simple purification
  - + improved efficiency
  - high temperature and pressure

- Assessing electrocatalytic performance of MXenes:



EDX-FE-SEM: an electron microscopy technique that generates images with microscale resolution and elemental composition.<sup>15</sup>

- Self-standing MXene membranes are suited to wastewater treatment.<sup>16</sup>
- Using the current method, membranes lose structural strength above ~1 cm<sup>2</sup> size.



- Future work will investigate electrochemical and UV etching; and optimise hydrothermal etching for membrane construction.
- Further characterisation (PXRD, TEM, Raman, XPS) for material and mechanistic insights into eNtRR and etching processes.

## Notes and acknowledgements

This work was supported by the UKRI EPSRC Centre for Doctoral Training in Green Industrial Futures EP/Y03550X/1.

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