Controlling Fe:Ni Ratios in Carbides to Affect Electrocatalytic Activity

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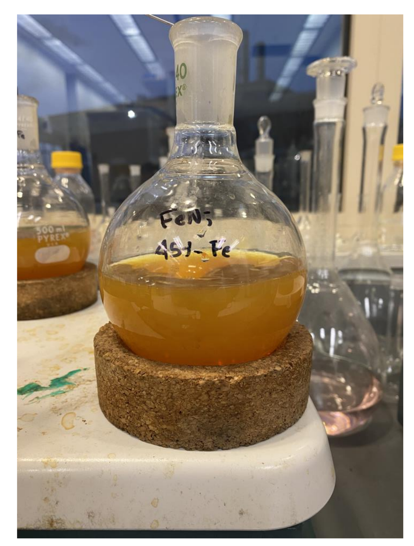
Introduction

- Our goal is to design earth abundant materials for the replacement of noble metal catalysts in the Oxygen Evolution Reaction (OER). OER represents both the kinetic and thermodynamic barriers for electrolytic water splitting, the reaction used to produce Hydrogen fuel. By finding an ideal Fe to Ni ratio in the generated bimetallic carbides, cheaper alternatives to the expensive state-of-the-art can be further explored.

FeNi PBA synthesis at different ratios. NiCl2 is added via syringe to the two samples on the left, and FeCl2 to the two samples on the right.

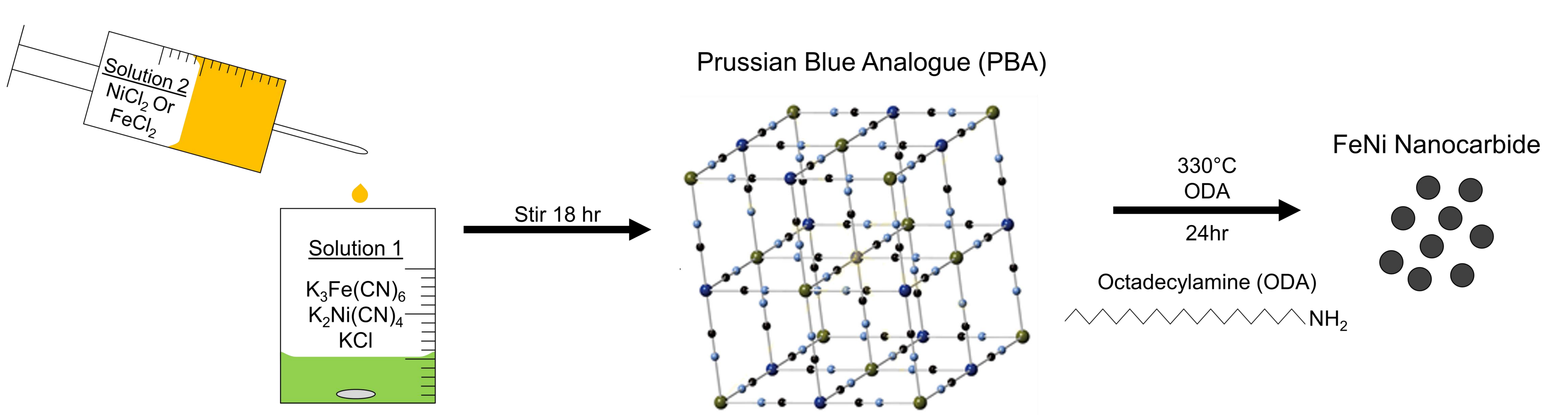


FeNi PBA synthesis at a ratio of 45% Fe.

FeNi PBA synthesis at a ratio of 55% Fe.

Materials & Methods

- In a typical PBA (Prussian Blue Analogue) synthesis two precursor solutions are prepared and upon addition a precipitation reaction occurs to form the PBA. Solution 2 is added to solution 1 at 5 mL/min and stirred for 18 hrs at room temperature. The precipitate is collected via centrifugation and dried overnight.
- In a typical nanocarbide synthesis, 200 mg of solid PBA is added to a three-neck round bottom flask with 40 mL of octadecylamine (ODA) and heated to 330°C under inert air for 24hrs. After 24hrs the reaction is quenched using toluene and the resultant nanocarbide is collected via magnetic separation and dried in an oven at 100°C for 15 minutes.



Visualization of PBA synthesis. NiCl2 is added to Solution 1 for % Fe<50, and FeCl2 is added for % Fe>50

Cubic PBA made up of Fe and Ni metal, connected with CN (cyanide) bridges.

Amorphous FeNi Nanocarbide generated

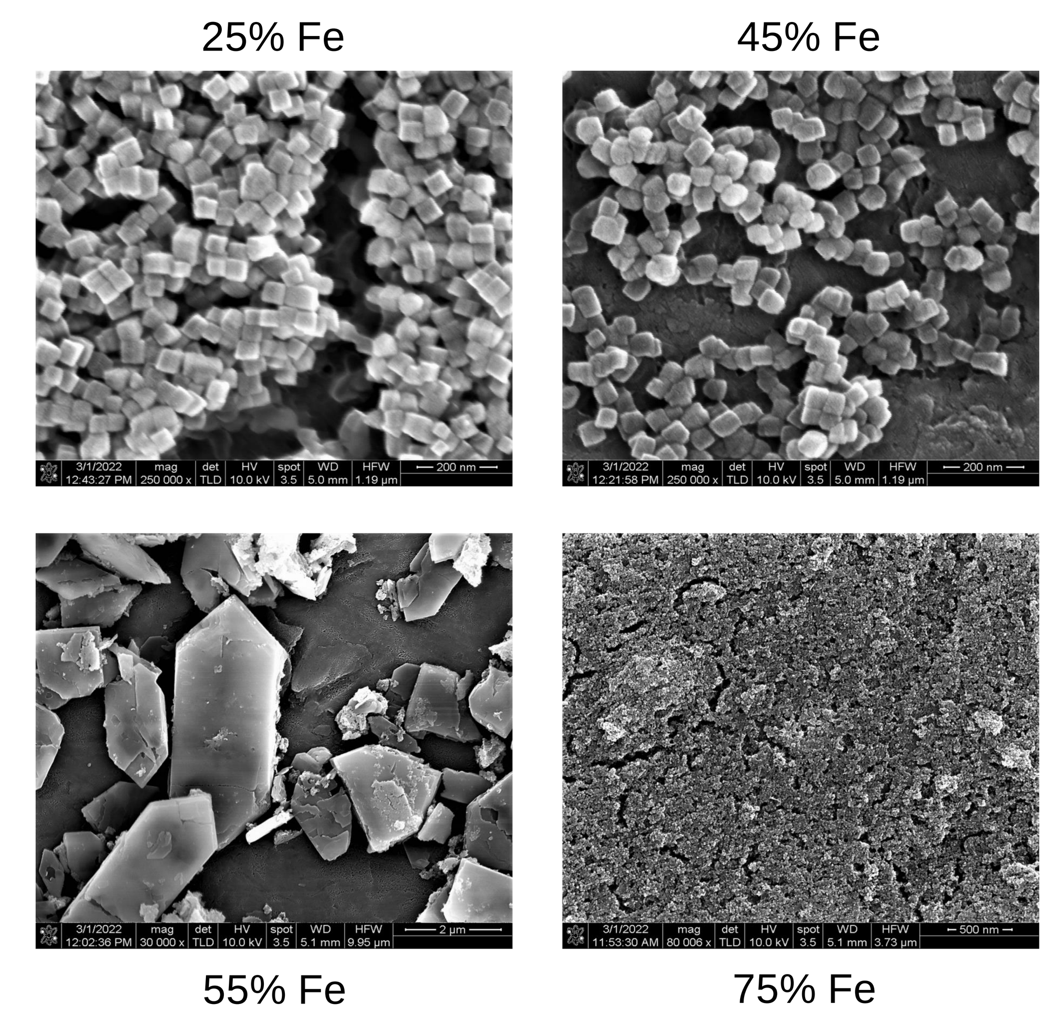
Physical Characterization

Elemental Analysis: XRF

Nominal % Fe	Actual % Fe	Actual % Ni
25%	24.536	75.464
45%	35.552	64.448
55%	53.528	46.472
75%	80.754	19.246

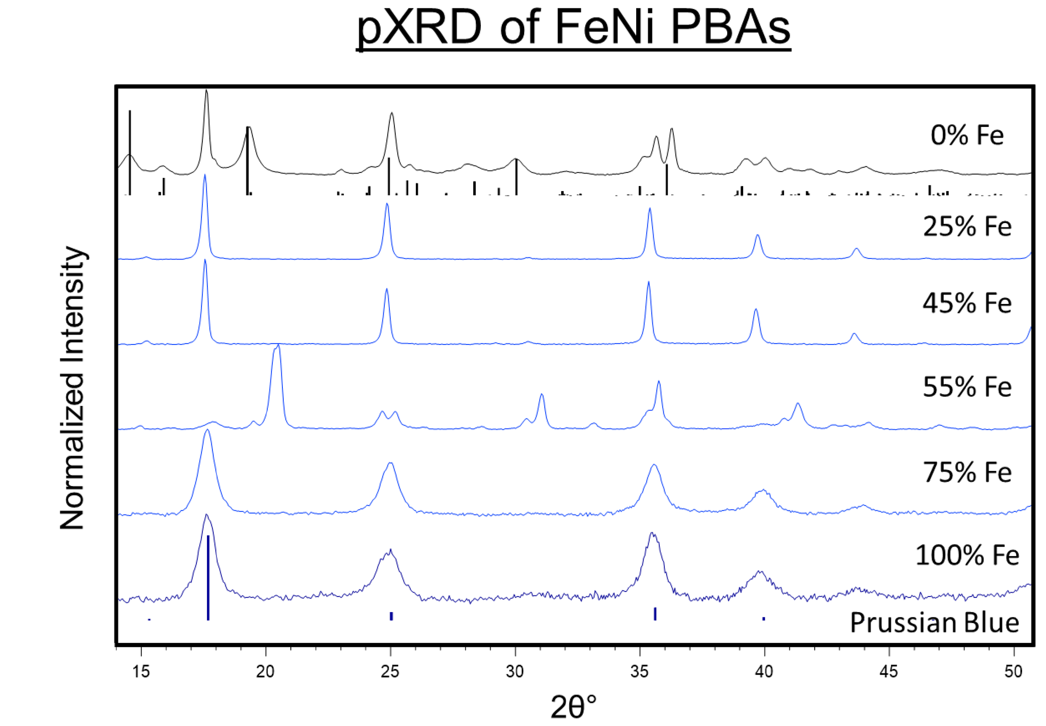
XRF confirming actual FeNi ratios in PBA

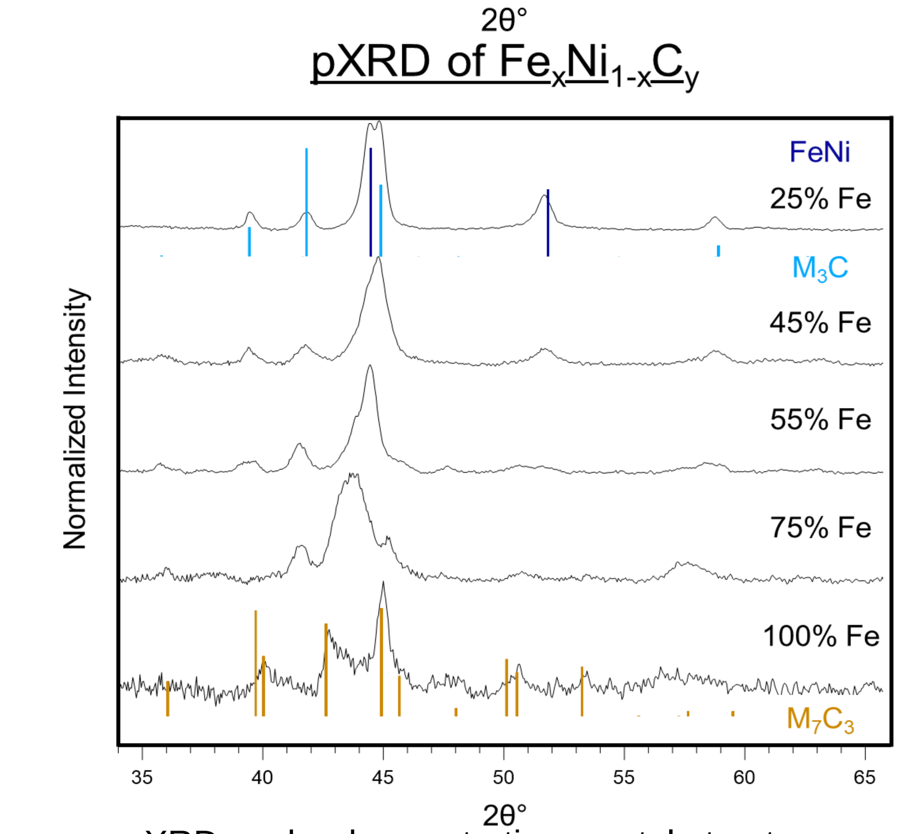
Size and Morphology: PBA SEM



Scanning electron microscope images of different FeNi ratios in PBA

Material Identification: pXRD





pXRD peaks demonstrating crystal structure comparison of FeNi PBA and carbide, respectively

Electrochemical Characterization

Electrocatalytic Activity of FeNi Nanocarbide

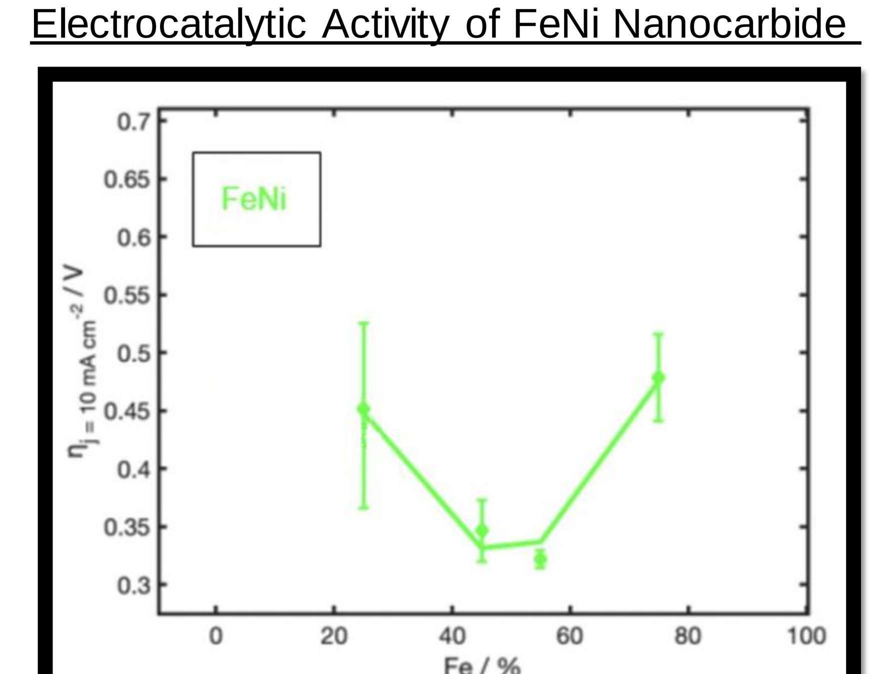


Figure 1: Electrocatalytic activity of FeNi based nanocarbides shown in overpotential (at a current density of 10 mA/cm²) versus % Fe.

Conclusions

- The results of Figure 1 show an optimum ratio of Fe to Ni at 55% Fe, consistent with results of previous literature on FeNi-based electrocatalysts.
- $Fe_xNi_{1-x}C_y$ are plausible alternatives for the current RuO_2 state-of-the-art as they are cheaper and superior OER performers
- These materials are promising electrocatalysts, more studies are on the way to further optimize these nanoparticles such as controlling phase, morphology, and measuring electrochemical stability.

References: