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Facile Synthesis of Pt-Ni-Ru Nanoframes with Superior Performance for Methanol Oxidation Reaction

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Facile Synthesis of Pt-Ni-Ru Nanoframes with Superior Performance for Methanol Oxidation Reaction

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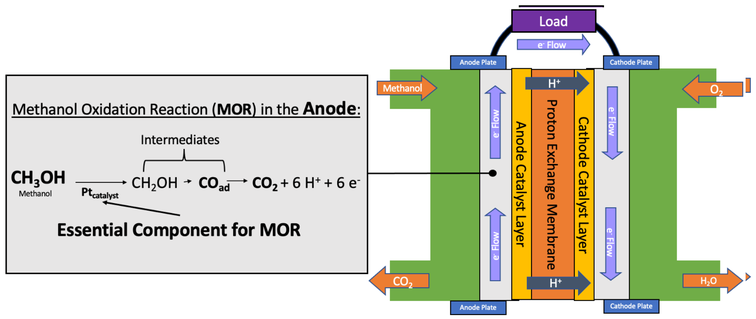
Introduction

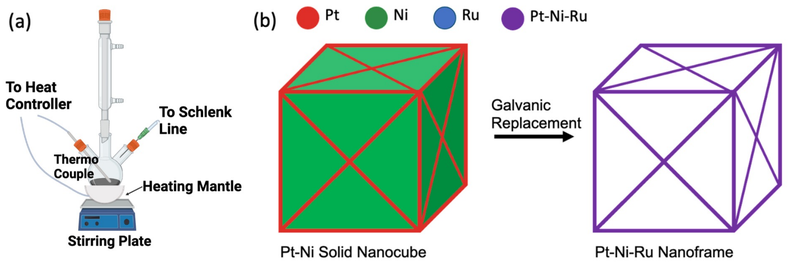
- The increasing demand for energy requires a sustainable approach to produce clean energy.
- A fuel cell converts chemical energy of fuels into electricity.



Schematic 1. Schematic representation of a direct methanol fuel cell (DMFC).

- The sluggish kinetics of MOR can be further improved with:
  - Alloying, for example with Ru which gave a higher activity
  - Nanoframes (NFs), which yielded more active sites
- This research aims to address the following objectives:
  - Synthesize Pt-Ni-Ru NFs through galvanic replacement of Pt-Ni solid nanocubes (NCs)
  - Evaluate the MOR activity with generated NFs.

Methods



Schematic 2. (a) The setup used for the colloidal synthesis of both Pt-Ni solid NCs and Pt-Ni-Ru NFs and (b) the schematic illustration of the preparation of Pt-Ru NFs via galvanic replacement.

Characterization Techniques

- Transmission Electron Microscopy (TEM) was used to analyze the morphology and size of the products.
- Energy Dispersive X-ray Spectroscopy (EDS) was used for elemental analysis of Pt-Ni-Ru NFs.
- Cyclic voltammetry was used to evaluate the MOR activity of Pt-Ni solid NCs and Pt-Ni-Ru NFs.

Results

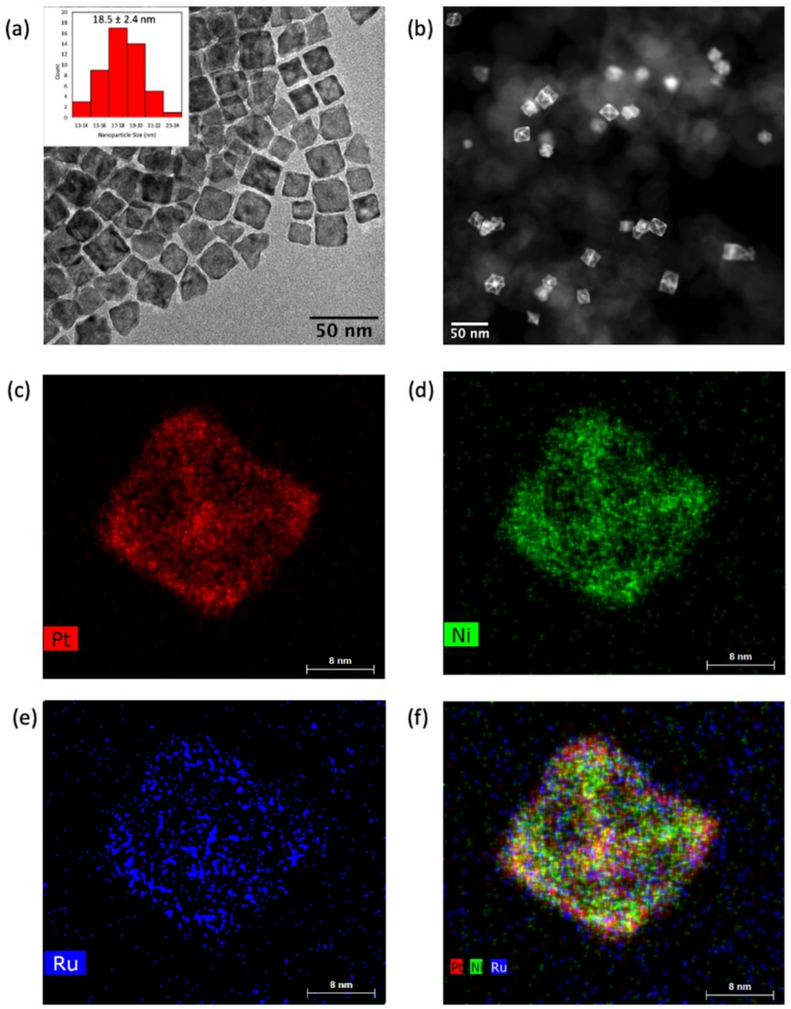


Figure 1. TEM images of (a) Pt-Ni solid NCs and (b) Pt-Ni-Ru NFs. (c-f) EDS mapping of Pt-Ni-Ru NF.

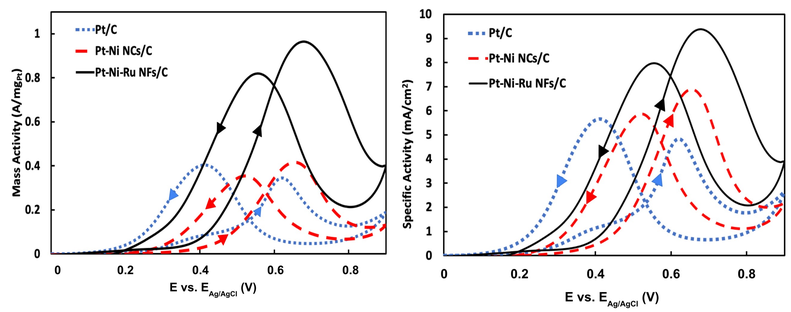


Figure 2. Cyclic voltammograms for the catalysts in 1.0 M methanol / 0.1 M $HClO_4$ at room temperature with a scan rate of 100 mV/s.

Results

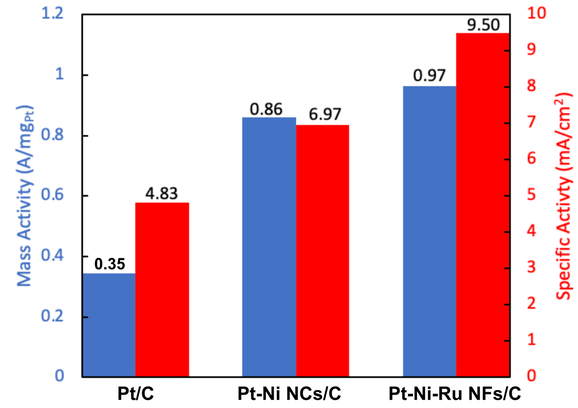


Figure 3. Specific and mass activities of MOR for Pt/C, Pt-Ni/C and Pt-Ni-Ru/C.

2.8x mass activity, **2.0x** specific activity vs. Pt/C

Conclusion

- Pt-Ni-Ru NFs were successfully prepared through the galvanic replacement of the Pt-Ni solid NCs.
- The resultant Pt-Ni-Ru NFs exhibited superior catalytic performance for MOR.
- The research presented herein provides a facile method for the synthesis of NFs through galvanic replacement.
- Pt-Ni-Ru NFs have the potential to replace commercialized Pt/C catalysts used in DMFCs.

Acknowledgements

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