Nanoparticles Synthesis for Formic Acid Catalyst

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Goals

To synthesize a new anode material for oxidation of formic acid (HCOOH) for direct formic acid fuel cells (DFAFCs). Nickel nanoparticles (NiNPs) and Copper nanoparticles (CuNPs) of size less than 15 nm were first synthesized using the successive reduction using hydrazine as a reducing agent. Palladium (Pd) shell was then deposited on CuNPs .

Introduction

The need of renewable and sustainable energy is crucial to reduce our dependency on fossil fuels and preserve the environment. Bimetallic catalysts (Pd-Cu) have been shown to improve the activity and stability when compare to monometallic (Pd) for direct HCOOH fuel cell. Trimetallic catalyst could be more effective due to sequential electronic transfer between atoms of different elements. The use of HCOOH fuel cell preserves the pollution of the atmosphere by recycling the CO_2.

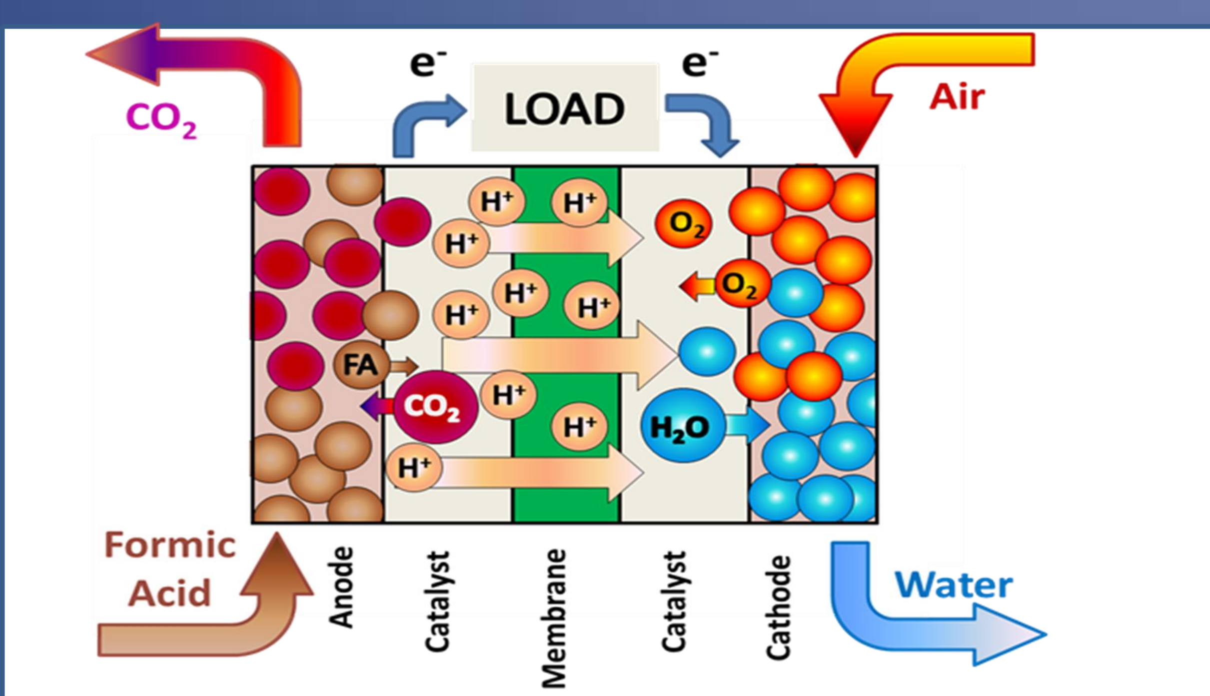
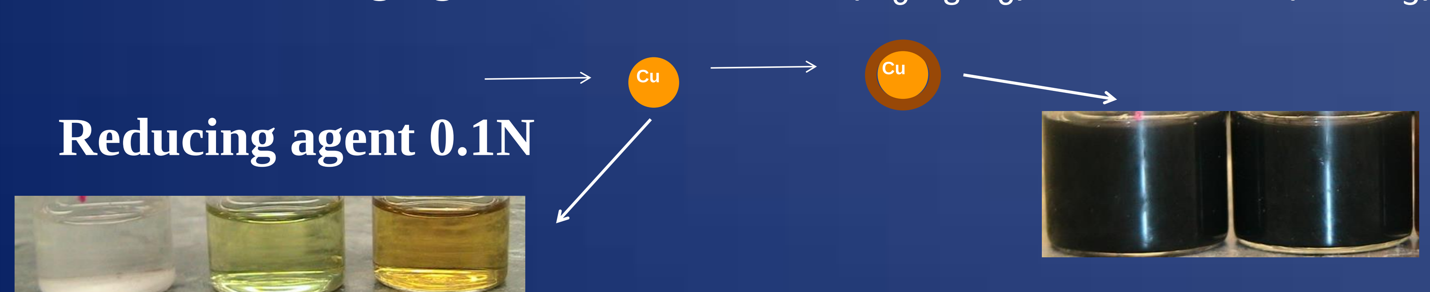


Fig.1: Illustration of a Formic Acid fuel cell

Materials and Methods

Cu-Pd Nanoparticles synthesis

Successive reduction
Precursors: Copper(II) chloride ($CuCl_2$), Palladium Chloride ($PdCl_2$)
Solvent/ reducing agent: Ascorbic Acid($C_6H_8O_6$), Nitric Acid(HNO_3)



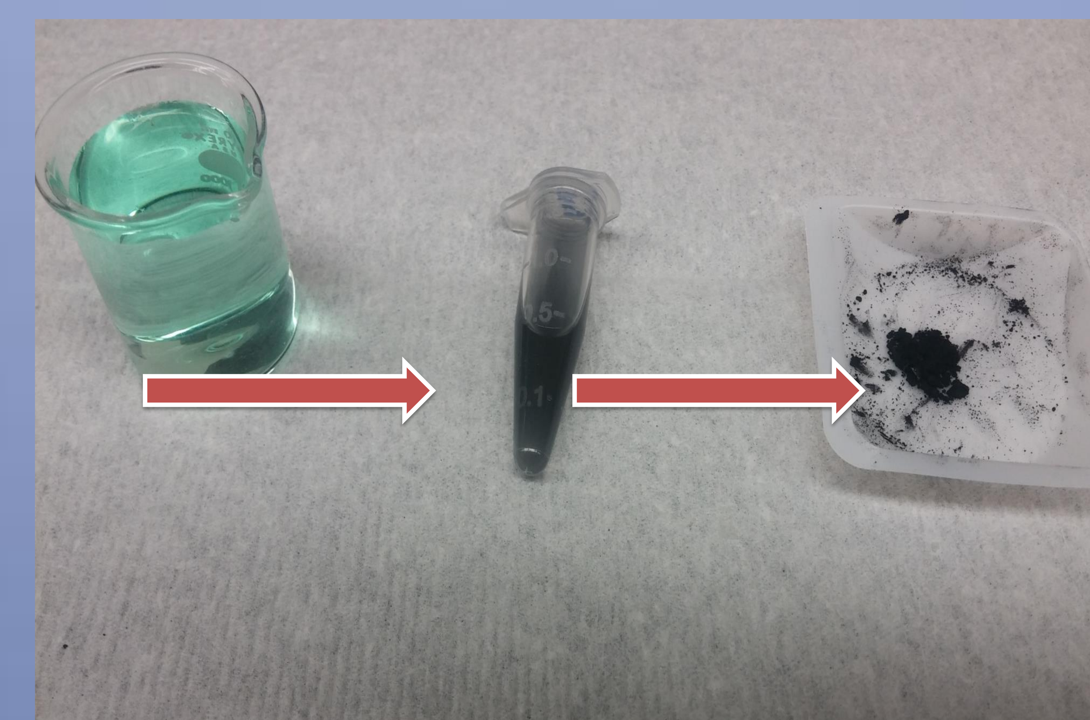
Cu Particle size increases with time

Cu@Pd Core-shell Structure characterized by TEM

Materials and Methods

Ni Nanoparticles synthesis

Successive reduction
Precursor Nickel(II) chloride hexahydrate (NiCl2.6H20).
Solvent/ reducing agent: Ethylene glycol (C2H6O2)/ Hydrazine (N_2H_4)



Results

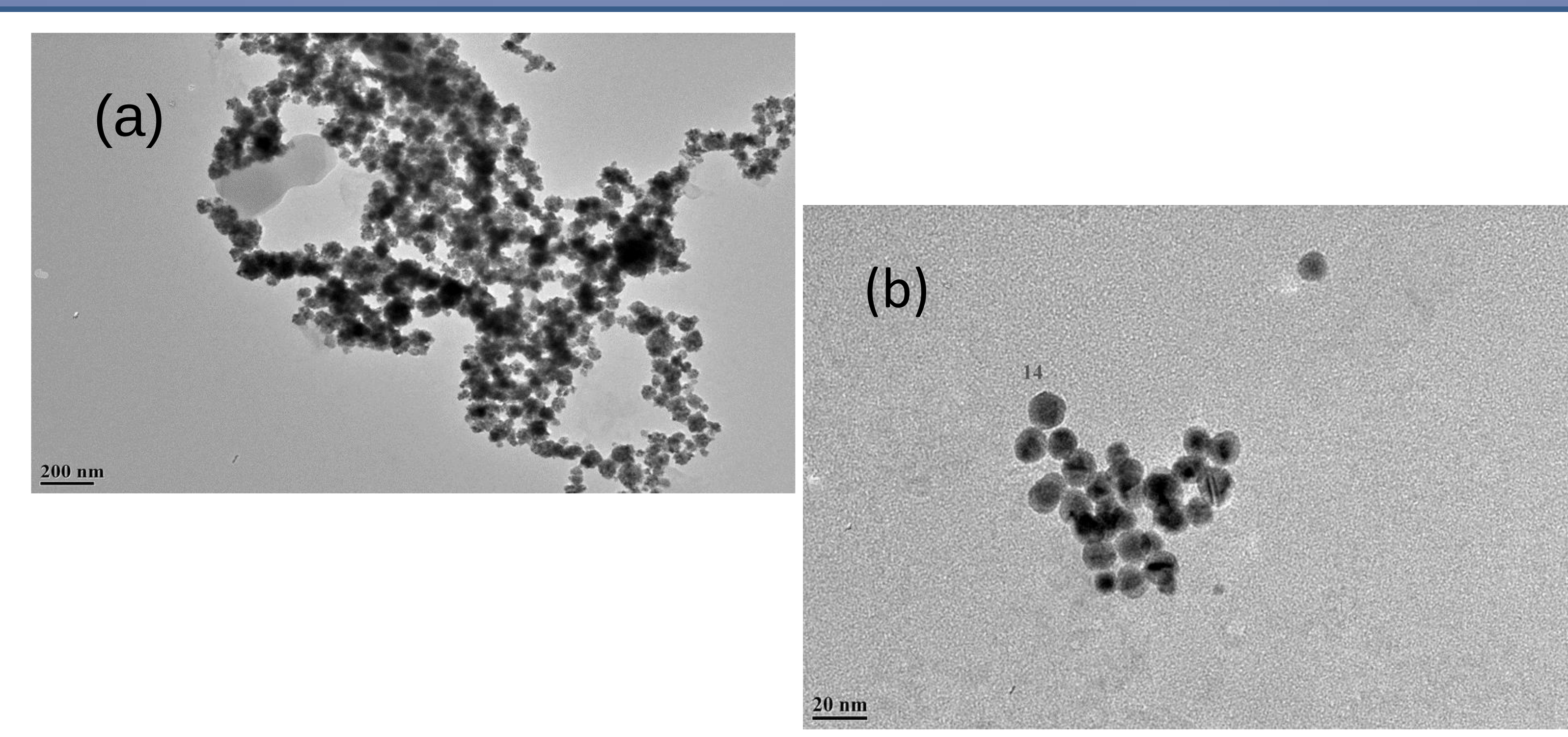


Fig.2 TEM micrographs of NiNPs (a) large size, (b) small size

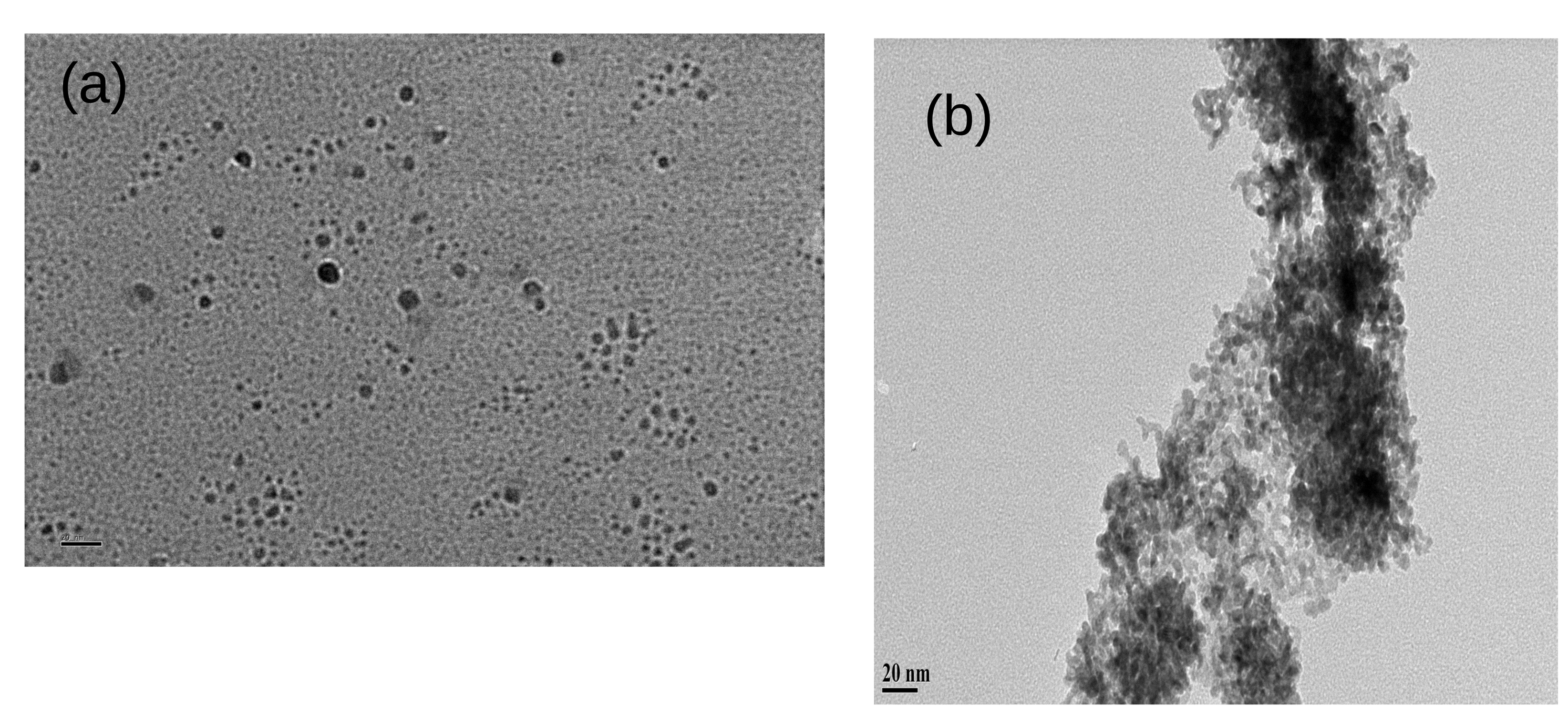


Fig.3 TEM micrographs of (a) CuNPs, (b) Cu-PdNPs

Conclusion

NiNPs and CuNPs were successfully synthesized by successive reduction method and characterized by TEM. The Trimetallic can be obtained by first synthesizing the bimetallic (Ni-Cu/Cu-Ni) and subsequently coating the core with Pd. Achieving this trimetallic has the potential for resolving the Pd-based catalyst poisoning issue and increasing activity and stability toward oxidation of formic acid .

Future works

- Synthesize Ni-Cu-Pd or Cu-Ni-PdNPs.
- HR-TEM on Ni-Cu-Pd, Cu-Ni-Pd.
- CV and XPS on Ni-Cu, Cu-Ni, Ni-Cu-Pd, and Cu-Ni-Pd.
- Testing of actual direct formic acid fuel cells using Ni-Cu-Pd/Cu-Ni-Pd core-shell NPs.

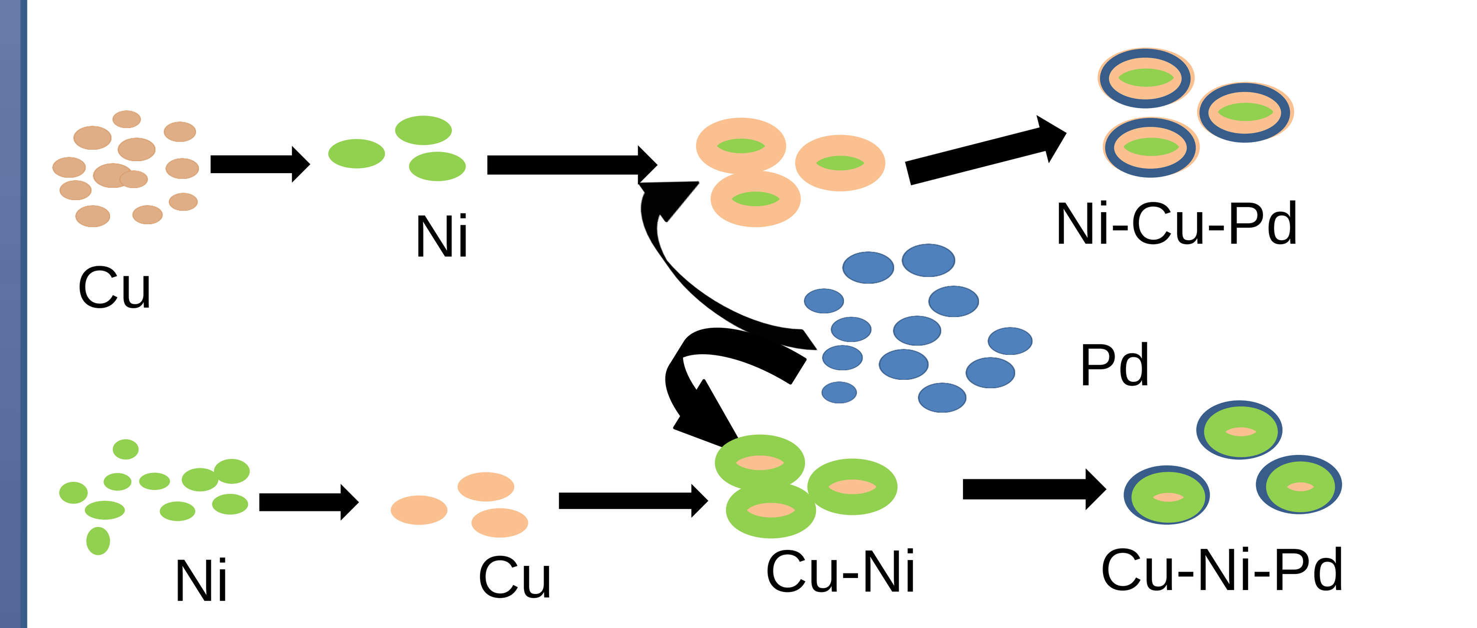


Fig.4 Illustration of trimetallic nanoparticles synthesis

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