Nickel for Your Thoughts:
Nickel Nanowire Ink Synthesis

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Introduction

STATUS QUO

Why Conductive Inks? [1]
- Inks made with metal particles
- Base of printed electronics

Conductive Material → **Gold & Silver Used**
- Gold & Silver are expensive
- Silver oxidizes quickly

Problems
- Solvents harm environment

SOLUTION

Zoomed in: NiNWs overlap → This makes ink conductive

Applications → Sensors[2], Devices, Electronical Components

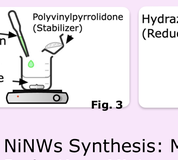
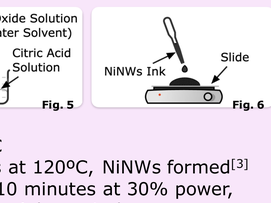


Fig. 1 NiNWs Ink Components:
- Nickel Nanowires
- Polymer Solution

Why NiNWs?
- Nanotechnology is emerging
- Cheap, easy to synthesize
- Environmentally friendly
- Long shelf life



Objectives

- Synthesize nickel nanowires with tunable characteristics
- Create more sustainable, stable, conductive inks for GEEETech Printer using nickel nanowires and water
- Use inks in printed electronics

Methodology

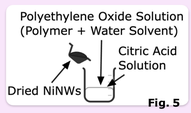
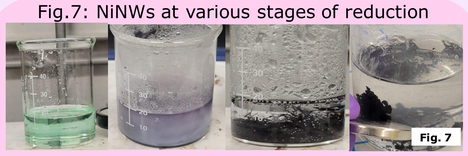


Fig. 3 NiNWs Synthesis: Mixture was heated to 120ºC
Fig. 4 Reduction: Mixture was reduced for 45 minutes at 120ºC, NiNWs formed[3]
Fig. 5 Creating Ink: Mixture was probe sonicated for 10 minutes at 30% power, decanted and dried NiNWs dispersed, conductive ink created
Fig. 6 Creating Films: Ink was pipetted onto a slide, left to dry at 40ºC, thin, conductive films formed [4]

Why Capping Agent?
- Used: PVP
- Decreases width of nanowires and length of thorns

Why Chelating Agent?
- Used: Citric acid [5]
- Increases dispersion
- Stabilizes inks
- Increases conductivity

Fig.7: NiNWs at various stages of reduction



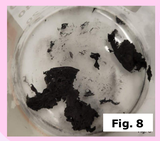
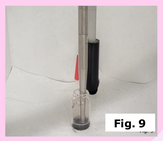


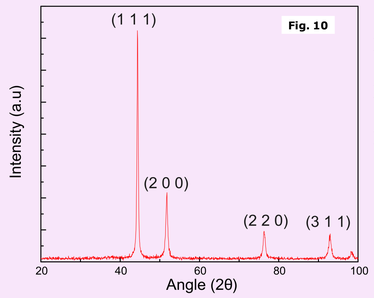
Fig. 8: Dried and Decanted NiNWs

Fig. 9: NiNWs Ink Sonicating



Results & Discussion

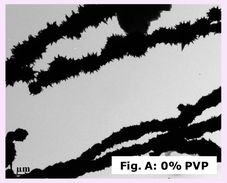
X-Ray Diffraction Analysis (XRD)

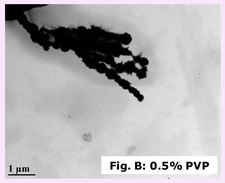


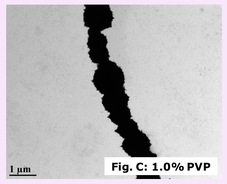
- NiNWs exhibit face-centred (FCC) structure with good phase purity
- FCC: 3 planes at 2θ= 44.50, 51.85, and 76.38°
- No traces of nickel oxide detected within XRD limits

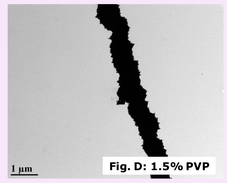
Fig. 10: XRD Graph: Intensity vs Angle

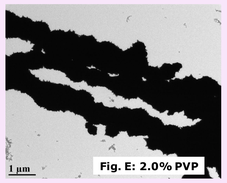
Transmission Electron Microscopy (TEM)



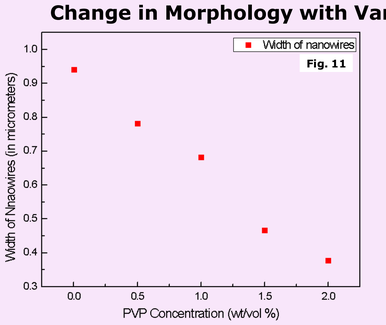


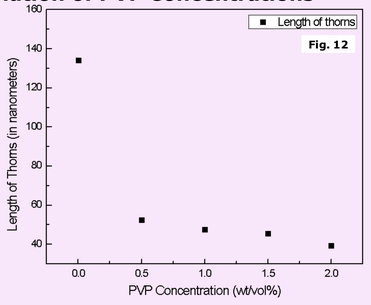






Change in Morphology with Variation of PVP Concentrations

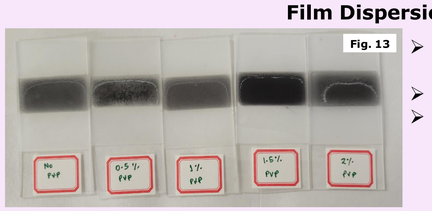




- NiNWs decreased in width as concentration of PVP increased
- Thorns on nickel nanowires decreased in length as concentration of PVP increased

Fig. 11: PVP Concentration vs Width Graph
Fig. 12: PVP Concentration vs Length Graph

Film Dispersion



- 1.5 wt/vol% PVP consistently showed most even dispersion
- Followed by 2.0 %, 1.0%
- 0% and 0.5% PVP samples were poorly dispersed

Fig. 13: Dispersion of films with varried PVP concentrations

Conclusion

- Nickel nanowrires with tunable characteristics such as length, width, and surface texture by using varying amounts of PVP were synthesized.
- Eco-friendly water-based inks were created from nickel nanowires, however, these inks were not stable as they separated when still.
- 1.5 wt/vol% PVP samples consistently were the most conductive in both ink and film form as well as demonstrated most even dispersion in films.
- Films with poor dispersion were not conductive.
- More work into the effects of changing nanowire concentration and adding chelating agents is needed.

Future Work & Applications

- Stabilize inks for more even dispersion
- Test and create most conductive ink combinations
- Use GEEETech Printer to print inks
- Use printed films in printed electronics

Applications
- Printed Electronics:
  - Capacitators
  - Sensors
  - Resistors
- Circuit Boards
- Handheld Electronics
- Touch Screens
- Food Packaging

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