Synthesis and Properties of Gold Nanoparticle Solution and Nanoparticle Necklace Networks (N^3)

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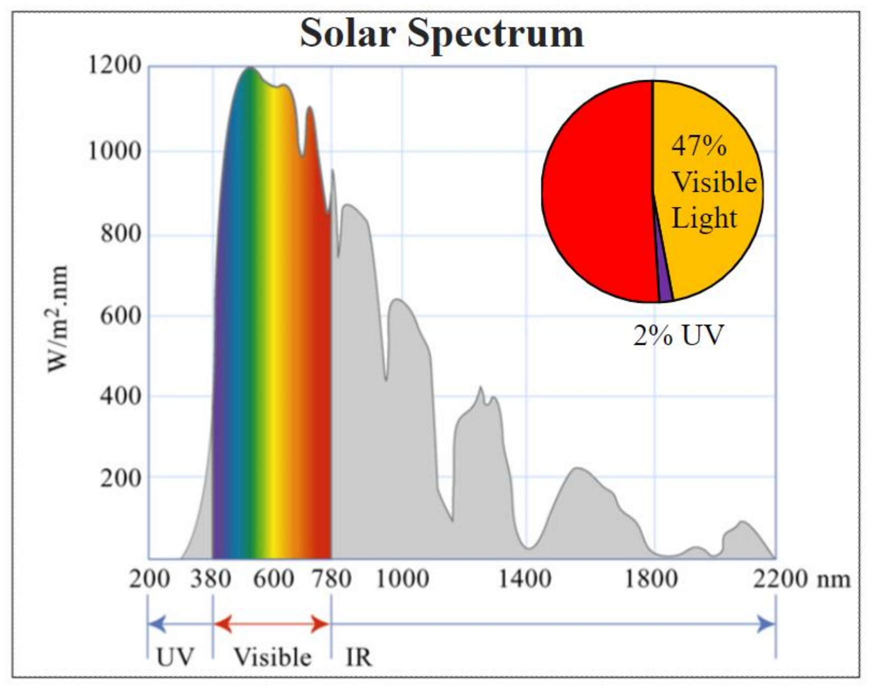
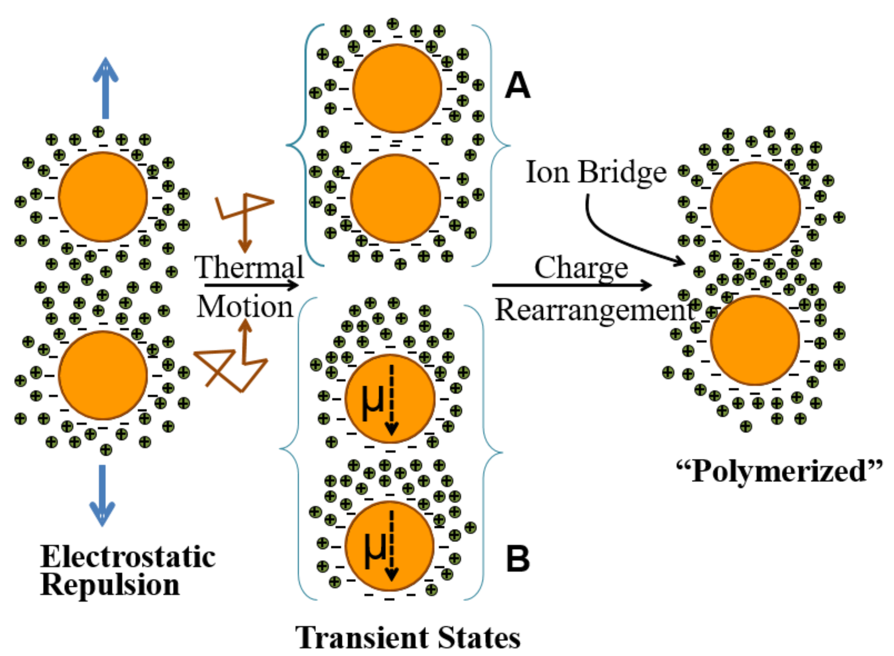
Background

- Climate change has spurred global research efforts toward improvements in renewable energy.
- Solar energy provides 3.9% of the United States' power but requires a large amount of land to operate, as the leading semiconductor materials absorb light only in the UV range.
- Gold nanoparticles harvest light throughout the visible spectrum, generating a free energy gradient by localized surface plasmon resonance (LSPR).
- LSPR absorption is increased further by assembling gold nanoparticle necklace networks (N^3).
- LSPR is shown to catalyze water splitting, allowing for integrated solar-fueled hydrogen energy.
- Hydrogen is unique in its versatility as a chemical energy carrier, with applications in fuel and manufacturing.

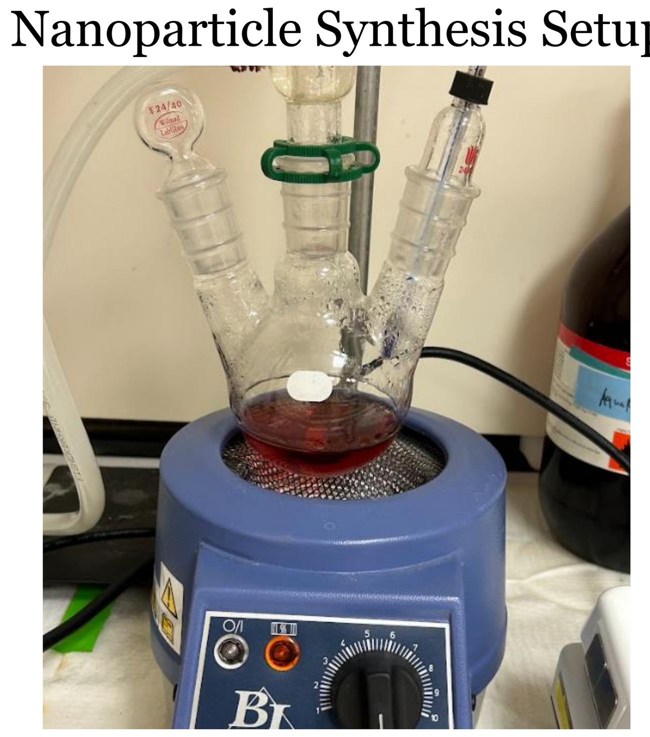




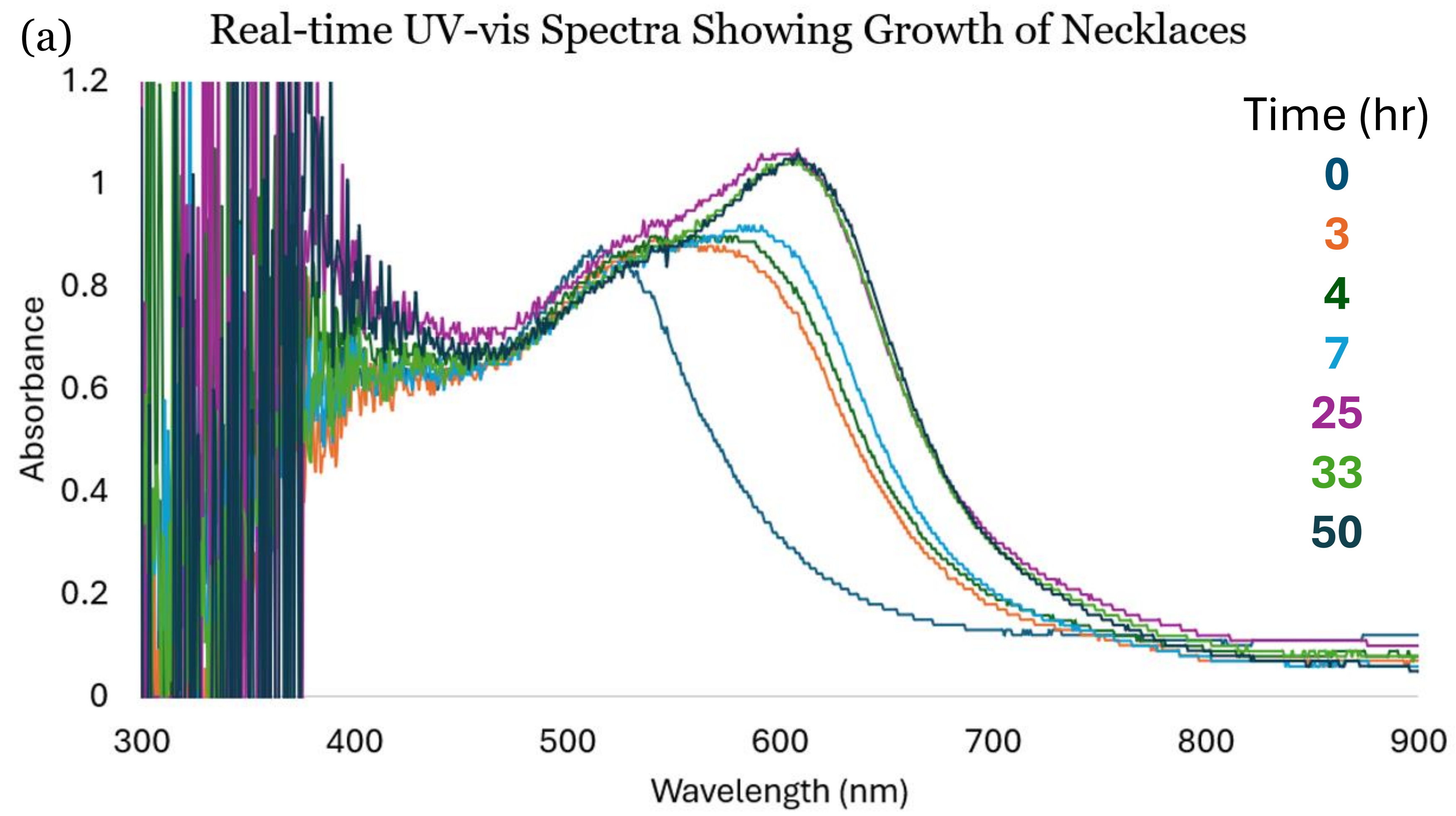
Highlights

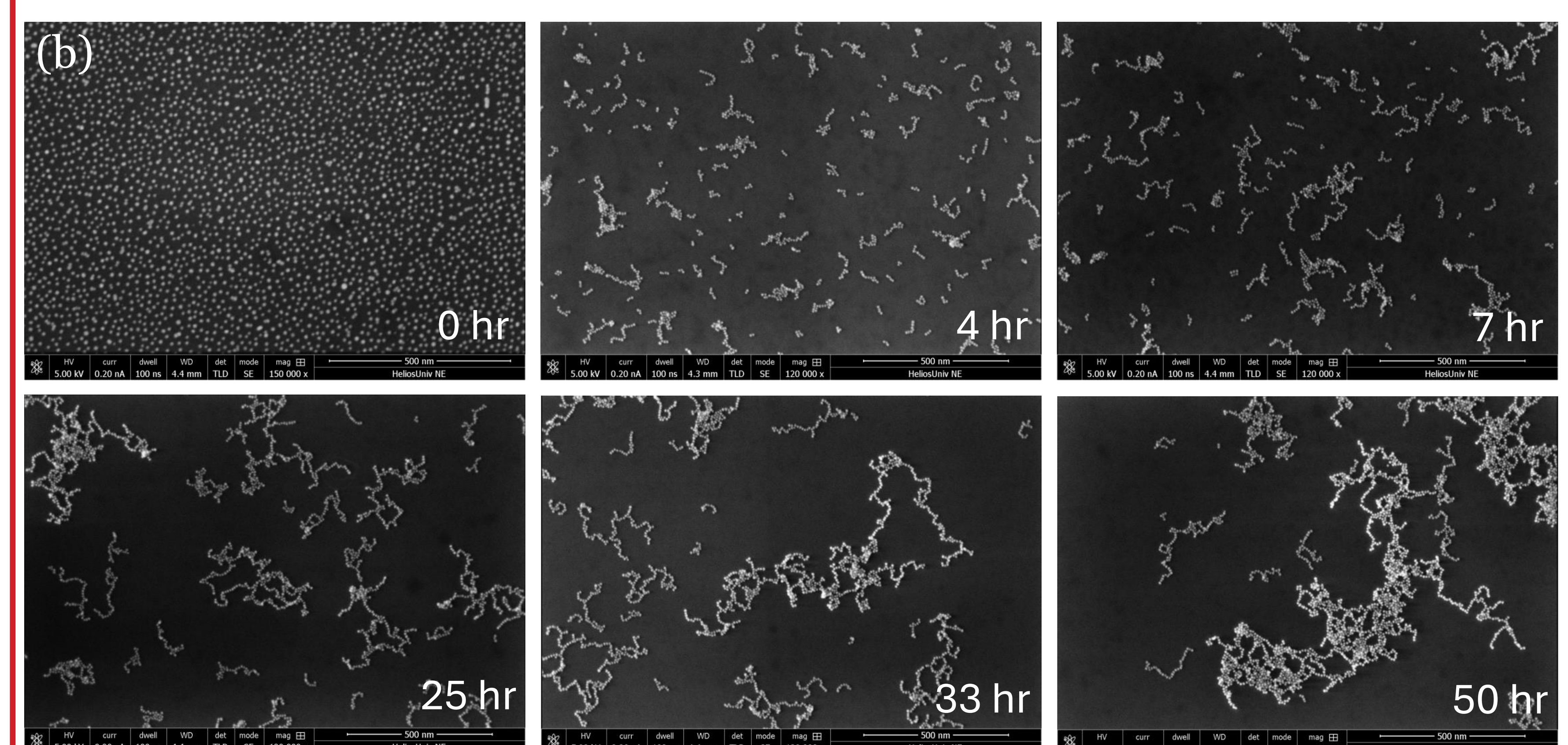
- N^3 can be used as a high-yield photovoltaic device and water electrolysis system.
- Nanoparticle size and monodispersity can be tailored with control over reagent concentration.
- Necklace formation can be monitored in real-time using UV-vis spectra.
- With more development, this technology promises to revolutionize solar and hydrogen energy production.

Nanoparticle Synthesis Setup



Necklace Growth

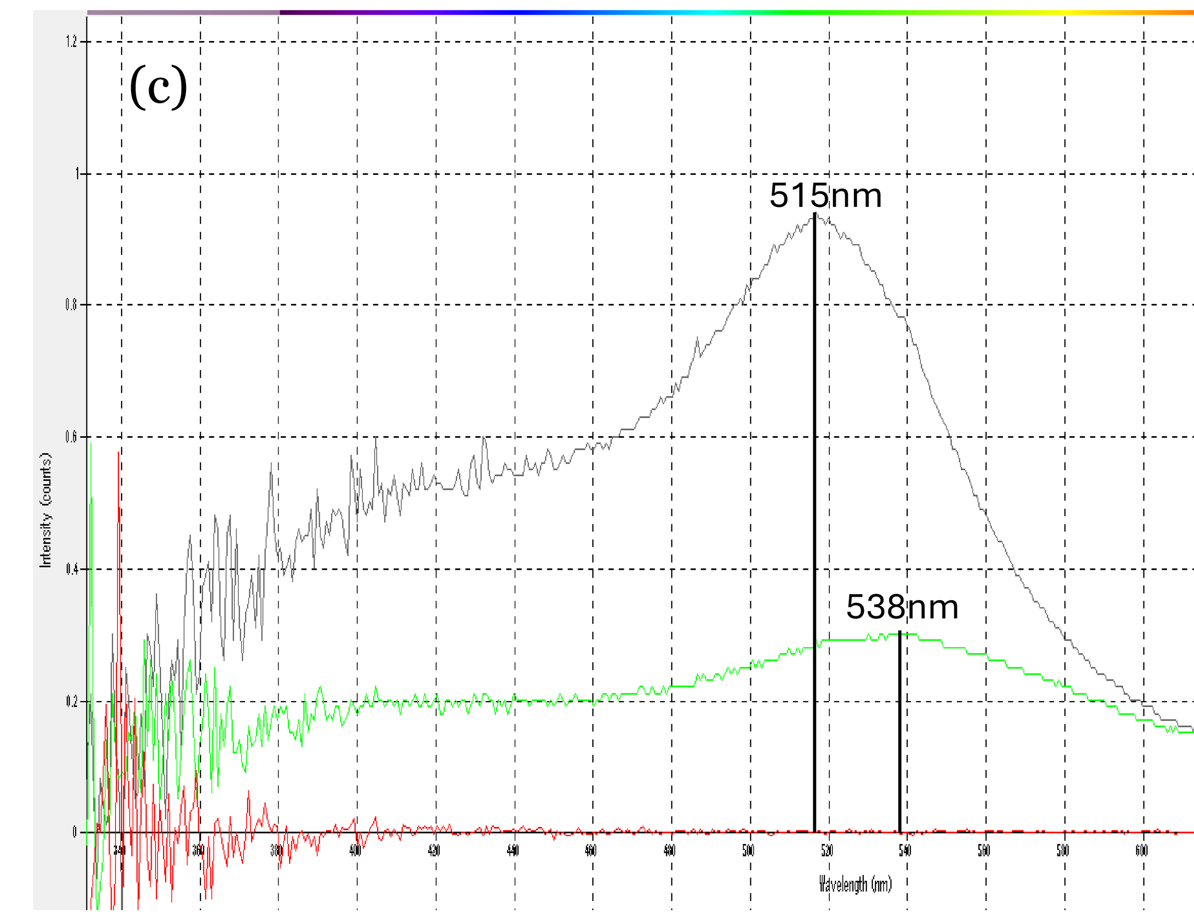


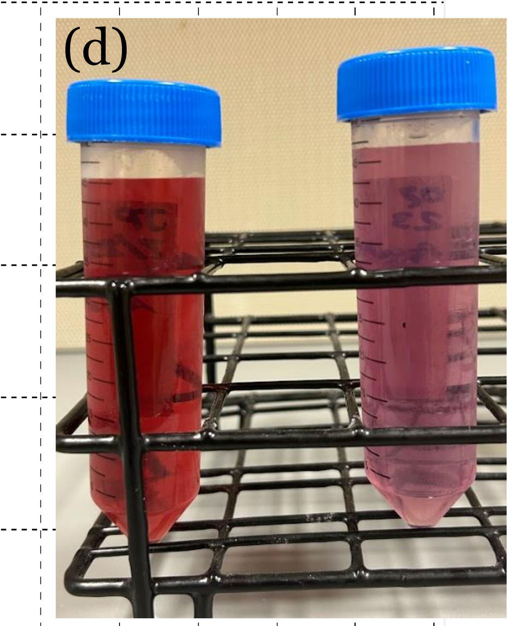


(a) UV-vis spectra showing the growth of N^3 at different time stamps. The original peak forms a "shoulder", which gives rise to a peak shift. (b) Scanning electron microscope (SEM) images of growing necklaces. Over time, islands of necklaces form, which enables their characteristic semiconductor properties.

- N^3 is made by combining gold nanoparticle solution with a volume of salt, 5mM $Zn(NO_3)_2$ in our case.
- Over time, nanoparticles form long chains, eventually reaching a desired coverage.
- Overdevelopment forms gold blankets that have ohmic resistance, not the desired non-ohmic resistance.

Nanoparticle Batch Control





(c) UV-vis spectra showing the absorbance of two batches of gold nanoparticles. The peak at 515nm was synthesized with a [SC]/[Au] of 10, with an estimated nanoparticle diameter of 15nm. The peak at 538nm was made with a [SC]/[Au] of 4, with an estimated diameter of >100nm.
(d) Photograph of both nanoparticle batches, with the 15nm batch on the left and the >100nm batch on the right.

- Sodium citrate (SC) concentration in relation to gold has an obvious impact on nanoparticle size.

Future Research

- Use SEM to measure nanoparticle diameter and monodispersity under a range of reaction conditions.
  - There is a lack of data on using tannic acid in conjunction with the reverse Turkevich method to grow gold nanoparticles.
- Interrogate how nanoparticle size and monodispersity impact necklace formation.

Acknowledgements

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