IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

SYNTHESIS OF TOXIC-FREE STAR SHAPED GOLD NANOSTRUCTURES USING MICROFLUIDICS AND ITS USAGE IN INTRACELLULAR DELIVERY

IITM Technology Available for Licensing

PROBLEM STATEMENT

- **Anisotropic gold nanoparticles**, with near-infrared tunability, are useful in cellular transfection and biomedical applications, **targeting cancer cells** and causing thermomechanical damage through laser radiation.
- **Gold nanoparticles** are created through **chemical reduction using reducing agents** like trisodium citrate, sodium borohydride, or acetic acid, **but controlling kinetics and producing nanostars** is challenging.
- **Microfluidics** technology offers **high** yields and low dispersion, **but** it requires large volumes of reagents and time.
- A **method to synthesize toxic-free star-shaped gold nanostructures is needed**, requiring **fewer reagents, reproducibility, cost-effectiveness, and time efficiency**.

TECHNOLOGY CATEGORY/ MARKET

Technology: Toxic-free star shaped gold nanostructures
Category: Micro & Nano Technologies
Industry: Bio-Micro/Nano, Biomedical Engineering
Application: Intracellular delivery using photoporation
Market: The global market size of **nanomaterials in personalized medicine** is expected to **increase from $346.7 billion in 2023 to $592.0 billion** by the end of **2028,** with a compound annual growth rate **(CAGR) of 11.3%** during the forecast period of **2023-2028.**

INTELLECTUAL PROPERTY

IITM IDF Ref. 2271, Patent No: IN 526929

TRL (Technology Readiness Level)

TRL-3, Experimental proof of concept ;

Research Lab

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TECHNOLOGY

A **method** to **synthesize toxic-free star shaped gold nanostructures** comprising steps of

1. **Preparing seed nanoparticles** by adding a reducing agent into a gold precursor;
2. **Diluting the seed solution** prepared in step (1);
3. **Adding the diluted seed solution** prepared in step (2) to a first inlet of droplet microfluidic device;
4. **Maintaining a low pH** throughout the synthesis by feeding a strong acid through a second inlet.
5. **Adding gold precursor** through a third inlet;
6. Simultaneously adding **ascorbic acid and silver nitrate in the next junction** through a fourth and fifth inlet, respectively;
7. **Adding silicone oil to the mixed** reagents solution and forming aqueous droplets in oil;
8. To **halt the growth process**, collecting the nanostar solution in PEG solution kept at ice-cold temperature; and
9. **Removing excess** oil and PEG by multiple centrifugations

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Microfluidic Device

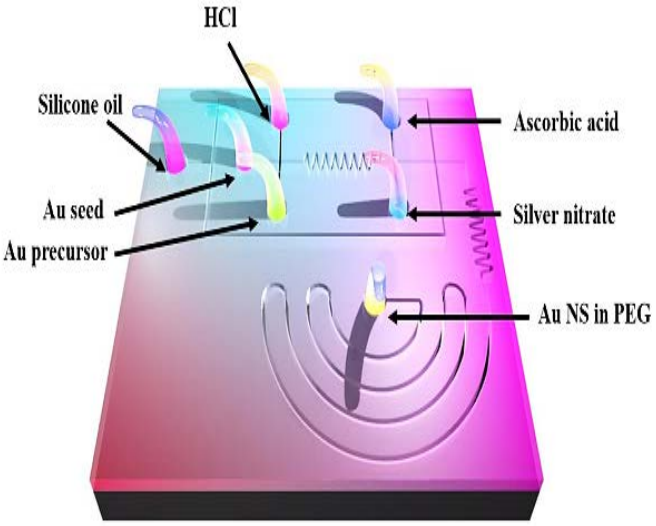

Figure 1 illustrates synthesis of toxic-free gold nanostars (Au NS) in PDMS-based droplet microfluidic device

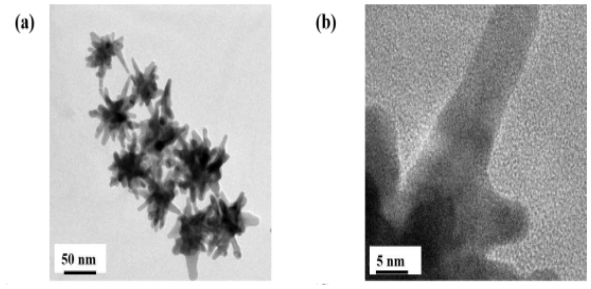

Figure 2 illustrates characterization of synthesized Au NS**: (a) and (b) are transmission electron microscopy (TEM) images and enlarged portion of a thorn of single NS**

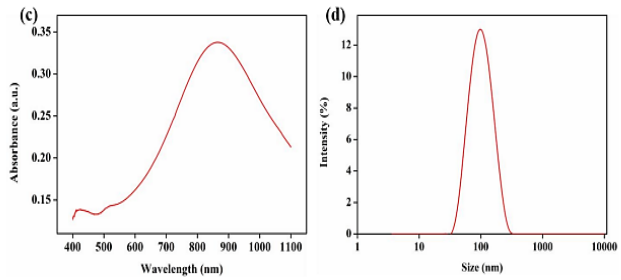

Figure 3 illustrates characterization of synthesized Au NS **(c) UV-Vis absorption spectrum and (d) DLS size distribution (lognormal) of NS.**

Key Features / Value Proposition

- **Application**
  - ✓ Effectively useful for **intracellular delivery**
- **Toxic Content**
  - ✓ Toxic-**free**
- **Shape**
  - ✓ **Star shaped** gold nanostructures and **crystalline nature**
- **Deliver mode**
  - ✓ Deliver biomolecules to the cells by **light activated technique** mediated by star shaped gold nanostructures
- **Synthesis**
  - ✓ **Droplet based** microfluidic device can be used to synthesize star shaped gold nanoparticles in a single step **without the use of any surfactant**
- **Gold precursor**
  - ✓ **Tetrachloroauric acid**
- **Strong acid** is **hydrochloric acid**
- **Thiolated polymer**
  - ✓ Poly(ethylene glycol) thiol
- **Reducing agent**
  - ✓ **Trisodium citrate** for **Au seed formation**
  - ✓ **Acetic acid** for **Nanostar formation**
- **Flow rates**
  - ✓ **150 to 900 µL/h** to achieve the **oil to aqueous phase** flow rate ratio as 1 to 6.
  - ✓ **At any point** of synthesis, parameters **can be tuned** by varying the flow rate of reagents and concentration ratio.
- **Time efficiency**
  - ✓ Au NS synthesis in microfluidic device takes **only few seconds & cost-effectiveness.**

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