Technology Transfer Office
TTO – IPM Cell

IIT MADRAS
Indian Institute of Technology Madras

Industrial Consultancy & Sponsored Research (IC&SR)

Method of Making Nanoparticles of Precise Isotopic Composition by Rapid Isotopic Exchange

IITM Technology Available for Licensing

Problem Statement

- Isotopic exchange in noble metal clusters is **not well understood**, unlike in molecules **like H2O and D2O.** Current methods cannot **effectively control isotopic exchange** in pure metal nanoparticles, restricting their applications.
- Understanding isotopic exchange in noble metal clusters is **crucial for grasping nanoscale material dynamics**, prompting further research and development.
- Hence, this invention is needed to address the **gaps** to understand & control **isotopic exchange** in metal nanoparticles, **unlocking their full potential** for applications in various industries.

Technology Category / Market

Categories: Chemistry & Chemical Analysis | Advance Material & Manufacturing

Industry: Nanoparticle Synthesis, Chemicals, Catalyst, Biomedical, Electronics, Energy

Applications: Catalysis, Biomedical imaging, Surface-enhanced Raman spectroscopy (SERS), Sensors, detectors, Electronics, Energy storage

Market: The global Nanoparticles market size was valued at **$ 2.9B in 2022**, it is expected to touch **$ 5.5B by 2032**, growing **at 6% CAGR** during forecasted period of **2022 to 2032**.

Technology

The instant invention discloses **a method for synthesizing isotopically pure ligand-protected metal nanoparticles of precise isotopic composition by rapid and spontaneous isotopic exchange. Refer FIG 1.**

Intellectual Property

IITM IDF No.: **1601** | IP No.: **355248 (Granted)**

TRL (Technology Readiness Level)

TRL- 3: Proof of Concept Stage.

Research Lab

Prof. Pradeep T; Department of Chemistry.

Method comprises

Mixing isotopically pure nanoparticles of the same metal in different molar ratios.

Controlling temperature within the range of -20°C to 60°C and concentration within the range of approximately 10^-5 mM to approximately 10^-1 mM.

Facilitating the exchange of metal atoms between isotopically pure metallic nanoparticles through collision-induced processes, driven by the entropy of mixing.

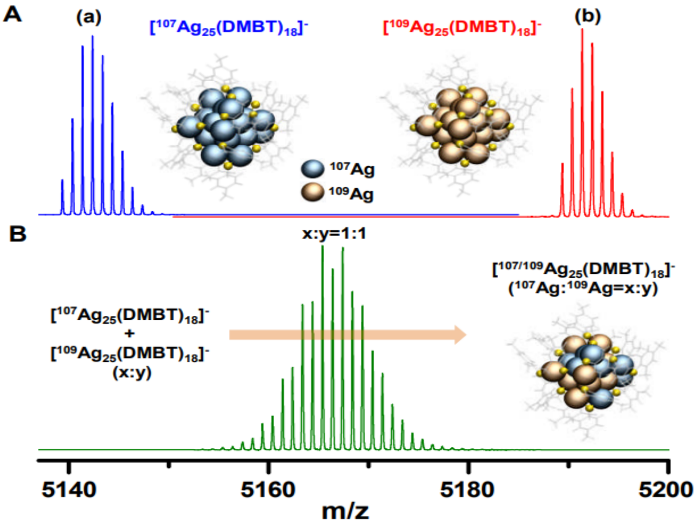

FIG 1 Mass spectra of the parent isotope clusters and the product of mixing.
(A) ESI MS of the as-synthesized isotopically pure clusters, (a) [107Ag25(DMBT)18] - and (b) [109Ag25(DMBT)18] - .
(B) Mass spectral distribution of the product obtained by mixing the two isotopic clusters at 1:1 molar ratio.
The spectrum was collected within 1 min after mixing the solutions of the clusters at 25 room temperature.

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Key Features / Value Proposition

User perspective:-

- Control isotopic composition precisely for tailored properties.
- Rapid exchange saves time and resources.
- Synthesize various compositions for needs.
- Mix nanoparticles for desired outcomes.

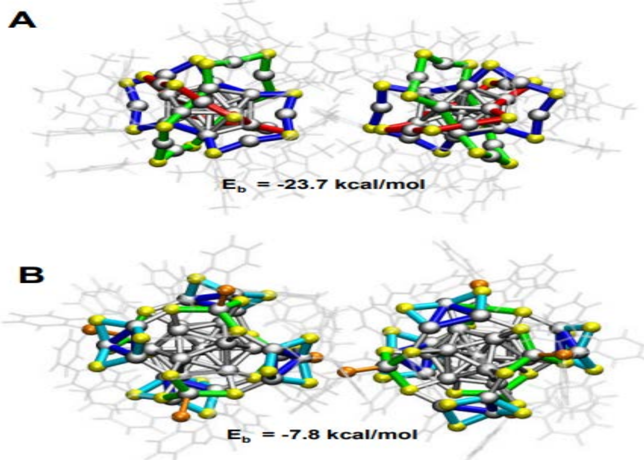
Industrial perspective:-

- Reduce manufacturing costs.
- Easily scale up for industrial use.
- Novel method for competitive edge.
- Ensure consistent high-quality output.

Technology perspective:-

- Cutting-edge exchange processes.
- Fine-tuned parameters for efficiency.
- Predict and optimize outcomes.
- Integrates multiple disciplines for innovation.

FIG 4 Molecular docking studies.
Force-field global minimum geometry (FFGMG) of two (A) [Ag25(DMBT)18] - and (B) [Ag29(BDT)12(TPP)4] 3- clusters, lying in close-proximity. Color codes: grey: Ag, yellow: S, orange: P, the overlapping Borromean rings are shown in blue, green and red in (A), staple units are shown in green and blue in (B), and ligand shell is shown in transparent grey.
Atomic diameters have been reduced to show the bonding clearly.



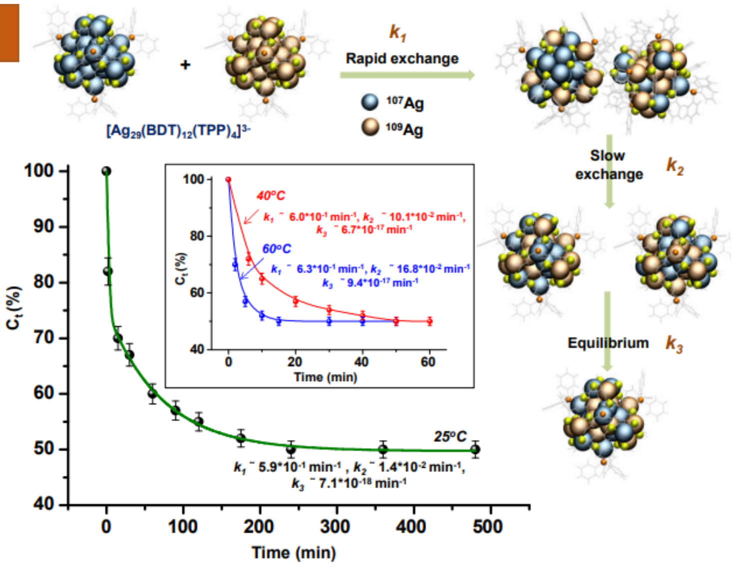


FIG 3 Kinetic study of isotopic exchange in [Ag29(BDT)12(TPP)4] 3- clusters. Plot of percentage of un-exchanged parent isotopic cluster (Ct) vs time (min) at room temperature (25o C). Kinetics at 40o C and 60o C are presented in the inset. Average of three kinetic measurements is plotted and the error bar is indicated at each point. A schematic showing the 7 different stages of isotopic exchange is also shown in the figure. Color codes: yellow: S, orange: P, transparent grey: ligands.

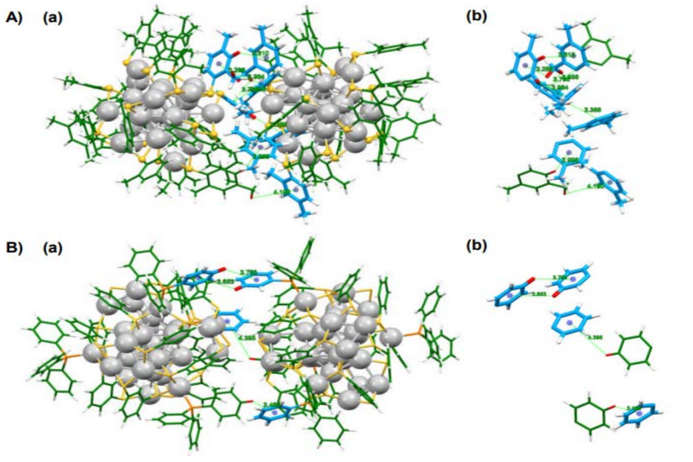


FIG. 5 Molecular docking studies. Lowest energy geometry obtained from docking two A) Ag25(DMBT)18 and B) Ag29(BDT)12(TPP)4 clusters. C-H…π interactions are indicated in the figure. Color codes: grey: Ag, yellow: S, orange: P, green: ligands. The H atoms involved in these interactions are shown in red and the benzene rings involved are shown in blue.
Expanded view of the ligands involved in these C-H…π interactions are shown in the insets b.

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