IIT MADRAS
Indian Institute of Technology Madras
Technology Transfer Office
TTO - IPM Cell
Industrial Consultancy & Sponsored Research (IC&SR)

Methods for Selective Visual Detection of TNT

IITM Technology Available for Licensing

Problem Statement

- **Traditional methods for detecting trinitrotoluene (TNT)** may have challenges in **spotting tiny amounts** of **explosives** or mistakenly flag other substances as explosives. False alarms can cause **needless chaos and evacuations**.
- Some current detection approaches could be **sluggish and time taking**. They could also rely on **intricate** and **expensive gear** - not **great** for **widespread use**.
- Regular security methods could be easily **bypassed by terrorists** using TNT-based explosives. Also, after explosive incidents, **effective cleaning is very important.**
- Some **TNT detection methods** might not work in many places. **Bulky & stationary TNT detection methods** are often not practical.
- These issues were taken into consideration previously but no proper method was identified. **The present patent discloses a noble method for selective visual detection of TNT**, addressing above mentioned issues.

Technology Category/ Market

Categories: Chemistry & Chemical Analysis, Micro & Nano Technology

Industry: Mining & Demolition, Environmental Monitoring, Chemical, Oil & Gas, Firearms & Ammunition Manufacturing, Defense, Military, Law Enforcement & Security, Transportation.

Applications: Catalysis, Bioimaging, Chemical Safety Processes, Security & Defense, Forensic Investigations, Customs & Border Control, Counterterrorism, Homeland Security & Public Safety, Environment Remediation.

Market: The global explosive detector market size was valued at **$5.97 B** in **2019** and is expected to reach **$11.10 B** by **2027**, growing at a **CAGR** of **8.2%** from **2020** to **2027.**

TRL (Technology Readiness Level)

TRL - 4, Experimentally validated in lab.

Research Lab

Prof. Pradeep T
Department of Chemistry

Intellectual Property

IITM IDF No: 880; IP Grant No: 442508

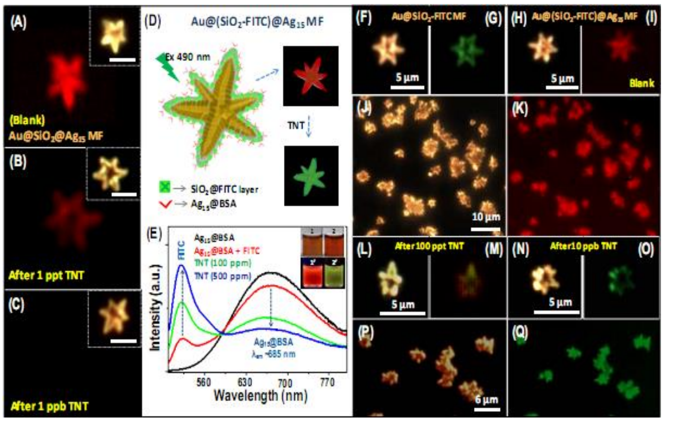

FIG 1 (A-Q) shows pictures of tiny particles (Au@SiO$_2$@Ag15 meso-flowers (MFs) taken using different light. It illustrates sensor & TNT detection. It shows the appearance of the sensing particle before & after TNT exposure. The emission spectra of a cluster/s mixed with a dye and exposed to TNT are included. Other particles (Au@(SiO$_2$-FITC) MFs), before & after modifications, after TNT exposure along with larger area images of before & after TNT exposure are presented.

Key Features / Value Proposition

- Offers **higher sensitivity and selectivity** in **detecting TNT**, reducing false alarms.
- The instant patent introduces **rapid TNT detection techniques**, allowing **real-time** or **near-real-time monitoring** of TNT presence.
- Offers **simplified, easier to deploy** and more **cost-effective detection** approaches.
- **Monitoring & preventing contamination,** that contributes in **environmental protection**.
- Enhances **workplace safety** by enabling **better detection and management of potential explosive hazards.**
- It strengthens **security measures** by making it more difficult in detecting TNT residues.
- **Versatile Detection Approaches** for **compact and portable TNT detection tools.**
- It reduces **false positives**, ensuring alarms are **triggered** when **TNT is generally present**.
- The instant patent method could aid in meeting **legal regulatory requirements effectively.**
- Assists in **cleanup operations** by accurate detection of **remaining TNT residues**.

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719

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Technology

The instant patent discloses **a method for selective identification (visual detection) of 2,4,6-trinitro-toluene (TNT), comprises:**

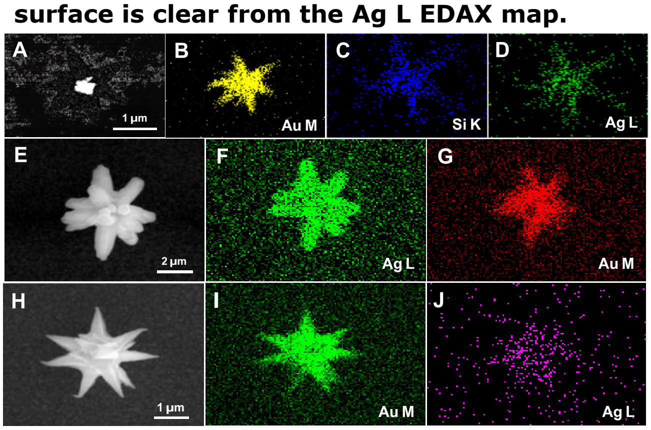
2 mg of Au MFs dispersed in 10 mL isopropanol, 1.5 mL ammonia solution, & 120 µL tetraethyl olihosilicate (TEOS) was added under rapid stirring for 1h to form Au@SiO_2.

The fluorescein isothiocyanate (FITC) added prior to addition of TEOS with Au@SiO_2 MFs results in the formation of Au@SiO_2-FITC MF.

1 mL of a fifteen atom anchored silver clusters (Ag15), embedded in bovine serum albumin (BSA) added with 2 mg of silica-coated Au MF dispersed in 1 mL distilled water, 0.5 mL 3-amino-propyl-trimethoxysilane (APTMS) & incubated for 30min resulting in Au@SiO_2-FITC @Ag15 MFs formation.

varying concentrations of TNT is exposed to Au@(SiO_2-FITC)@Ag15 MFs.

Figure 2 shows images **(SEM & EDAX)** of **different hybrid MFs loaded with clusters**: (A-D) Au@SiO_2@Ag15 MF, (E-G) Au/Ag@Ag15 MF, and (H-J) Au@Ag15MF.
The presence of cluster coatings on the MF surface is clear from the Ag L EDAX map.

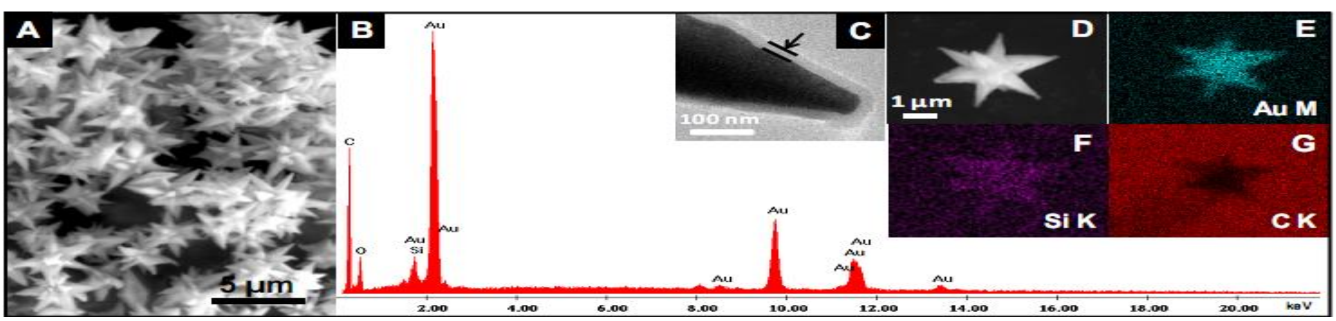


Characterized in that, exposure of TNT to **Au@(SiO_2-FITC)@Ag15 MFs** decreases its luminescence intensity significantly while optical image remains unaffected, wherein green emission of **FITC** from the particle as the red luminescence from the cluster was quenched completely was observed under **visible & UV light**. Wherein:

- The **quenching of cluster luminescence** is due to the formation of a **Meisenheimer complex** by the chemical interaction between **TNT & free amino groups in BSA.**
- **15 atom silver cluster** protected with **BSA** is red luminescent water soluble quantum cluster (QC); wherein silver clusters exhibits **high quantum yield (10.7%) in water,** it is stable in a **wide pH range & exhibits emission in solid state.**
- **Au@(SiO_2-FITC)@Ag15 MFs** after further functionalization with Ag QCs, shows **red & green emission of FITC is suppressed**.
- Colour of the solution **turns dark red** & the **formation of complex** was confirmed by emergence of features at **340, 450 and 525 nm** in **UV absorption spectra**.
- Specificity of **Meisenheimer complexation** makes cluster selective to TNT and closely similar molecules **do not quench its luminescence**.
- **Disappearance of the luminescence of Ag15** on MF and simultaneous appearance of luminescence of another embedded fluorophore can be used for **easy identification of analyte**.

Figure 3 shows:

- **SEM image of large area and EDAX spectrum of Au@SiO_2 MFs.**
- **Magnified TEM image of MF tip showing uniform silica coating (arrow).**
- **SEM and EDAX images of a single MF, displaying Au and Si presence.**
- **Carbon is from the measurement substrate.**



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https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719