Preparation of Crystalline Gold Nanoparticles and their Prospects in Enhancement of Solar Energy Conversion Efficiency

By

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Nanotechnology in Industry

**Life Sciences**
- Medical/molecular imaging
- Targeted drug/therapeutic delivery
- Medical implants
- Tissue regeneration

**Energy**
- Solar cells
- Fuel cells
- Batteries
- Fuel borne catalysts

**Techmedia**
- Displays utilising carbon nanotubes
- Intelligent textiles
- Quantum cryptography
- Nanotransistors

**Automotive industry**
- Composite materials
- Nanostructured glasses
- Sensors

**Textiles**
- Sensors and monitoring, smart fabrics,
- Medical applications

**Building industry**
- Nanocomposite plastics with nanoclays

**Food industry**
- Nanocomposites for gas barriers

**Cosmetics**
- TiO₂ nanoparticles for UV filters
How small is a nanometer? (and other small sizes)

Start with a centimeter. A centimeter is about the size of a bean.

Now divide it into 10 equal parts. Each part is a millimeter long. About the size of a flea.

Now divide that into 10 equal parts. Each part is 100 micrometers long. About the size (width) of a human hair.

Now divide that into 100 equal parts. Each part is a micrometer long. About the size of a bacterium.

Now divide that into 10 equal parts. Each part is a 100 nanometers long. About the size of a virus.

Finally divide that into 100 equal parts. Each part is a nanometer. About the size of a few atoms or a small molecule.
History of gold nanoparticles (GNPs)

GNPs in glass
25 nm — red reflected
50 nm — green reflected
100 nm — orange reflected
The Lycurgus Cup

The Lycurgus Cup made by the Romans dates to the fourth century AD. One of the very unusual features of the Cup is its colour.

When viewed in reflected light, (in daylight) it appears green.

When a light is shone into the cup and transmitted through the glass, it appears red.
**Bulk Gold Vs Nanogold**

**Bulk Gold**
- Is shiny
- Always gold in colour
- Is inert
- Conducts electricity

**Nanogold**
- Vary in appearance depending on size and shape of cluster
- Are *never* gold in colour
- Are found in a range of colours
- Are very good catalysts
- Are not “metals” but are semiconductors.
Nanotechnology

Size

Bulk Gold = Yellow
Nanogold = Red

Numbers

Surface Area (S/V)
Reflection Of Light

Bulk Au

Nano Au

All light is reflected in the same direction

Light is reflected in the different directions (scattered)
Size & Shape Determines Colour of GNPs
Confirmation of the formation gold nanoparticles (GNPs) by UV-vis absorption spectroscopy
X-ray diffraction (XRD) spectra of gold nanoparticles (GNPs).
Size distribution of colloidal GNPs.
TEM of GNPs confirms their spherical shape
Prospects of gold nanoparticles in Solar Energy Conversion
• Fluorescent Solar Concentrator (FSC) was proposed. It was consisting of a transparent sheet doped with appropriate fluorescent species.

• Sunlight absorbed by the dye is then emitted isotropically and trapped in the sheet by total internal reflection.

• Trapped light is converted at the edge of the sheet by a solar cell with band-gap just less than the luminescent energy.
Effect of GNPs concentration on the fluorescence spectra of (PMMA/ 100 ppm MACROLEX Fluorescent Red G) film.
Metal Enhanced Fluorescence (MEF)

![Graph showing Fluorescence Intensity vs. Wavelength](image)

- Tuned monomer fluorescence
- Monomer fluorescence
- Excimer Fluorescence
Enhanced Photostability of Fluorescent Solar Concentrators by GNPs
The tuned monomer fluorescence spectra of (PMMA/ 20 ppm GNPs/100 ppm MACROLEX Fluorescent Red G) nanocomposite film, compared to the spectral response of silicon solar cells: amorphous (a-Si); multicrystalline (mc-Si); crystalline (c-Si).
Enhanced Conversion Efficiency of Fluorescent Solar Concentrators by GNPs
Conclusions

• This paper reports on the enhancement of excimer fluorescence of a coumarin derivative molecules (MACROLEX Fluorescent Red G), by using GNPs in PMMA.

• We explained the fluorescence enhancement factor on the basis of localized surface plasmon resonance (LSPR) spectra of gold nanoparticles.

• PMMA/GNPs nanocomposite has a superior advantage that it can be overloaded with high laser dye concentrations, without the formation of dye dimers which was a great problem due to their weak fluorescence.

• Incorporating GNPs is PMMA/dye matrix, increases the photostability of dye, since the calculated value of dye photodegradation rate is doubled after adding GNPs to PMMA matrix.

• Our results is have incredible impact in enhancing solar energy conversion by commercial photovoltaic cells. This can be achieved by using the the optimized PMMA/GNPs nanocomposite as a fluorescent solar concentrator (FSC) and fluorescent down-shifter (FDS).
Work in Progress
Synthesis of gold nanorods for medical and Energy Applications
AFM of Spherical Nanogold Thin Films
Thanks