

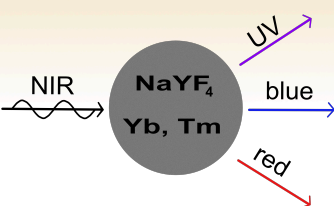
Synthesis and Characterization of Upconverting Nanoparticles in Suspensions and Chitosan-Matrix Thin Films

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Introduction



Anti-Stokes effect:

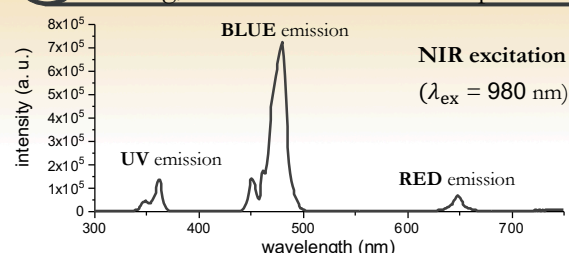
After the absorption of multiple photons, a photon of higher energy is emitted.

Potential applications:

- Photodynamic therapy
- Photocatalytic reactions
- Solar cells

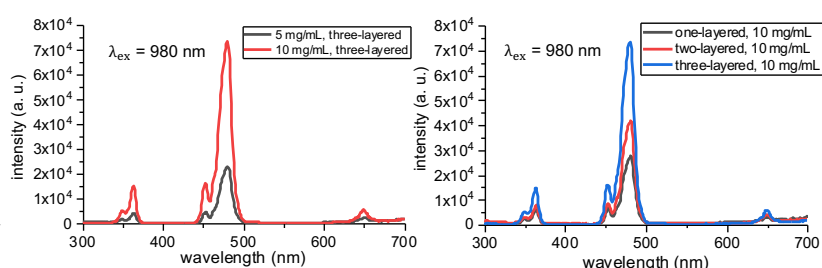
Results

1 Anti-Stokes emission spectrum of 1 mg/mL ethanolic UCNPs-suspension



2 Emission spectrum of chitosan-matrix composite UCNPs-coatings

↑ amount of UCNPs ⇒ ↑ emission intensity ⇐ ↑ layer thickness



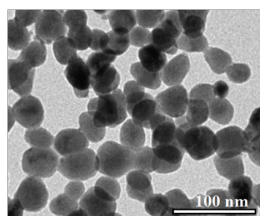
1 Synthesis and characterization of $\text{NaYF}_4 : \text{Yb}^{3+}, \text{Tm}^{3+}$ UCNPs.

2 Preparation of **composite coatings** in which UCNPs retain their **high upconversion emission intensities**.

3 Studying **energy transfer processes between UCNPs and fluorescent Rhodamine-6G dye molecules** under NIR radiation.

Synthesis of UCNPs

$\alpha\text{-NaYF}_4 : 20\% \text{Yb}^{3+}, 0.5\% \text{Tm}^{3+}$



TEM image

Solvothermal method:

ethylene glycol solvent

$\text{NaF}, \text{LnCl}_3 \cdot 6 \text{H}_2\text{O}$ ($\text{Ln} = \text{Y}, \text{Yb}, \text{Tm}$)

PVP ($M = 40\,000 \text{ g/mol}$)

1 mg/mL ethanolic suspensions

were made after several washing steps.

Average size: $34 \pm 7 \text{ nm}$

Activator ion	UC emission	Tm^{3+}
Sensitizing ion	Energy transfer	Yb^{3+}
Host lattice	Low phonon energy	NaYF_4

Preparation of coatings

Chitosan-matrix
UCNP-containing film

mesoporous titania

compact silica

glass substrate

Spin-coating method

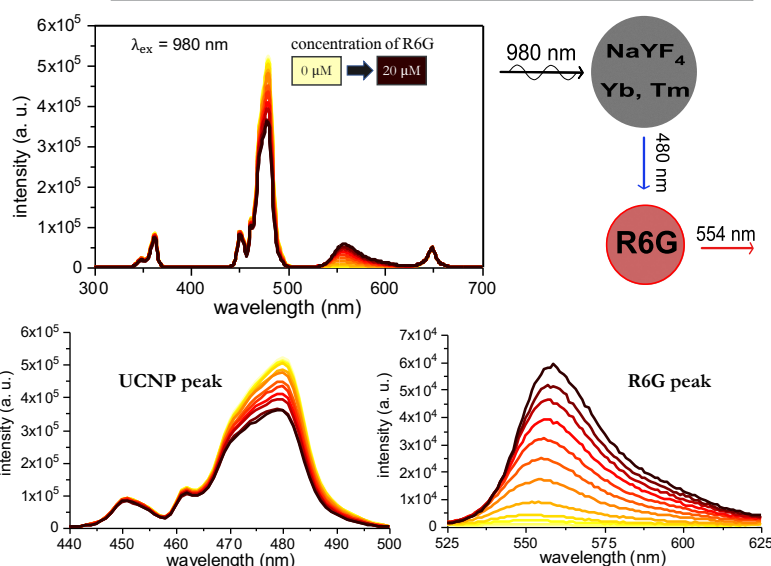
(50 μL droplet, 7000 rpm, 60 s)

Dip-coating method

($d = 154 \pm 5 \text{ nm}$, $\varepsilon = 52 \pm 1 \%$)

Dip-coating method ($d = 202 \pm 5 \text{ nm}$)

3 Energy transfer between UCNPs and R6G in aqueous suspension under NIR excitation



Conclusions

- Colloidal particles with **intensive anti-Stokes emissions** were synthesised.
- Using UCNPs containing **chitosan-matrix thin films**, high emission intensities were obtained under NIR excitation.
- **Förster resonant energy transfer (FRET)** was observed between UCNPs and R6G fluorescent dye molecules.
- **Future aims** include studying energy transfer processes in UCNPs/semiconductor oxide photocatalytic systems.