Synthesis strategy and application of Rare earth doped upconverting Nanoparticles in Bio-Imaging

Nidhi Malviya[1], Vinita Rajput Chouhan[1], Prachi Tadge Dhote, Sudeshna Ray[2]

[1]Research Scholar, AISECT University, Bhopal, M.P. , India

[2]Assistant Professor, AISECT University, Bhopal, M.P. , India

ABSTRACT: Upconversion luminescence, a nonlinear process, which re-emits a photon at a shorter wavelength by the absorption of more than one photon, successively at longer wavelengths via long-lived intermediate energy states, is useful for important applications in various fields like fluorescence bio-imaging and lasers. This NIR up-conversion nanoparticle provides high penetration depth into biological tissue and results in high contrast optical imaging due to absence of an auto fluorescence background and decreased light scattering. Excitation at long wavelengths also minimizes damage to biological tissues. Herein, we report, the different mechanisms for the Upconversion process of rare-earth (Er3+, Ho3+, Tm3+) doped nanoparticle and different methods are used to synthesize and decorate up converting nanoparticle.

Keywords: - Upconversion, Nanoparticles, chemical, etc.

INTRODUCTION

Upconversion is a optical process .Upconversion is a process in which two low energy photon added up to gives one higher energy photon .In since 1960 s studied started and widely applied in optical devices and further studied Over the past decade, Upconversion Nanoparticles have been synthesized for different method used with the rapid development of nanotechnology and are becoming more important in biological sciences. The main difference between the Upconversion Nanoparticles emits into NIR to Visible and other Nanomaterials emit UV to visible radiation. Lanthanide-doped Upconversion nanocrystals (UCNPs), which emit high energy photons by the near-infrared (NIR) light and emission are shown visible light. These nanoparticles have been found potential applications in many fields, including biomedicine and are found improved tissue penetration and higher photochemical stability as compared with traditional down-conversion fluorescence imaging and Quantum dot. The unique Upconversion process of upconverting nanoparticles may be used to activate photosensitive therapeutic agents for applications in Photodynamic therapy. Upconversion luminescence imaging in vivo is expected to be the next generation photoluminescence imaging technique since it provides high sensitivity and spatial resolution. Due to some special properties such as their multicolour emission, high brightness and long lifetime, lanthanide ions based luminescent Nanomaterials have tremendous promise as indicators and photon sources for numerous application such as boilable, light-emitting devices, sensor technology, and low-threshold lasers. So it is very important to successfully prepare the rare-earth doped

inorganic nanocrystals with good dispensability in organic solvents and also prepare water soluble upconversion nanoparticle.

In the Up conversion phenomenon has been study on transition metals, actinides, and rare earth metal, but mainly in the rare earth elements, which contain the lanthanide (Ln) series. Ln^{3+} ions have special $4f^n$ inner shell configurations that are well – shielded by outer shell and have rich unique energy level structures. The Ln^{3+} ions can exhibit sharp luminescence emission via intra-4f or 4f-5d transitions. The significance of luminescence material as narrow bandwidth, long-time emission, and anti-stokes emission. They have been widely applied in lasers, solar cell, analytical sensors, optical imaging, and photodynamic therapy.

Most of the fluorescent materials are generally excited by ultraviolet (UV) or visible light, which may induce auto fluorescence and photo damage to biological samples, resulting in low signal-to-noise ratio and limited sensitivity. This drawback prompted the development of a new type of high-quality water soluble with high emission intensity and narrow size with controlled shaped these nanomaterials known as up conversion Nanomaterials (UCNs) [1-7]. Lanthanide-doped Upconversion (UC) nanophosphor are promising optical Contrast agents for biomedical applications due to their photo stability, sharp emission peaks, and long emission lifetime [8, 9]. For bioimaging, the use of NIR excitation minimizes absorbance, strong scattering, and colour fading of phosphor, from cells and tissues [13]. In different other fluorescence material, such as organic dyes and quantum dots, must be imaged against a background of Stokes-shifted tissue auto fluorescence induced by UV, excitation radiation [14]. Due to some limitations so used Upconversion mechanism in biological application.

Bio-imaging it has been covers the complex chain of acquiring, processing and visualizing structural or functional images of living mammals including image-related information for example organs, tissues. The upconversion nanoparticles used in bioimaging such as high penetration depth , easily coupled with proteins or other biological sample and used from bio-detection to Cancer therapy ,viruses and bacteria, tumor cells, corneal imaging and drug tracking. For bioimaging the Anti-Stokes luminescence it is advantages over traditional down conversion emission observed with organic fluorphores. Because their low background fluorescence and high signal-to-noise ratio. Upconversion nanoparticle Fluorescence targeted bio-imaging in vivo has proven very useful in tumour recognition and drug delivery.

MOTIVATION OF MY WORK

Lanthanide-doped Upconversion-luminescent nanoparticles (UCNPs), have been very useful for *in vitro* and *in vivo* imaging studies in tumour recognition and drug delivery.

The NIR light excited by UCNPs such as high photo stability, low cytotoxicity, low auto-fluorescence, high penetration depth, less harmful to small animals

making them attractive as biomedical imaging applications. In this review, we will mainly focus on the latest development of a new type of water soluble lanthanide-doped UCNP material .The applications for *in vitro* and *in vivo* molecular and cellular imaging. This paper we discuss the challenges and future perspectives for lanthanide doped Upconversion nanoparticles.

New materials with high Biocompatibility and more intense emission spectra are needed to be developed so for deep tissue imaging, also synthesis of water soluble UCNP, with functionalized surface by Ligand Engineering, with high emission intensity. Synthesis of UCNP of narrow-size distribution with controlled shape.

CONCLUSION

The past decade a large number of scientists have investigated the potential application of UCNPs in bioimaging. A variety of Upconversion nanophosphor has been developed for bioimaging, and most of them are based on rare earth doped $NaYF_4$. Other kinds of RE doped nanoparticles, such as $NaGdF_4$, $NaLaF_4$, Y_2O_3, GdF_3, CeO_2, $LiNaF_4$, $Ca_3(PO_4)_2$, ZrO_2 and GdOF etc. have also been considered as excellent UCNPs in recent years due to their strong Upconversion luminescence intensity and good photo stability**.** But due to some limitation and drawbacks development of new upconversion nanoparticle is more important in application of bioimaging.

REFERENCE

1. F. Auzel, Chem. Rev. 2004, 104, 139;
2. F. Wang, X Liu, Chem. Soc. Rev. 2009, 38, 976;
3. D. K. Chatterjee, M. K. Gnanasammandhan, Y. Zhang, Small 2010, 6, 278
4. M. Haase, H. Schafer, Angew. Chem. Int. Ed. 2011, 50, 5808.
5. D. K. Chatterjee, A. J. Rufaihah, Y. Zhang, Biomaterials 2008, 29, 937
6. J. Zhou, Y. Sun, X. Du, L. Xiong, H. Hu, F. Li, Biomaterials 2010, 31, 3287;
7. L. Xiong, T. Yang, Y. Yang, C. Xu, F. Li, Biomaterials 2010, 31, 7078.
8. Wu SW, Han G, Milliron DJ, Aloni 8 S, Altoe V, Talapin DV, et al. Proceedings of the National Academy of Sciences of the United States of America. 2009; 106: 10917-21. doi:DOI 10.1073/pnas.0904792106.
9. Mai H-X, Zhang Y-W, Si R, Yan Z-G, Sun L-d, You L-P, et al. J Am Chem Soc. 2006; 128: 6426. doi:10.1021/ja060212h.
10. Boyer J-C, Cuccia LA, Capobianco JA. Nano Letters. 2007; 7: 847-52. doi:10.1021/nl070235
11. Heer S, Kömpe K, Güdel HU, Haase M..Advanced Materials. 2004; 16: 2102-5. doi:10.1002/adma.200400772.
12. Chen GY, Ohulchanskyy TY, Kumar R, Agren H, Prasad PN. ACS Nano. 2010; 4: 3163-8. doi:Doi 10.1021/Nn100457j.
13. Nyk M, Kumar R, Ohulchanskyy TY, Bergey EJ, Prasad PN. Nano Letters. 2008; 8: 3834-8. doi:10.1021/nl802223f.
14. Wang M, Mi CC, Wang WX, Liu CH, Wu YF, Xu ZR, et al.. ACS Nano. 2009; 3: 1580-6. doi:Doi 10.1021/Nn900491j.