# $YVO_4:Eu^{3+}$ Nanoparticles for Drug Delivery Applications

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*keywords: sol-gel, functionalization, Cisplatin, $YVO_4$: $Eu^{3+}$, 3-chloropropyltrimethoxysilane.*

## Introduction

Skin cancer due to exposure to excess sun ultraviolet rays is very common in Brazil. This condition accounts for about 25% of diagnosed malignant tumors. Nowadays, researchers have focused on strategies that can cure cancer patients. *cis*-Diamminedichloroplatinum (II) (Cisplatin, Cisp) is one of the main compounds used in anticancer chemotherapy. It is estimated that 50-70% of the patients with cancer use this drug worldwide. However, Cisp has countless side effects and may adversely affect the patients' kidneys, stomach, auditory system, and even the central nervous system. To minimize such undesirable effects and boost the efficacy of cancer treatment, researchers have turned to drug delivery systems. Such systems must reach the tumor cells, penetrate the cell and nuclear membranes, and then release the drug that will interact with the DNA of the tumor cell, to prevent their replication. The present work has dealt with the synthesis of europium(III)-doped yttrium vanadate nanoparticles measuring between 30 and 50 nm by the sol-gel methodology. The nanoparticles were functionalized with 3-chloropropyltrimethoxysilane and with the chemotherapeutic agent Cisp. In vitro e in vivo biological assays helped to evaluate the antitumoral action of the prepared compounds.

## Results and Discussion

The powder X-ray diffraction (XRD) patterns of the samples revealed defined peaks ascribed to the tetragonal structure of the $YVO_4$ phase (JCPDS file nº 17-341). Functionalization did not affect the $YVO_4$ structure. The thermogravimetric curve showed total mass loss of 33%, attributed to the organic part of the alkoxide agent and cisplatin. These results confirmed matrix functionalization with CPTES and cisplatin. The broad excitation band located at 324, 327, and 318 nm for the samples $YVO_4:Eu^{3+}$, $YVO_4:Eu^{3+}$:CPTES, and $YVO_4:Eu^{3+}$:CPTES:Cisp, respectively, referred to the $O^{2-}V^{5+}$ charge transfer (LMCT). The emission spectra of the samples presented the characteristic bands of the transition from the excited state $^5D_0$ to the fundamental state $^7F_J$ (J = 0, 1, 2, 3, and 4). The excitation and emission spectra of the $Eu^{3+}$ ion in $YVO_4:Eu^{3+}$, $YVO_4:Eu^{3+}$:CPTES, and $YVO_4:Eu^{3+}$:CPTES:Cisp did not change, so functionalization did not affect the matrix structure.

Figure 1 shows the infrared spectrum of the samples $YVO_4:Eu^{3+}$, $YVO_4:Eu^{3+}$:CPTES, and $YVO_4:Eu^{3+}$:CPTES:Cisp.

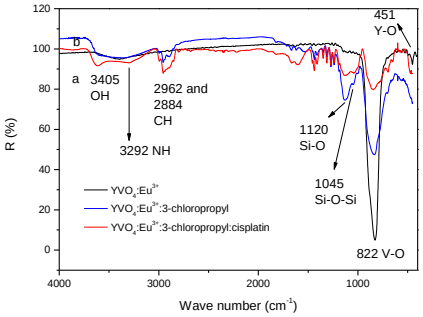


**Fig. 1:** FTIR spectra of the samples treated at 800 °C (a) $YVO_4:Eu^{3+}$, (b) $YVO_4:Eu^{3+}$:CPTES, and (c) $YVO_4:Eu^{3+}$:CPTES:Cisp.

The in vitro assays showed that the nanoparticles can function as drug delivery systems. They are not cytotoxic, and their luminescent properties attested that they can ppenetrate the cell and nuclear membranes.

The in vivo assays based on models of melanoma revealed that the nanoparticles containing Cisp significantly reduced the tumors without eliciting the side effects typical of the treatment with Cisp alone.

## Conclusion

The sol-gel methodology allowed for the synthesis and functionalization of europium(III)-doped yttrium vanadate nanoparticles with adequate particle size to reach the tumor cell nucleus and act as drug delivery systems. In vivo assays showed that this strategy killed tumor cells without giving rise to the common side effects of the chemotherapeutic agent.

## Acknowledgement

FAPESP, CNPq, and CAPES