Near-Infrared Emitting Zn^{II}/Ln^{III} Metallacrowns: Photophysical Properties and Biological Imaging Applications

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Near-infrared (NIR) emitting probes based on trivalent lanthanide(III) cations, Ln^{III}, open new perspectives in molecular imaging. Their unique optical properties i.e. sharp emission bands, spectral positions of which are not affected by the local microenvironment, temperature and pH, large difference between excitation and emission wavelengths and high resistance to photobleaching, overcome some of the limitations exhibited by commonly-used fluorescence probes.[1] However, there are two main fundamental challenges for the design of NIR-emitting lanthanide(III) compounds: (i) an efficient sensitization through appropriate chromophores, and (ii) an efficient protection from non-radiative deactivations through O-H, N-H and C-H vibrations.

Recently we have demonstrated that in Zn^{II}/Ln^{III} "encapsulated sandwich" metallacrowns (MCs) obtained by the self-assembly of Ln^{III}, Zn^{II} ions with derivatives of hydroxamic acids (Fig. 1a), characteristic emission of Yb^{III}, Nd^{III} and Er^{III} ions in the NIR can be sensitized with outstanding efficiency (Fig. 1b).[2,3,4] This versatile and innovative approach allows the localization of lanthanide(III) ions at a predetermined and shielded position to achieve high quantum yields and long luminescence lifetimes.

Herein, we will discuss how the properties of Zn^{II}/Ln^{III} MCs can be tuned by varying the nature of the hydroxamic acid ligands. We will also demonstrate that $Ln^{III}[Zn(II)MC_{pyzHA}]$ MCs built from a derivative of the pyrazine hydroxamic acid, can operate as NIR-emitting probes for the nucleus and the cytoplasm of necrotic HeLa cancer cells (Fig. 1c). In addition, a promising photochemical phenomenon will be described for HeLa cells incubated with a high concentration of $Ln^{III}[Zn(II)MC_{pyzHA}]$ (> 150 µM) and shortly exposed to UV-A light . It will be shown that such treatment leads to the combined cell fixation effect, similar to the one obtained following the classical procedures using formaldehyde or methanol, and a whole-cell NIR counter staining (Fig. 1d).[5]

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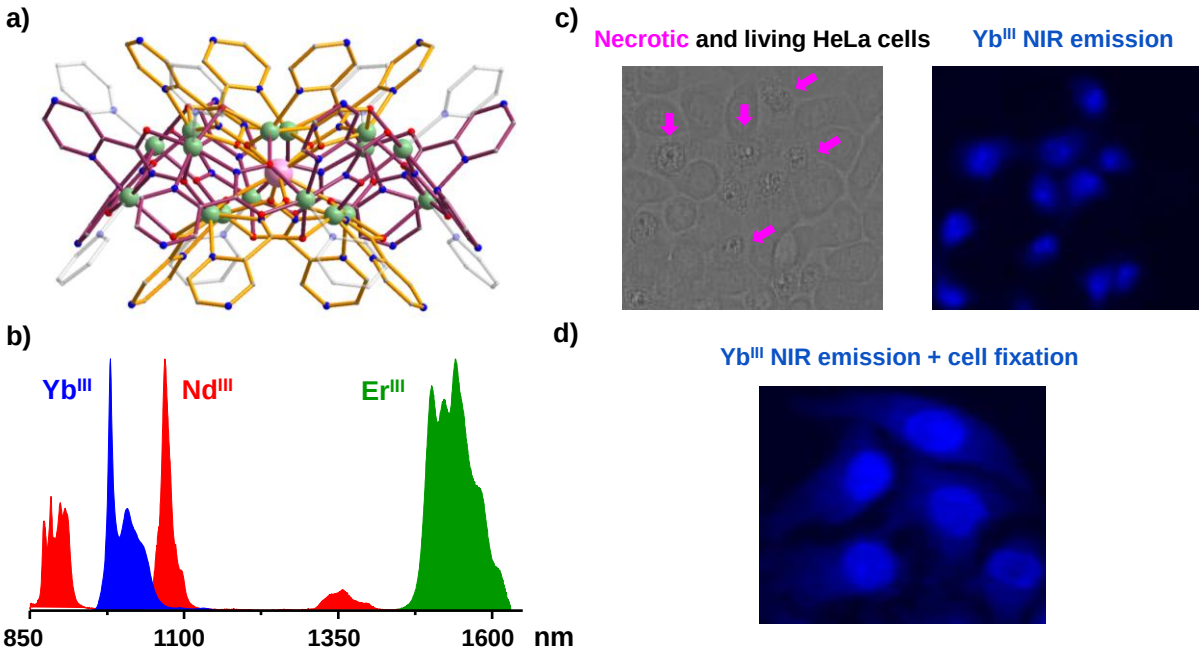

Figure 1. a) Crystal structure of Zn^{II}/Ln^{III} MC with pyrazine hydroxamic acid, $Yb^{III}[Zn(II)MC_{pyzHA}]$. b) Characteristic emission spectra of Zn^{II}/Ln^{III} MC (Ln^{III} = Yb, Nd, Er). c) Epifluorescence microscopy images (brightfield and NIR emission) of necrotic and living HeLa cells incubated with a 45 µM solution of $Yb^{III}[Zn(II)MC_{pyzHA}]$ during 15 min. d) Epifluorescence microscopy image (NIR emission) of HeLa cells incubated with a 150 µM solution of $Yb^{III}[Zn(II)MC_{pyzHA}]$ during 15 min followed by an illumination with UV-A light (selected with a 377 band pass 50 nm filter) for 8 min and further incubation during 1h.

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