DOCTORAL THESIS

Development of luminescent iridium(III) complex-based probes for monitoring analytes in environmental and biological systems

Wang, Wanhe

Date of Award:
2019

ABSTRACT

Transition metal complexes offer potential alternatives to fluorescent organic compounds in various sensing applications. They show several characteristic properties over organic dyes, such as strong luminescence emission, long emission lifetime and large Stoke shift. Among transition metal complexes, cyclometalated iridium(III) (Ir) complexes are most widely explored for sensing applications, due to their bright and tuneable phosphorescence emission. Up to now, Ir(III) complexes have been successfully applied to detect a range of analytes in environmental and biological systems, such as cations, anion, small molecules and proteins. In this thesis, we deeply explored the capability of Ir(III) complexes to the detection of a range of targets including metal ions, small molecules and biomarkers. Several strategies are used to improve the biocompatibility of Ir(III)-based probes while retaining their desirable characteristics.

In chapter 2, we developed a novel Ir(III) complex for the detection of Al^{3+} with a detection limit of 1 μM. The long lifetime of the complex was harnessed to distinguish luminescence response to Al^{3+} from autofluorescence in biological samples by TRES experiment, while the probe was also successfully applied for imaging Al^{3+} in living cells. The results have been published as *Chem. Commun.,* 2016, *52*, 3611. In chapter 3, we reported a new reaction-based luminogenic probe for imaging both H_2S and hypoxia in living zebrafish. This probe demonstrated their utility for the detection of H_2S in solution, living cells and zebrafish model, while it was also capable of discriminating hypoxic from normoxic cells and zebrafish model. The results have been published as *Sens. Actuator B-Chem.,* 2018, *255*, 1953. In chapter 4, we conjugated a natural product oridonin to an Ir(III) scaffold for tracking intracellular NF-κB. This complex was successfully applied to track NF-κB translocation induced by TNF-α, without affecting the translocation process. The results have been published as *Chem. Eur. J.*, 2017, *23*, 4929. In chapter 5, an Ir(III) scaffold with galactose moiety was designed and synthesized for discriminating ovarian carcinoma cell lines from normal cell lines. This probe can selectively "light up" ovarian carcinoma cells with negligible luminescence in normal cells. The results have been published as *Anal. Chem.,* 2017, *89,* 11679.

These works have further demonstrated the utility of Ir(III) complex in the monitoring environment and studying biomolecules in living systems. In particular, the conjugation of endogenous molecule galactose or a natural compound oridonin to Ir(III) scaffolds highlights an effective solution to develop biocompatible probes. However, it should be pointed out that there is a need for developing a general strategy to improve the biocompatibility of luminescent Ir(III) complex-based probes, while there is huge potential for incorporating luminescent Ir(III) complexes-based sensing platforms into portable devices, and exploring theranostic probes.

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