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Commentary

Magneto-chiral detection of reactive oxygen species

Shaowei Chen

Department of Chemistry and Biochemistry, University of California, 1156 High Street, Santa Cruz, CA 95064, United States

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Reactive oxygen species (ROS) are critical metabolic products and may serve as signaling agents regulating a range of biological functions. Yet, ROS are generally unstable with a limited lifetime, and the high chemical reactivity means that too high a concentration of ROS within the cell may lead to ready damages to an array of cellular components, such as membranes, proteins, nucleic acids, etc, and could even result in cell death. Thus, development of reliable technologies for the accurate and selective detection of ROS has been a focus of continuing research. Traditional sensing probes are based on oxidizable organic fluorescence dyes, where the fluorescence emissions can be readily manipulated in the presence of highly active ROS. Significantly, some of these dyes even exhibit chemical selectivity to a specific ROS, a unique property that can be exploited for ROS speciation. For instance, dihydroethidium (DHE) is a superoxide-specific dye which upon chemical oxidation shows a clear change of the emission from blue to red.

Yet organic dyes are susceptible to photobleaching and autooxidation, and the cytotoxicity may limit their applications, in particular, in *in vivo* detection and analysis. Thus, development of new detection platforms is of fundamental and technological significance. In a recent study by Li et al. [1], magneto-chiral $Co(OH)_2$ nanoparticles are found to exhibit a remarkable sensing performance of ROS. The nanoparticles are synthesized by a simple titration reaction between $CoCl_2$ and NaOH in the presence of either D- or L-aspartic acid, and exhibit an almost mirror image of the circular dichroism (CD) profiles, where the nanoparticle chirality is ascribed to distortion of the crystalline lattice at the nanoparticle surface by the chiral ligands. Remarkably, the CD profiles display a clear variation upon the addition of hypochlorite acid (HClO), a common ROS, where the CD peak at ca. 505 nm diminishes in intensity and concurrently a new peak emerges at 650 nm, with increasing HClO concentration. This is ascribed to the oxidation of Co^{2+} to Co^{3+} by HClO on the nanoparticle surface. Such a spectroscopic evolution can be exploited for the ratiometric detection of HClO. Similar behaviors are observed with other ROS, such as H_2O_2, $O_2^{\bullet-}$, •OH, etc. In living cell tests, the limit of detection is markedly lower for the D-aspartic acid functionalized $Co(OH)_2$ nanoparticles than for the L-aspartic acid coated ones, due to preferred endocytosis of the former over the latter.

The magnetic activity of the nanoparticles can also be exploited for ROS detection by magnetic resonance imaging (MRI) analysis. Specifically, the T_1-weighted image shows an apparent color change from red to green in the presence of HClO, and the T_1-weighted signal displays a linear correlation with the HClO concentration. The latter can be exploited as a calibration for ROS quantitative analysis.

Notably, the performances of ROS detection in multiple cell lines based on the CD and MRI measurements are actually comparable to those with a commercial HClO kit. In addition, due to the biosafety of the chiral $Co(OH)_2$ nanoparticles, the feasibility of using the nanoparticles for *in vivo* ROS analysis is demonstrated with tumor-bearing mice, by further functionalization of the nanoparticles with AF568 fluorescence dyes. Nevertheless, more deliberate surface structural engineering is needed to render the nanoparticles specific to a unique ROS and/or active to other reactive species, such as reactive chlorine species (RCS), reactive nitrogen species (RNS), and reactive sulfur species (RSS).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

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E-mail address: shaowei@ucsc.edu.

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