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EDITORIAL

Special Topic: Near-infrared I/II Theranostics

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Owing to the development of material science, nanotechnology and optical imaging techniques, theranostic agents that can be excited by near-infrared I/II (NIR I/II; NIR I, λ = 700–900 nm; NIR II, λ = 1000–1700 nm) light and/or emit fluorescence within these ranges are gaining momentum in the biomedical field. Compared to ultraviolet and visible light, the use of excitation light sources or fluorescent emissions in the NIR I/II windows holds several advantages, including deeper tissue penetration, less light scattering, diminished autofluorescence, negligible phototoxicity, and superior spatial resolution. NIR I/II imaging techniques can provide anatomical and molecular information at high resolutions, holding great potential for early disease diagnosis and monitoring of treatment effects. Meanwhile, the combination of photosensitizers or photothermal agents with NIR I/II laser irradiation allows for precise treatment of deep-seated lesions. Additionally, NIR-I/II light-activated luminescent and photothermal nano-transducers have recently been adopted to selectively modulate neurons and neural circuits, opening the door for manipulation of specific biological processes and beyond, characterized by precise timing and targeted locations.

To highlight the recent development and applications of NIR I/II theranostics in preclinical studies and provide readers with a comprehensive and systematic understanding of this field, *Journal of Analysis and Testing* curated this special issue with three review papers and five research articles.

Profs. Song and Li and coworkers from Fuzhou University reviewed the synthesis, photoluminescence (PL) tuning strategies, and bioimaging applications of gold nanocluster (AuNC)-based nanoprobes with NIR-II PL. Due to the fantastic NIR-II PL properties, multivalency and size tunability, biocompatibility and minimal toxicity, AuNCs hold a high clinical translation potential for in vivo bioimaging applications. In addition, the unique advantages of NIR II imaging have fostered great interests in developing diverse fluorescent fluorophores. In this context, Prof. Liu and Prof. Wang from Nankai University summarized the recent advances in the development of different NIR-II fluorophores, including organic fluorophores, single-walled carbon nanotubes, quantum dots, and rare-earth nanoparticles. By virtue of their improved resolution and signal-to-background ratio, these fluorophores have been studied in various aspects, including bioimaging, biosensing, phototherapy, and surgical navigation. Moreover, the use of NIR light as an external stimulus has propelled their applications in the biomedical field. Profs. Lin, Tang and coworkers from Xiamen University highlighted the NIR light-responsive nanozyme-based systems, including their mechanisms, construction strategies, and diverse applications ranging from antibacterial treatments to anticancer therapeutics.

For research papers, a wide range of excellent studies are reported. Profs. Yao, Miao, Zhang and coworkers from Zhejiang Sci-Tech University developed melanized paclitaxel self-assembly nanoparticles for synergistic anti-tumor therapy. The disulfide bond in paclitaxel dimer conjugates within the nanoparticle could be cleaved by the high-level glutathione in tumor cells, leading to the release of paclitaxel for chemotherapy. Meanwhile, upon exposed to NIR light irradiation, polydopamine could generate a photothermal effect to further promote the release of paclitaxel and exert a synergistic anticancer effect. This design addressed the issues of unmanageable drug release and drug resistance. In general, photodynamic therapy (PDT) or photothermal therapy (PTT) often suffers from undesirable antitumor efficacy due to the hypoxic tumor microenvironment and acquirement of thermal resistance of cancer cells. To this end, Profs. Yang, Wang and coworkers form Hebei University constructed a hollow mesoporous silica nanoparticle capable of simultaneously loading photodynamic and photothermal agents.

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The combination of PDT and PTT complements the intrinsic drawbacks of a singular therapeutic modality. Except for antitumor therapy, NIR light has also been applied for antibacterial applications. For example, oxidative stress mediated by the PDT can damage bacterial cells. However, the hypoxic infection microenvironment severely compromises the therapeutic outcome. To address this issue, Prof. Wu, Liu and coworkers from Henan University utilized the photothermal effect of oxidized mesoporous carbon nanoparticles to melt a phase change material on the surface, triggering the liberation of alkyl radicals. Benefiting from the collaboration with photothermal effects, the generated radicals achieved strong synergistic sterilization outcomes both in vitro against *Propionibacterium acnes* and in treating *Propionibacterium acnes*-induced cutaneous abscesses in murine models. Drug-resistance bacteria caused by the abuse of antibiotics are a potential threat to the human society. Addressing this pressing need, Prof. Zhou and coworkers from Guangzhou University provided an innovative antibacterial nanoplatform based on CeO_2 and N-doped carbon-based heterogeneous structure. This nanoplatform enables dual-modal photothermal/photodynamic inactivation of bacteria under 808 nm laser irradiation. Interestingly, the applications of photothermal agents in areas other than diagnosis and therapy also play an important role. Given that attainment of the optimum enzyme activity generally requires temperatures higher than room temperature, Prof. Zhang and coworkers from Zhejiang Sci-Tech University constructed a blackbody porous sponge as a photothermal conversion bioreactor to facilitate whole-cell catalysis. *Escherichia coli* expressing β-glucosidase was employed in this system and exhibited enhanced catalytic activity up to more than 6 times under NIR I light and sunlight irradiations.

Although great achievements have been achieved in the field of developing innovative NIR I/II theranostics, there are still some critical challenges to overcome. On one hand, the penetration depth of NIR I/II light is still limited to depth below several centimeters. The implementation of NIR I/II theranostics is reliably conducted in murine models, which may not fully represent human physiology. On the other hand, NIR I/II agents with higher absorption, extinction coefficients, and photon conversion efficiencies need to be explored to counteract the energy dissipation of low power density of laser. Moreover, it is crucial to fully consider challenges from animal experimental research to clinical aspects related to biosafety, clinical application standards, and ethical issues. In the future, with continuous breakthroughs and innovations, NIR I/II theranostics will spur a new era in the biomedical field.

While this special issue only covers a small portion of NIR I/II theranostics, we hope that it could be helpful for readers to get a knowledge of the current state of this field. To conclude, we appreciate all authors and reviewers very much for their kind contributions to this special issue. In addition, we greatly appreciate the assistance provided by the Editorial Office of *Journal of Analysis and Testing*.

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