

Cite this: *Chem. Sci.*, 2020, **11**, 6940

DOI: 10.1039/d0sc90119a

rsc.li/chemical-science

## Advances in optical and electrochemical techniques for biomedical imaging

Yi-Tao Long<sup>a</sup> and Thomas J. Meade<sup>b</sup>

As the flagship journal of the Royal Society of Chemistry, this retrospective themed collection in *Chemical Science* collects some exceptionally significant and highly representative publications from the imaging field. The types of articles include both edge articles and minireviews, mainly covering optical imaging (for minireviews please see ref. 1–3) and electrochemical imaging (for a minireview please see ref. 4).

Optical methods serve as widely practicable techniques for biological imaging. Fluorescence in the NIR region (>700 nm) is superior in biomedical sensing due to the high penetration depths and low autofluorescence interference. To make this technique more applicable for *in vivo* detection, novel biocompatible fluorescent probes with high selectivity and sensitivity are urgently needed in this field. This motivation drives various new strategies in molecular design.

For example, a small molecule NIR fluorescent probe, ACy7, was designed for the *in situ* visualization of ozone in the brains of mice, which incorporates a Cy7-like molecule as the precursor of the fluorophore and 3-butenyl as the recognition group.<sup>5</sup> The plasma membrane could be specifically imaged by a water-soluble near-infrared (NIR)-emissive fluorescent molecule with aggregation-induced

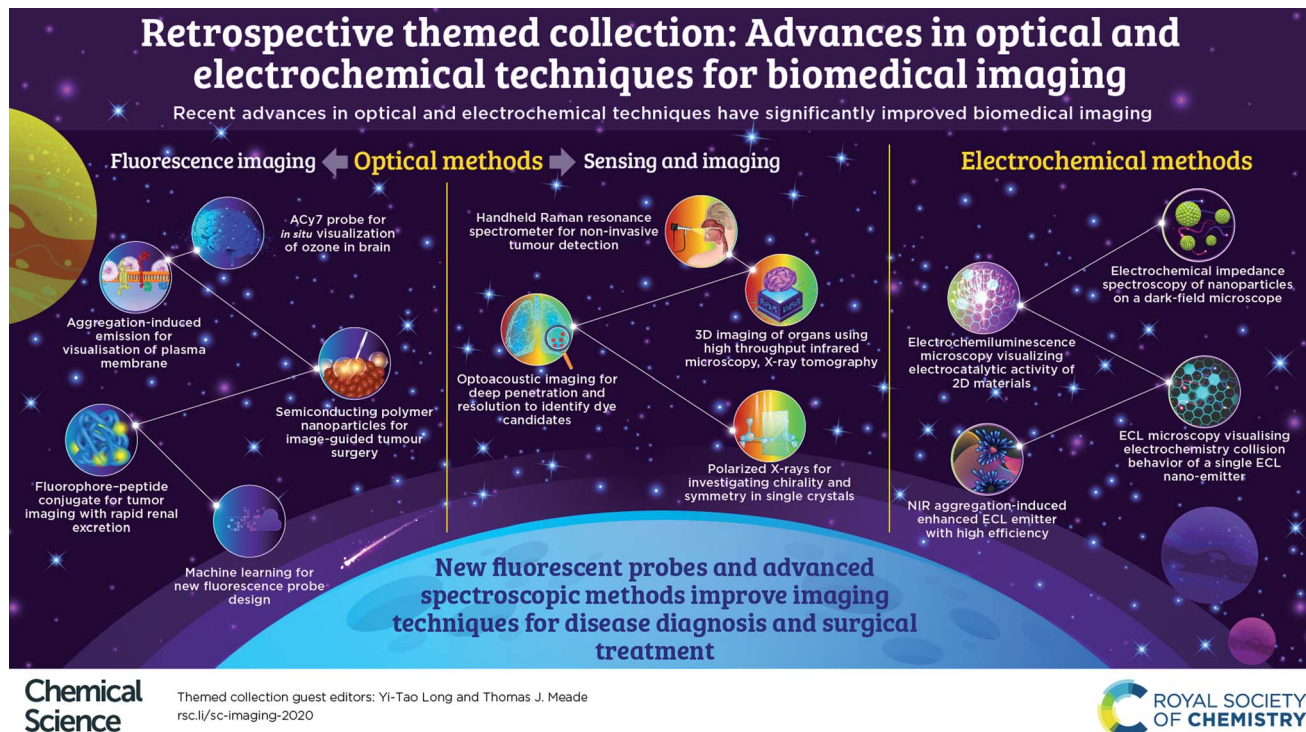
emission (AIE).<sup>6</sup> This fluorescent “light-up” probe allows a short staining period (at the second-level) with a wash-free process. Further, a fluorophore–peptide conjugate was developed for tumor imaging in the “transparent” near-infrared II (NIR-II) window with rapid renal excretion and low off-target tissue exposure.<sup>7</sup> Meanwhile, a semiconducting polymer nanoparticle is designed for efficient NIR-II image-guided tumor surgery by using multiple pathological models.<sup>8</sup> These methods promote clinical translation in disease diagnosis and surgical treatment. We are pleased to see that machine learning has been involved in predicting material properties,<sup>9</sup> and could be expected to facilitate the design of novel fluorescence probes.

In addition, new highly sensitive optical methods have been developed for sensing and imaging. For example, a unique hand-held surface enhanced spatially offset resonance Raman spectroscopy (SESORRS) has been reported. This technique has the ability to yield enhanced Raman signals at a far greater sub-surface level for non-invasive detection of cancerous tumors.<sup>10</sup> To achieve 3D chemical imaging of a complete organ, a high throughput infrared microscopy method was established by combining X-ray tomography and subsequent data analysis.<sup>11</sup> Moreover, optoacoustic imaging has been proven to be a new sensing method capable of deep

penetration with a higher spatial resolution compared to fluorescence imaging. In addition, a library screening approach was utilized to identify and evaluate the available dyes for multi-spectral optoacoustic tomography (MSOT) imaging.<sup>12</sup> Regarding the study of enantiomers, polarized X-rays provide an original approach for the investigation of chirality and symmetry in single crystals. This flexible technique based on an anion exchange strategy was proposed for the enantiomeric resolution of an extended metal atom chain (EMAC).<sup>13</sup>

To promote the fundamental understanding of single entities, electrochemistry shows remarkable advances in the development of various electrochemical microscopy techniques. Specifically, the electrochemical impedance spectroscopy of individual nanoparticles was imaged on a dark-field microscope with an optical-to-electrochemical conversion.<sup>14</sup> Accordingly, the electrocatalytic activity of 2D materials could be imaged directly by electrochemiluminescence microscopy (ECL), presenting nonuniform ECL distribution at single particles.<sup>15</sup> ECL microscopy could facilitate the imaging and study of electrochemistry collision behavior of single ECL nano-emitters.<sup>16</sup> Since the design of new ECL emitters has attracted growing interest, a new near-infrared aggregation-induced enhanced ECL emitter has been developed that shows high ECL efficiency and excellent

<sup>a</sup>Nanjing University, China<sup>b</sup>Northwestern University, USA



biocompatibility.<sup>17</sup> The thriving research on nanoscale electrochemistry will likely accelerate the exploration of new chemistry through single entities.

As guest editors of this themed collection, we thank all the authors for their outstanding contributions. We have brought together high-quality articles on the theme of imaging, especially optical and electrochemical imaging, in this themed collection. We hope researchers from various fields will enjoy examining this themed collection.

## References

- 1 F. Ding, Y. Zhan, X. Lu and Y. Sun, *Chem. Sci.*, 2018, **9**, 4370–4380.
- 2 R. Chouket, A. Pellissier-Tanon, A. Lemarchand, A. Espagne, T. Le Saux and L. Jullien, *Chem. Sci.*, 2020, **11**, 2882–2887.
- 3 A. I. Pérez-Jiménez, D. Lyu, Z. Lu, G. Liu and B. Ren, *Chem. Sci.*, 2020, **11**, 4563–4577.
- 4 T.-E. Lin, S. Rapino, H. H. Girault and A. Lesch, *Chem. Sci.*, 2018, **9**, 4546–4554.
- 5 P. Li, J. Wang, X. Wang, Q. Ding, X. Bai, Y. Zhang, D. Su, W. Zhang, W. Zhang and B. Tang, *Chem. Sci.*, 2019, **10**, 2805–2810.
- 6 D. Wang, H. Su, R. T. K. Kwok, X. Hu, H. Zou, Q. Luo, M. M. S. Lee, W. Xu, J. W. Y. Lam and B. Z. Tang, *Chem. Sci.*, 2018, **9**, 3685–3693.
- 7 R. Tian, H. Ma, Q. Yang, H. Wan, S. Zhu, S. Chandra, H. Sun, D. O. Kiesewetter, G. Niu, Y. Liang and X. Chen, *Chem. Sci.*, 2019, **10**, 326–332.
- 8 K. Shou, Y. Tang, H. Chen, S. Chen, L. Zhang, A. Zhang, Q. Fan, A. Yu and Z. Cheng, *Chem. Sci.*, 2018, **9**, 3105–3110.
- 9 X. Zheng, P. Zheng and R.-Z. Zhang, *Chem. Sci.*, 2018, **9**, 8426–8432.
- 10 F. Nicolson, L. E. Jamieson, S. Mabbott, K. Plakas, N. C. Shand, M. R. Detty, D. Graham and K. Faulds, *Chem. Sci.*, 2018, **9**, 3788–3792.
- 11 A. Ogunleke, B. Recur, H. Balacey, H.-H. Chen, M. Delugin, Y. Hwu, S. Javerzat and C. Petibois, *Chem. Sci.*, 2018, **9**, 189–198.
- 12 S. Roberts, C. Andreou, C. Choi, P. Donabedian, M. Jayaraman, E. C. Pratt, J. Tang, C. Pérez-Medina, M. J. de la Cruz, W. J. M. Mulder, J. Grimm, M. Kircher and T. Reiner, *Chem. Sci.*, 2018, **9**, 5646–5657.
- 13 A. Srinivasan, M. Cortijo, V. Bulicanu, A. Naim, R. Clérac, P. Saintavit, A. Rogalev, F. Wilhelm, P. Rosa and E. A. Hillard, *Chem. Sci.*, 2018, **9**, 1136–1143.
- 14 T. Liu, M. Li, Y. Wang, Y. Fang and W. Wang, *Chem. Sci.*, 2018, **9**, 4424–4429.
- 15 M.-M. Chen, W. Zhao, M.-J. Zhu, X.-L. Li, C.-H. Xu, H.-Y. Chen and J.-J. Xu, *Chem. Sci.*, 2019, **10**, 4141–4147.
- 16 C. Ma, W. Wu, L. Li, S. Wu, J. Zhang, Z. Chen and J.-J. Zhu, *Chem. Sci.*, 2018, **9**, 6167–6175.
- 17 J.-L. Liu, J.-Q. Zhang, Z.-L. Tang, Y. Zhuo, Y.-Q. Chai and R. Yuan, *Chem. Sci.*, 2019, **10**, 4497–4501.

