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Editorial: Thought leaders in analytical science research

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Editorial on the Research Topic

Thought Leaders in Analytical Science Research

Introduction

Analytical science research has received an enormous amount of attention in the last 2 decades and has developed significantly since the COVID-19 pandemic caused a worldwide catastrophe. There were efforts to develop more efficient, rapid, and cost-effective analytical tools and methods over the existing ones. In this context, we started a special issue with the research topic “Thought Leaders in Analytical Science Research”, which received good responses from researchers worldwide, and we published eleven articles, encompassing original research, perspectives, and reviews, that embody the innovative methodologies and impactful applications emerging in the modern analytical sciences. These contributions, spanning pharmaceutical quality assessment, novel approaches in mass spectrometry for protein detection, proteomics, separation of isobaric phosphorothioate oligonucleotides in capillary electrophoresis, multi-energy calibration of plasma-based optical emission spectrometry, wastewater-based epidemiology, high-precision ratiometric sensing, 3D printing for instrument fabrication, and protein-templated metal nanoclusters, illustrate the creativity and breadth of analytical scientists confronting today’s research challenges. Together, they underscore how thoughtful analytical science underpins advancements in drug safety, disease diagnostics, environmental protection, instrument design, and more. Furthermore, the review articles and perspectives provide an overall update of the developments in analytical science research and future directions.

Overview of contributions

This collection features works that reinforce the critical role of methodical testing, optimization, and validation in analytical science. **Wondmkun et al.** present a comparative quality assessment of nine hydrochlorothiazide formulations, revealing all of them meet the quality control parameters; however, some of the tablet brands fail in their hardness and friability test, underscoring the need for rigorous *in vitro* equivalence testing. **Bezstarosti et al.** highlight the advantages of parallel reaction monitoring (PRM) over traditional immunoblotting, demonstrating superior sensitivity and specificity in quantifying complex biomarkers, while **Ghassemi et al.** explore the potential of cyclodextrin-based additives in capillary electrophoresis to achieve high chemo- and stereoselectivity for the separation of phosphorothioate oligonucleotides. In another study, **Jofre et al.** introduce multi-energy calibration (MEC) in plasma-based optical emission spectrometry for precise mineral determination in animal feeds, resulting in more accurate feed formulations to ensure optimal livestock nutrition. **Cheng et al.** employ ultra-high performance liquid chromatography coupled with quadrupole time-of-flight mass spectrometry (UPLC-QTOF-MS) to elucidate the phytochemical composition of Zishen Yuzhen Pill with 152 compounds, 99 metabolites, and 70 prototype components identified in rat tissues after being fed with the pill. The analysis offers a better understanding of the pills in promoting osteogenic differentiation in the pill-treated animals. Additional contributions from perspectives and reviews spotlight new frontiers in proteomics and environmental monitoring. Elucidation of protein carbamylation and its biological function is always challenging because urea, which is used in proteomics procedures, induces carbamylation. **You et al.** discuss various issues in detail regarding the post-translational modification of proteins and their role in regulating enzymatic activity and disease. The authors provide future directions in proteomic analysis for investigating the effect of post-translational modification of proteins on regulating protein function, activity, localization, interaction, and turnover, with co-purification of acetylated and carbamylated peptides with anti-acetyl-lysine antibodies. **Picó et al.** provide a clear perspective on wastewater-based epidemiology by determination of small-molecule drug metabolites and proteins to a more inclusive “sewage exposome,” through high-resolution MS. Meanwhile, **Kundu et al.** review the capabilities of microalgae for phytoremediation and the uptake mechanisms, proposing a sustainable, low-cost solution to remove nutrients and emerging contaminants from wastewater, and provide future perspectives.

Several authors emphasize the transformative potential of advanced detection methods and design strategies for improving analytical precision. In this context, **Madhu et al.** examine how ratiometric approaches offer self-calibrating, high-precision measurements in diverse modes—fluorescence, Raman, electrochemistry, and mass spectrometry—mainly when dealing with complex matrices. **Malinick et al.** discuss improvement in analytical performances of various techniques using 3D-printed devices that streamline microfluidic, optical, and mechanical components, foreshadowing open-source analytical instrumentation. Lastly, **Chu et al.** explore protein-templated metal nanoclusters (MNCs), highlighting protein scaffolds’ unique luminescent properties and biosensing capabilities, thereby expanding the frontiers of highly sensitive molecular detection.

The authors project MNCs as one of the alternatives to conventional dyes to overcome limitations in fluorescence microscopy.

Concluding remarks

Altogether, these eleven articles capture the deep ingenuity and synergistic nature of ongoing analytical research. From robust, cost-effective techniques ensuring pharmaceutical quality to real-time detection of disease biomarkers and toxicants to sophisticated exploitation of quantum and biomaterial phenomena. Each study conveys the pivotal role of advancement of analytical tools and methods in improving precision and solving modern scientific problems. We trust these works, born from close collaborations and well-honed methodological expertise, will continue to inspire innovation among the next-generation of leaders in analytical science research.

Author contributions

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