Sensors & Diagnostics

EDITORIAL

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Cite this: *Sens. Diagn.*, 2024, **3**, 1767

Introduction to Supramolecular Sensors: From Molecules to Materials

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DOI: 10.1039/d4sd90034k

rsc.li/sensors

This themed collection highlights the ongoing advancements in supramolecular sensor chemistry, a research area that continues to attract significant interest. Over the past few decades, substantial progress has been made in the rational design of chemosensors for the detection and quantification of a wide range of critical analytes, including anions, cations, toxic chemicals, hazardous substances, and biomolecules. In their perspective article (**https://doi.org/10.1039/D4SD00022F**), Wynne and Elmes highlighted the supramolecular sensing and therapeutic applications of modified synthetic peptides. Synthetic peptides can be tuned to be highly selective and responsive sensor systems for specifically detecting target analytes with improved sensing properties. Given their structural diversity, chemical versatility, and tunable functional properties, synthetic peptides have been well-adapted for their use in supramolecular sensing platforms.

Phosgene is a highly toxic and hazardous chemical warfare agent that poses a severe threat to human health. Consequently, developing effective chemical sensors for the trace detection and identification of phosgene is crucial to ensure public safety. In their tutorial review article (**https://doi.org/10.1039/D4SD00048J**), Gunnlaugsson and the Shanmugaraju group provided a comprehensive overview of reactivity-based fluorescent chemosensors for selective sensing of phosgene. Building on this, the article offers an in-depth summary of the latest advancements in using amino-1,8-naphthalimide-based small-molecule fluorescent sensors for the selective detection of phosgene.

Heavy-metal contamination of the environment is a contemporary issue of modern life. Among the different heavy-metal ions, Pb(II) and Ag(I) are recognized as particularly severe contaminants, causing environmental damage and posing significant threats to living organisms. Therefore, the design of an effective colorimetric and fluorescence chemosensor for monitoring the concentration of these heavy-metal ions is essential. In response to this need, numerous fluorescent sensors incorporating various fluorescence moieties have been developed and successfully used for sensing applications. In their critical review article (**https://doi.org/10.1039/D3SD00289F**), Watkinson and co-workers showcased a wide array of pyrene-containing small-molecule chemosensors utilized for the colorimetric and fluorescence-based detection of Pb(II) and Ag(I) ions. They provided a detailed account of various design strategies employed in sensor development and explored how structural aspects influence the sensitivity of pyrene sensors. The design and development of fluorescent sensors for detecting biologically relevant analytes stimulates significant research interest. In particular, turn-on fluorescent sensor designs offer enhanced photophysical properties that are particularly beneficial for biological ion detection. Due to their tunable structure and functions, ease of synthesis, biocompatibility, and high photostability, Schiff-base-containing fluorescent chemosensors have long been extensively studied for their applications in sensor chemistry. In their critical review article (**https://doi.org/10.1039/D3SD00110E**), Swamy and co-workers described a variety of Schiff-base-based 'turn-on' fluorescent probes for sensing biologically important metal cations. In addition to discussing solution-state fluorescence sensing, their work provides an in-depth exploration of the application of Schiff-base sensors in cellular imaging, offering insights into the specific localization of fluorescent probes within cellular organelles.

Hydrogels are polymeric soft materials that have attracted significant research attention due to their structural diversity and versatile applications, including biosensing and

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diagnostic bioimaging. A key advantage of hydrogels is that their structure and functional properties can be tailored to mimic the biological functions of biomolecules, thereby replicating their molecular interactions. This adaptability has made hydrogels particularly intriguing for use in 3D immunoassays, an area that has become a major focus of research. Hydrogels are employed as soft matrices to encapsulate biomolecules under native-like conditions. Bergamaschi and Gori's team presented (**https://doi.org/10.1039/D3SD00313B**) a proof-of-concept demonstration of a composite Aga-Q3 hydrogel microarray for entrapment of extracellular vesicles within the 3D environment. Designing effective sensors for chemical-explosive detection is important for national security, civilian safety, and protecting the environment. In their article (**https://doi.org/10.1039/D4SD00151F**), Shanmugaraju and Nanjan *et al.* reported the synthesis and fluorescence sensing properties of a new 2′-benzyloxy flavone towards picric acid. In addition to its efficient detection of picric acid, 2′-benzyloxy flavone has also demonstrated differential fluorescence sensing responses to pH.

Inspired by natural photosynthesis, various artificial light-harvesting systems based on different chromophores have been designed and employed in a range of applications. Xiao and co-workers (**https://doi.org/10.1039/D3SD00297G**) developed a Schiff base containing a tripodal sensor system featuring an aggregation-induced emission (AIE)-active tetraphenylethylene luminogen, which exhibited typical AIE behaviour in a binary solvent system. Additionally, they developed a novel functional nanoparticle system by integrating this sensor with naphthalene diimide, which functions as an energy acceptor. The fluorescence sensing and light-harvesting properties of these newly designed nanoparticles were further elaborated, revealing their potential for advanced applications. Finally, in their work (**https://doi.org/10.1039/D3SD00188A**), Gupta and co-workers described the synthesis and luminescence sensing properties of an alkyne-functionalized Zn(II) metal–organic framework (MOF) for ultrafast detection of Cu(I) and Pd(II) metal ions in aqueous medium.

This themed collection brings together some of the most significant contributions from leading experts in the field, offering a thorough overview of the current landscape in supramolecular sensor chemistry. The articles featured here not only highlight the innovative approaches and techniques propelling this field forward, but also provide valuable insights and inspiration for future research. We are confident that readers will find this collection both informative and thought-provoking, sparking further advancements in the development of sophisticated sensor systems for the detection and monitoring of critical analytes.