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SPECIALTY SECTION
This article was submitted to
Nanoscience,
a section of the journal
Frontiers in Chemistry

RECEIVED 13 July 2022
ACCEPTED 21 July 2022
PUBLISHED 06 September 2022

CITATION
Asif M, Xiao F, Govindasamy M and Sun Y
(2022), 2D Nanoarchitectures
for Sensing/Biosensing Applications.
Front. Chem. 10:992793.
doi: 10.3389/fchem.2022.992793

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2D Nanoarchitectures for Sensing/Biosensing Applications

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KEYWORDS

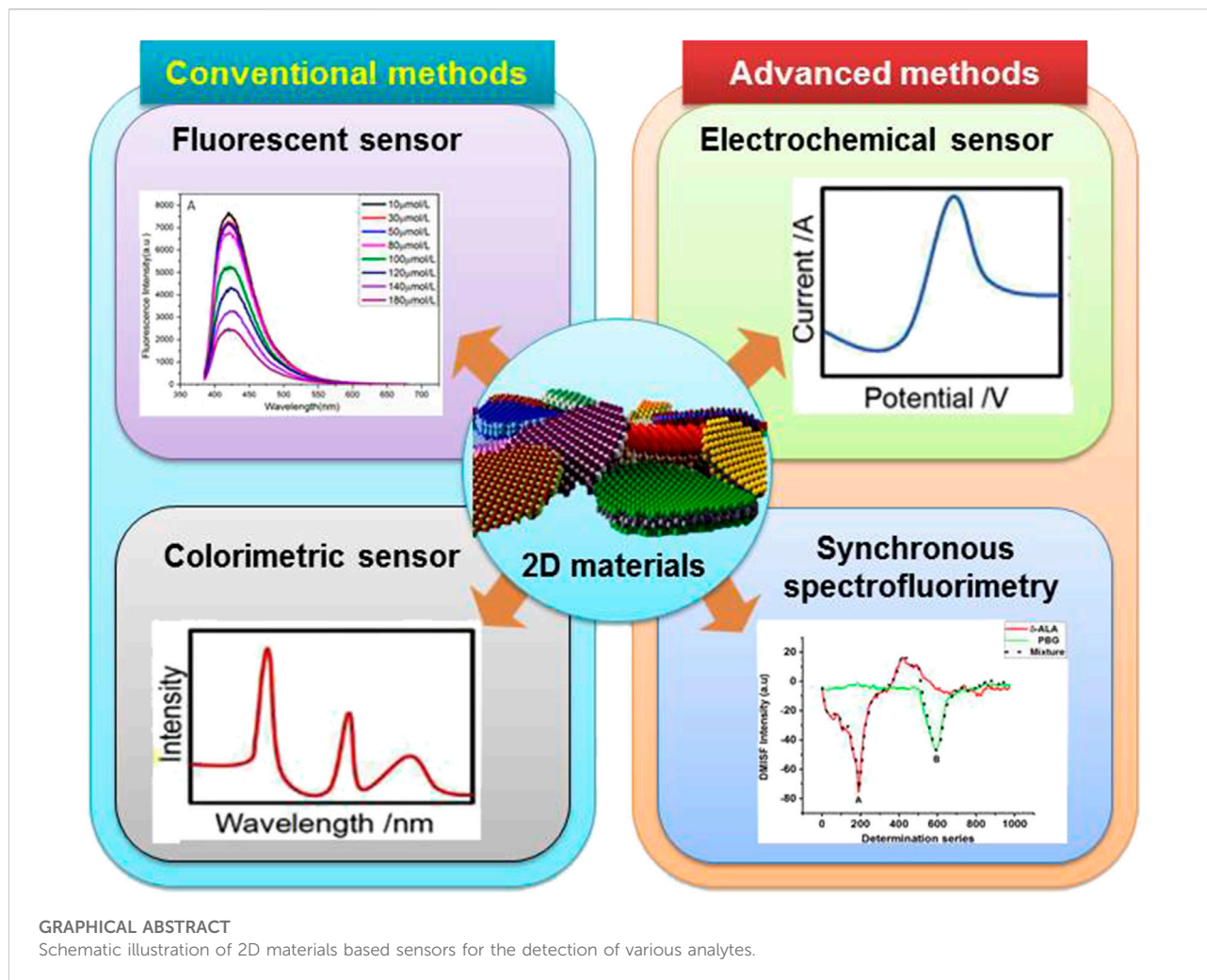
sensors, biosensors, 2D nanomaterials, pollutants, biomolecules, point-of-care

Editorial on the Research Topic

2D Nanoarchitectures for Sensing/Biosensing Applications

In analytical chemistry, sensing and biosensing are among the most important research areas for carrying out the analysis of a number of target analytes (Hermawan et al., 2021). The growing number of analytes that can be detected using various approaches, along with the large number of sensing platforms that produce analytically beneficial outcomes, highlight the significance of sensing techniques (Asif et al., 2018). Sensing and biosensing techniques are regarded as highly sensitive, specific, and capable of multitasking as shown in Graphical abstract (Zhang et al., 2020).

In comparison to other nanomaterials, 2D nanostructures exhibit encouraging application potential for the *in vitro* detection of small biological molecules, neurotransmitters, and proteins, which in turn are used as biomarkers. These nanostructures are cost-effective and easy to synthesize, and they offer rapid response times in terms of the screening and monitoring of various disorders, including potentially fatal cancers (Iftikhar et al., 2021). They also play a role in improving the sensitivity, selectivity, and stability of the sensing platforms (Aziz et al., 2019). Moreover, 2D nanoarchitectures, when coupled with emerging types of nanostructures and advanced nanotechnology, not only improve sensing capabilities for the real-time detection of gases, pollutants, and small biomolecules but also help these technologies execute *in vitro* and *in vivo* diagnosis (Dral and Johan, 2018). The introduction of point-of-care testing devices, in particular, has revolutionized sensing systems. These devices offer portability, flexibility, non-invasiveness (Asamoah et al., 2021), low cost, time-effectiveness, improved sampling frequency, and implantability (Xu et al., 2019). Meanwhile, trials involving the wireless transmission of analytical data to medical centers for processing have been successful, while the development of ready-to-use and



reusable sensors continues to lag behind due to the complexity and high cost of these devices (Asif et al., 2021).

In short, the research field is quite broad, which makes it a bit difficult to represent all the exciting developments in sensing platforms explored in these articles. This Research Topic covers a total of eleven articles, ten of which represent original research and one of which is a review. All articles were contributed by experts in the sensing and biosensing field.

To date, a great deal of effort has been devoted to improving the efficiency and biocompatibility of sensors. In this regard, Wang et al. successfully fabricated a composite material through the polymerization of indole-5-carboxylic acid into poly-5-carboxyindole nanostructures (PI-5-CA), which were further hybridized with carboxylated single-walled carbon nanotubes (C-SWCNTs). The electrode modified with PI-5-CA/C-SWCNTs was used as an electrochemical immunosensor to detect *E. coli* O157:H7, demonstrating a wide linear concentration range of 2.98×10^1 to 2.98×10^7 CFU/ml and a limit of detection (LOD) of 2.5 CFU/ml. Interestingly, the sensor

was also used to detect bacteria in water specimens, with decent accuracy.

Colorimetric assays are considered quick and easy to use because they involve a color change phenomenon (Asif et al., 2020). Zhang et al. have developed a rapid and highly sensitive colorimetric method for the detection of L-Histidine (L-His) that uses Cu^{2+} ions, which inhibit the oxidation of the 3,3',5,5'-tetramethylbenzidine (TMB)- H_2O_2 system. The as-constructed sensor showed two linear concentration ranges of 60 nM–1 μM and 1 μM –1 mM, with a LOD of 50 nM, and proved to be efficient for the detection of L-His in urine samples.

Wang et al. fabricated fluorescent copper-based nanoarchitectures of 5–6 nm in size and employed them as sensors for the detection of NO_2^- and temperature. The copper nanomaterials produced fluorescence, which was selectively quenched by nitrite ions. The intensity of the fluorescence also correlated well with temperatures ranging between 20 and 60°C. These nanomaterials are good enough to be used in nanothermometers, devices that, with their high degree of

sensitivity and specificity, are considered necessary for, e.g., the detection of dissolved gases in oil, and therefore capable of, e.g., diagnosing faults in power transformers. Keeping this in mind, [Jia et al.](#) constructed a gas sensor based on an Ag₃-HfSe₂ monolayer for the detection of C₂H₄ and CO molecules and explored their mechanisms and adsorption behaviors. The adsorption effect on C₂H₄ was greater than that on CO. The electrical sensitivity of C₂H₄ was found to increase up to 55.49% after adsorption, a phenomenon known as chemisorption. This sensor has the potential to efficiently monitor the working status of power transformers.

[Tang et al.](#) prepared MnO₂ nanosheets with glutathione (GSH) to detect Cu²⁺ ions using a simple colorimetric assay. The fabricated sensor exhibited a wide linearity range of 10–300 nM, with an LOD of 6.9 nM, and demonstrated superb anti-interference capability in Cu²⁺ detection from tap water samples. The sensor performed efficiently without any additional H₂O₂ or complicated modification processes.

Furthermore, [Wu et al.](#) developed a fluorescence sensor for the detection of Bi³⁺ ions. The authors prepared glutathione-protected non-noble transition metal copper nanoparticles (GSH-CuNPs) that carried out their sensing applications via aggregation-induced luminescence. Mechanistically, the fluorescence of the CuNPs was inhibited upon the addition of Bi³⁺ ions. The fabricated sensor was simple, fast, and selective, displaying a linearity range of 0 mmol/L–100 mmol/L, with an LOD of 10 mmol/L. [Ajmal et al.](#) presented a two-step approach, based on derivative matrix-isopotential synchronous fluorescence spectrometry (DMISFS) and the Hantzsch reaction, for the rapid, reliable, and simultaneous detection of δ -aminolevulinic acid (δ -ALA) and porphobilinogen (PBG) in urinary samples. The authors envision their sensor as a novel diagnostic tool for patients with severe abdominal pain and as a potential alternative to the δ -ALA/PBG detection kits currently in use, with both clinical and scientific applications.

[Yang et al.](#) discussed the recent progress on electrocatalysts based on metal–organic frameworks (MOFs) in the context of electrochemical sensing applications. In this review, the authors briefly present different types of MOFs-based nanomaterials by classifying them into metal-based, carbon-based, and other MOF-based nanostructures. They also elaborate on the structure–activity–performance relationships between these catalysts and extensively discuss the effects of metal cations and synthetic ligands.

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[Tong et al.](#) and [Huang et al.](#) differentiated between cancerous and normal cells by precisely and accurately detecting H₂O₂ via sensors based on an Au nanoparticles-polydopamine-polyacrylic acid-graphene (Au NPs-PDAPAA-graphene) nanohybrid, and on a Cu₂(OH)₃NO₃-wrapped ZnO nanorod assembly [Cu₂(OH)₃NO₃@ZnO], respectively. Owing to the synergistic effects of multicomponent systems, the former electrochemical sensor offered higher sensitivity (LOD of 0.02 μ M) than the latter (LOD of 1 μ M). Both sensors were successfully employed in real-time tracking of H₂O₂ excreted by different types of live cells.

The last contribution to this Research Topic was by [Siddique et al.](#) The authors fabricated Cu-ZnO nanorods, which were used in the electrochemical sensing of H₂O₂. The constructed sensor exhibited good reproducibility, stability, and selectivity, with a linearity range up to 11 mM and an LOD of 0.16 μ M.

In summary, this Research Topic highlights the development of nanomaterials, their structure–activity–performance correlations, their improvements to sensing platforms, their performances, and their various potential applications.

Author contributions

MA drafted the manuscript. MA, FX, MG, and YS edited and proofread the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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