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Advanced biosafety materials for prevention and theranostics of biosafety issues

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Since its global outbreak in 2020, the coronavirus disease 2019 (COVID-19) has been a severe threat to life and health and aroused worldwide concern about biosafety [1]. Capitalizing on this, various disciplines, such as mathematics, physics, biology, chemistry, material science, and computer science, have been urged to develop novel protocols for the prevention and theranostics of biosafety issues. In particular, chemistry and material science have been addressed to provide unique strategies for solving biosafety issues, such as infections by pathogenic microorganisms like viruses or bacteria. Based on this, a new field termed “biosafety materials” has emerged.

Typically, the new area termed biosafety materials emphasizes the applications of materials to prevent and control biosafety issues [2,3]. Specifically, biosafety chemistry and biosafety materials can support existing local and governmental protocols for rapid responses toward outbreaks or pandemics of diseases. This exemplary includes the timely detection and early treatment of pathogenic microbial infections in the face of pathogen invasion, the development of personal protective equipment, or the prevention of alien species invasion. In addition, biosafety materials could also possess pharmacological properties and therefore be applied as carriers to deliver drugs, genes, or proteins, resulting in an optimized diagnosis or treatment of infectious diseases [4]. As such, biosafety materials could have feasible properties for clinical applications and translation, ultimately enhancing the ability to tackle biosafety-related problems.

The contents of this special issue cover the rapid detection and elimination of pathogenic microorganisms and the control of infectious diseases. The primary way to control the spread of infectious diseases is to improve the diagnosis technique of pathogens. The clustered regularly interspaced short palindromic repeat/associated proteins (CRISPR/Cas) technology identifies viral genome sequences to diagnose infectious diseases. Vectors based on biosafety materials can transport the CRISPR/Cas system and address the biosafety concerns and off-target effects of conventional viral vectors. Zhang et al. summarized the applications of different biosafety materials, including lipids, polymers, peptides, inorganic materials, extracellular vesicles, and so forth, to enhance the genetic diagnosis of diseases [5]. Another technique to improve the specificity and sensitivity of pathogen detection is based on sensitive biosensors. Qi et al. presented the use of electrochemiluminescence (ECL) sensing platforms to detect microbes and proposed which requirements are necessary for incorporating ECL into biosafety materials [6]. Fluorescent optical sensors based on conjugated polymers were summarized by Liu et al. Biosensors based on biosafety materials could be used for the ultra-sensitive detection of pathogens due to the excellent light trapping and light signal amplification capabilities [7]. In addition to detection techniques, the collection of potentially biohazardous samples is crucial for diagnosing infectious diseases. Ren et al. found a highly increased detection sensitivity of two orders of magnitudes between nasopharyngeal swab head materials, which were commercially purchased from different manufacturers to detect COVID-19, emphasizing the importance of biosafety materials in the diagnosis of pathogenic microorganisms [8].

Apart from diagnosis, advanced biosafety materials are also believed to play a crucial role in preventing and treating pathogenic microbial infections. Protein-based biosafety materials have emerged as promising antiviral tools due to their ability to interact with antiviral drugs and vaccines. Han et al. summarized the functions of different proteins in improving the stability of liquid vaccines at room temperature. This finding could enhance vaccine immunogenicity, control the delivery of bioactive molecules, and highlight the unique properties of protein-based biosafety materials for antiviral applications [9]. Complementarily, Li et al. summarized the relationship between drug release kinetics and optimization of the therapeutic efficacies of vaccines, establishing new rules for the design of bioactive materials [10]. Nucleic acid therapy is a promising clinical treatment for immune-related diseases. Li et al. described different delivery systems for nucleic acids and discussed their biosafety concern in a preclinic/clinic study. This involves biological evaluation of the carrier, the treatment of disease, or the administration method, emphasizing the importance of material biosafety [11].

Besides, advanced biosafety materials could also be applied to kill hazardous pathogens. As a class of active oligopeptides widely distributed in nature, antimicrobial peptides (AMPs) can attack pathogenic microorganisms by penetrating and destroying their membrane structures [12]. Wei et al. reviewed the routes for the biosynthesis

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and therapeutic applications of AMPs, pointing out the importance of developing effective and low-toxic AMP formulations [13]. Original research covering the eradication of bacteria included a study from Xie et al. about using the metal–organic framework (MOF) based biosafety materials for synergistic sterilization by efficient photodynamic and photothermal catalysis [14].

Overall, the current special issue reports on a diverse intersection of advanced biosafety materials for addressing various biosafety problems. Specifically, this involves the applications of biosafety materials toward the detection, identification, and treatment of pathogenic microorganisms. These multiple and interdisciplinary investigations build a bridge between fundamental material innovation and clinical medical translation, thus providing a powerful toolbox for professionals to solve biosafety-related problems [2]. Based on the unprecedented experience from the outbreak of COVID-19, we should promote the development of related technologies through close international cooperation and prepare for a possible biosafety crisis in the future.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Author Contributions

Jianxun Ding: Conceptualization, Data Curation, Writing – Original draft, Writing – Review & Editing. **Haihua Xiao:** Conceptualization, Writing – Review & Editing. **Xuesi Chen:** Conceptualization, Writing – Review & Editing, Supervision.

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