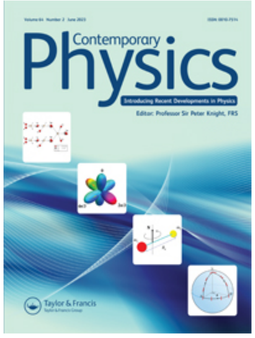

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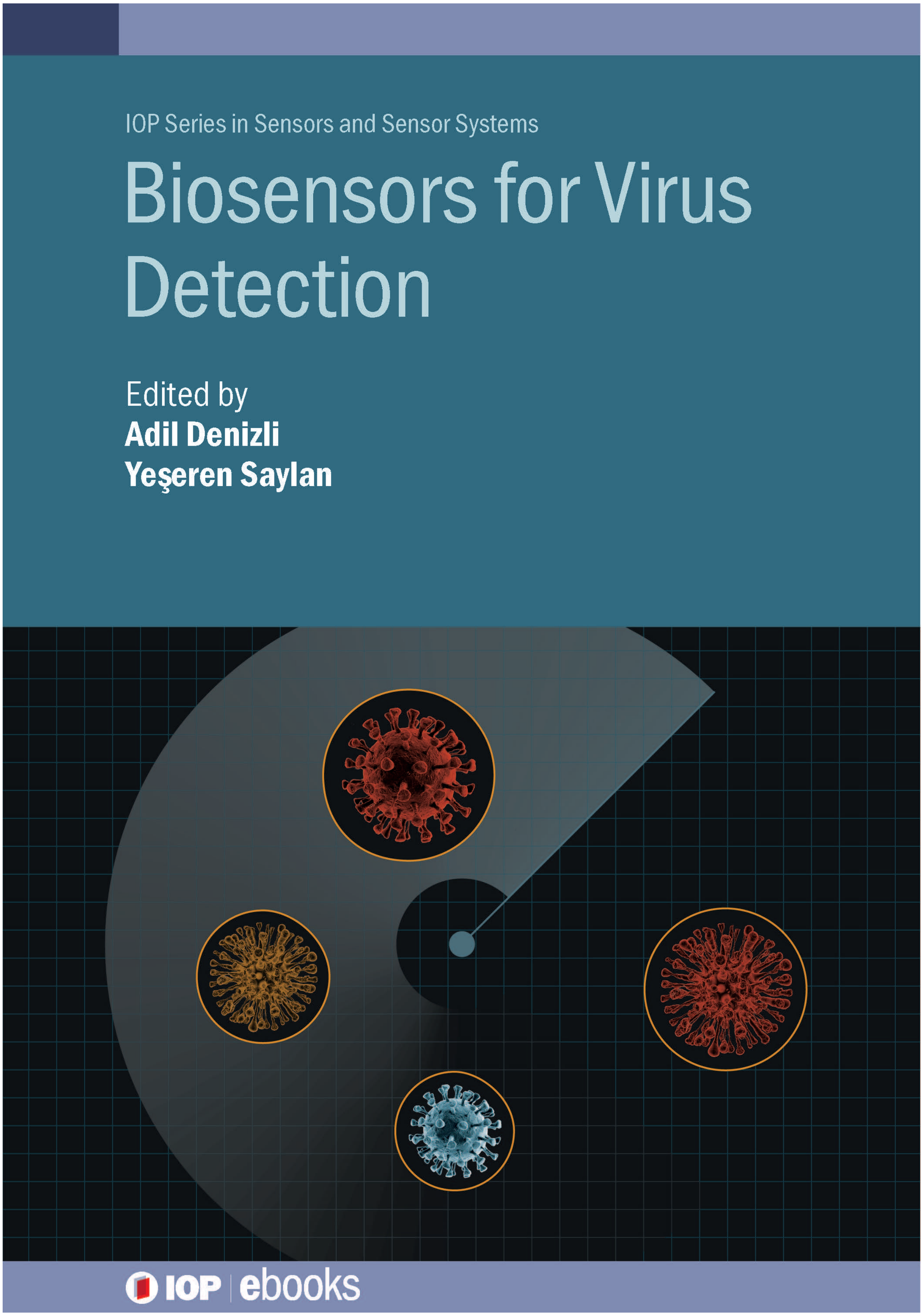

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ESSAY REVIEW

Biosensors for virus detection by Adil Denizli and Yeseren Saylan, Bristol, IOP Publishing, 2021, 184 pp., $190.000 (hardcover), ISBN 9780750338677. Scope: textbook. Level: advanced undergraduate, postgraduate, researcher, scientist.

Viruses are non-living entities that replicate in host organisms and are capable of causing serious diseases. Virus detection is very crucial since viruses have been causing a lot of problems and losses all over the world. Not only affect the deadly health problems like Ebola virus, Marburg virus, HIV (Human Immunodeficiency Virus), Zika virus, SARSCOV, and so on, the virus outbreak can also have an adverse impact on the political, social, and economic sectors of the country. To address these challenges, advanced biosensor platforms are essential for detecting the presence of viruses, facilitating appropriate prevention and treatment.

The primary challenge in developing advanced biosensor technology lies in creating systems capable of detecting target molecules with a high degree of accuracy, stability, and reliability. The fundamental basis of novel biosensor technologies today is to capture target molecules and translate their interactions into quantifiable signals. As such, biosensors must incorporate a variety of transducers and recognition components. Meeting these demands necessitates various innovative approaches. This book provides a comprehensive and in-depth overview of the latest developments in the field of biosensors, exploring various available methods and highlighting the practicality and convenience offered by each approach.

The book clearly outlines how advancements in biosensor technology can enhance the precision of target molecule detection. With a focus on stability and reliability, the book discusses various transducers and recognition elements that can be used to achieve this goal, elucidating a range of innovations in biosensor development that can assist scientists and researchers in understanding the pivotal role of this technology across various disciplines.

The book comprises eight chapters, each with several sub-chapters, offering comprehensive information about various types of biosensors. The primary objective of each chapter is to provide fundamental knowledge about different biosensor types, including their principles, preparation, properties, characterisation techniques, and technological advancements. The book also emphasises the importance of biosensors in detecting various viruses. Furthermore, the chapters discuss the integration of biosensors with other cutting-edge technologies for potential medical applications.

The authors begin this book by introducing general information about viruses in a clear and detailed manner, followed by an explanation of some worst killer viruses as well as other types of viruses that are often found and cause many problems. Meanwhile, other sections in this book specifically discuss each type of current virus biosensor technologies.

In chapter 2, the authors explain the basic principle of optical biosensors, where an element and a transducer detect and measure target molecules. By adapting their response to the signals, the element and transducer can estimate the combination and function of target molecules. The presence of target molecule is recognised by the binding reaction of the target molecule-receptor association. Optical biosensors are capable of measuring various change in the reflection, absorption, refractive index, Raman spectra, fluorescence, infrared spectrum, chemiluminescence, or energy transfer by the time the complex between recognition element and target molecule is detected. The transducer then transforms the alteration into a signal to be measured by a detector.

The importance of optical biosensors as an effective application field in medical diagnosis is highlight by the authors. They describe some alternative ways to improve the detection performance of optical biosensors. Besides that, several recent findings in optical biosensors are also spelled out clearly. One notable innovation comes from Qiu et al., who created a dual-mode optical biosensor for coronavirus detection. This biosensor utilises a combination of localised surface plasmon resonance and plasmonic photothermal effects, incorporating gold nanomaterials on a glass surface. They modified the nanomaterial with complementary DNA receptors for detection, improving sensing accuracy by employing two different sample angles and achieving a detection limit of 0.22 pM. The readers can find out more explanations about novel discovery in optical biosensors for other dreadful viruses; HIV, Hepatitis, Ebola, Zika, Norovirus, Influenza, and more through this book. This part is very beneficial for the readers because the authors explain the basic principle of the biosensors with excellent writing skill, provided a colourful schematic representation, and mention the advantages of each biosensor.

The next chapter begins by elucidating the fundamental principle underlying electrochemical sensors. These sensors rely on chips with affinity ligands, and their operation is based on the creation of an electric signal when a target molecule binds to the sensor. The chapter effectively breaks down the intricacies of this principle, making it accessible to a wide range of readers. Electrochemical sensors consist of two main components: the recognition part and the physicochemical transducer. The recognition part can include enzymes, antibodies, proteins, or molecularly imprinted polymers. Meanwhile, the physicochemical transducer transforms electrochemical information into a measurable signal, typically involving working, reference, and counter electrodes.

Furthermore, the chapter delves into various types of electrochemical sensors, including potentiometric, amperometric, cyclic voltammetry, capacitance, and impedimetric-based sensors. Each sensor type is explained in terms of its working principle and potential applications.

The chapter also highlights the significant role of nanomaterials, such as graphene, carbon nanotubes, and metal nanorods, in enhancing the performance of electrochemical sensors. These materials increase surface area, sensitivity, and selectivity, leading to more efficient and effective sensing platforms.

In addition, the chapter underscores the application of electrochemical sensors in virus detection. It discusses how electrodes can be modified with viral proteins, complementary probes, or antibodies to detect specific viruses. Case studies, including the detection of influenza, human papillomavirus, and hepatitis B virus, demonstrate the practicality of these sensors in addressing real-world medical challenges.

Chapter 4 serves the material about piezoelectric as biosensor for virus detection, which has previously been very popular in the areas of drug delivery mechanism, environmental pollution, food control, etc. As a principal basic of this biosensor, piezoelectric materials convert mechanical energy into electrical energy and vice versa which makes piezoelectric biosensor devices based on label-free techniques have made great findings and have been successfully used for virus detection. The interaction between the biosensor chip's metal surface and the target analyte is direct and does not require the application of any specific reagent or sample processing. This section delves into the principles of piezoelectric biosensors, especially for some dangerous and most influential viruses through the novel invention by the researchers. One example which is interesting to highlight is piezoelectric quartz crystal chip established by Skládal et al. It was modified from piezoelectric quartz crystal resonators using oligonucleotide probes for the detection of the hepatitis C virus in serum samples. Not only explain the principle, but the authors also give a review for each sophisticated biosensors technology. In fine, piezoelectric will become an ideal tool for further research in the development of portable and wearable biosensors.

The authors explain fluorescence-based optical biosensor in chapter 5. Fluorescence-based optical biosensors have become a prominent group of sensors due to their widespread use, facilitated by the availability of fluorescent probes, optical fibres, and related instruments. What sets fluorescence biosensors apart is their ability to detect viruses through various parameters like intensity, energy transfer, lifetime, and quantum yield. Förster resonance energy transfer (FRET) plays a crucial role in these biosensors, enabling the detection of close interactions between analytes and fluorophores, often with an emphasis on upconverting and downconverting fluorescence modes.

Fluorescence spectroscopy, with its remarkable sensitivity, has been employed for ultra trace-level virus detection. Techniques such as plasmon-enhanced fluorescence (PEF) and metal-enhanced fluorescence (MEF) have extended the capabilities of fluorescence biosensors, enabled the use of weak quantum emitters and expanded the potential for high-resolution imaging. Researchers have developed innovative methods, including localised surface plasmon resonance (LSPR)-induced fluorescence immunosensors for influenza virus detection and a novel approach for detecting multiple serotypes of HIV. The combination of lateral flow techniques with surface-enhanced fluorescence (SEF) has also shown promise in detecting viruses like the Ebola virus glycoprotein.

Chapter 6 discusses the principle behind thermal sensors for biosensing involves measuring the heat generated or absorbed during a biochemical reaction. The total heat (Q) is directly related to the product formed and the molar enthalpy change (ΔH) of the reaction. This relationship is dependent on the heat capacity (Cp) of the reaction medium. Organic solvents are preferred in some cases because they offer greater sensitivity due to their lower heat capacity compared to aqueous solvents. Sensitivity can also be improved by modifying the biochemical reaction, such as co-immobilising enzymes or using specific buffer ions.

Thermal sensors have evolved into modern and sophisticated biosensors since the discovery of thermistors. They find extensive applications in healthcare due to their simplicity and ease of use. Miniature thermal biosensor devices have been developed for applications in bioprocess industries. Emerging trends include the use of Y-cut quartz resonators, which offer exceptional temperature sensitivity, and MEMS (Microelectromechanical systems) thermal biosensors, known for their low sample volume requirement and high sensitivity. Research is ongoing to develop multiplexed thermal biosensors for various analytes, including uric acid, glucose, insulin, and applications involving living systems.

The 7th chapter discusses magnetic biosensors. Magnetic biosensors are employed to detect changes in magnetically induced outcomes or magnetic properties in response to biological reactions. These biosensors use superparamagnetic or paramagnetic crystals or particles to measure alterations in their magnetic characteristics, typically through coil inductance or resistance.

There are two main categories of magnetic biosensors: substrate-based and substrate-free. Substrate-based biosensors involve probes with magnetic nanoparticles (MNPs) that bind directly to the biosensor's surface after the analyte is targeted. In contrast, substrate-free biosensors rely on changes in the resonance behaviour of MNPs after probe and target hybridisation. Magnetic biosensors offer unique advantages in terms of signal-to-noise ratio, biosensor size, types of particles used, experimental approach, and amplification techniques. This chapter is fully filled with the latest applications of fluorescence biosensors for virus detection, an overview of molecularly imprinted polymers fluorescence-based virus detection, and future perspectives.

The authors emphasise discussing Plasmon-enhanced fluorescence (PEF) and Metal-enhanced fluorescence (MEF) or plasmons enhanced fluorescence or surface-enhanced fluorescence (SEF).

The last chapter explains micromechanical biosensors which play a vital role in the detection of specific analytes in various environments, including liquid, air, or vacuum. These sensors are based on micro-nanomechanical structures, such as cantilevers, which can generate acoustic waves and respond to surface stress. These sensors have their origins in the development of the atomic force microscope (AFM), which used a cantilevered sharp tip to probe surfaces. Cantilevers in AFM can operate in static or dynamic modes. In static mode, the deviation caused by contact with the surface is used as feedback, while in dynamic mode, the cantilever vibrates near its resonance frequency, and the vibration amplitude is used as feedback. These principles have been adapted for micro- and nanometer-scale cantilevers, offering various modes for actuation and sensing, including electrostatic, optical, mechanical, and electromagnetic methods.

Even though the materials on biosensors platform are quite heavy, the authors are able to make the reader feel addicted to sweeping away all the information presented through the author's appealing writing style. This writing seems to hypnotise the reader to dive into the information presented in depth with the hot topics discussion. The information is presented in an easy-to-understand style, while also being detailed and structured. In addition, the coloured illustrations help the readers imagine every component in each biosensor. This book also presents a future perspective that can provide an overview of opportunities for certain types of biosensors in the future. However, in chapters 4 and 6 this section does not yet exist. The existence of a further reading or additional reading section enriches the material for understanding biosensors.

In conclusion, the book discusses hot topics, offers a comprehensive understanding of various biosensor technologies for virus detection, highlighting their principles, applications, and recent advancements. It serves as a valuable resource for students, researchers, and healthcare practitioners interested in the field of biosensors and their role in combating viral infections. The new innovations presented in this book have the potential to inspire the development of more practical and effective biosensor technologies. Briefly, I highly recommend this book because it is such a great discovery! This book is full of new information and literature about biosensors for virus detection which makes this book very rich and worth having.

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