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Editorial

Special Issue on Electroporation Systems and Applications

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1. Introduction

High pulsed electric fields (PEF) trigger the phenomenon of a transient increase in the permeability of the plasma membranes of biological cells, which is known as electroporation [1,2]. In the case of high-intensity PEF, the process can be irreversible, resulting in cell death. The capability to employ electroporation for drug and gene delivery [3,4], food processing [5], tissue ablation [6] and biorefinery [7] ensures the high relevance of the topic and the method, which will persist decades. Due to a variety of biological phenomena triggered by PEF and its wide array of applications, the field is highly transdisciplinary, joining together electrical and electronics engineers, medical doctors (cardiology, oncology, immunology, dermatology, etc.), microbiologists, chemists, molecular biology specialists and many others. More than 17,500 publications are indexed in Clarivate Analytics Web of Science (access date: 26 February 2023) on the topic; the summary of keyword co-occurrence is shown in Figure 1.

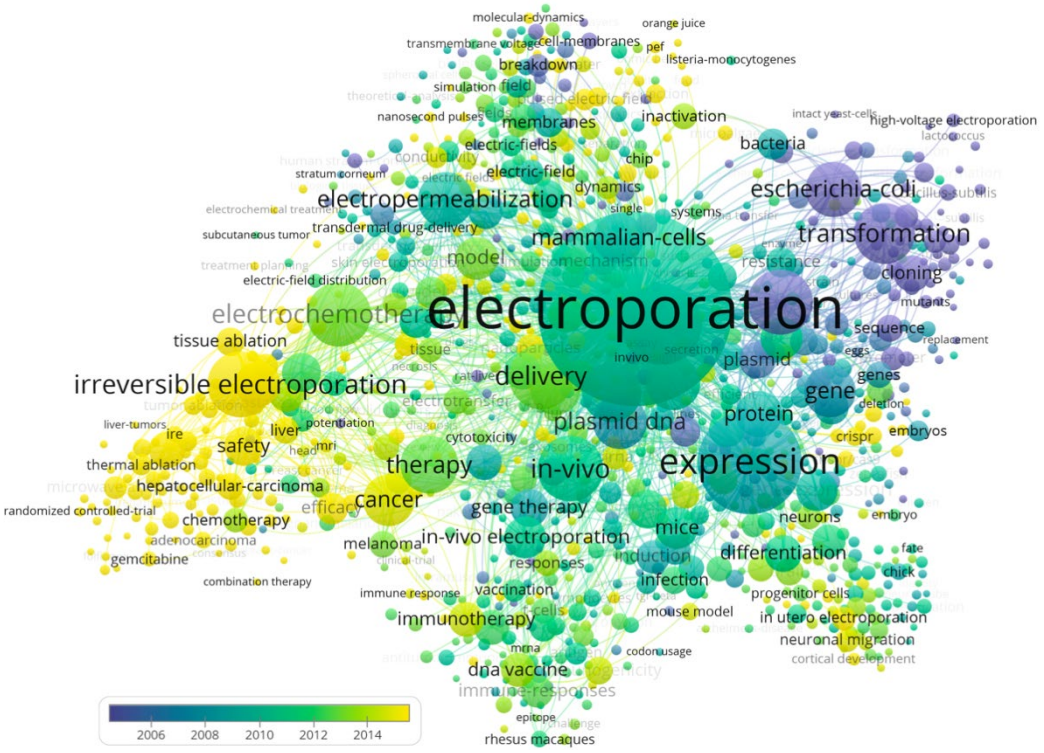

Figure 1. The co-occurrence of electroporation-based topics and keywords in scientific publications (source: Clarivate Analytics Web of Science; keyword: "electroporation"; access date: 26 February 2023). Processed using VOSviewer, version 1.6.18 (Leiden University). Larger circle size corresponds to a higher rate of occurrence of a keyword.

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It can be seen that, in recent years, the applied aspects of the methodology have been the central focus (i.e., irreversible electroporation and cancer treatment applications), which indicates the successful transition from fundamental science into clinical practice. In the early 2000s, the applied aspects of the electroporation methodology were mainly limited to non-viral transfection of microorganisms as a biotechnological step in routine research.

2. Special Issue on Electroporation Systems and Applications

In light of the above, this Special Issue (SI) was introduced to collect the latest research on the topic of electroporation, as well as to grasp the recent, state-of-art advances in the applied aspects of electroporation. A total of 10 papers were published, with more than 45 contributing authors from different countries. A summary of the articles published in the Special Issue is shown in Figure 2.

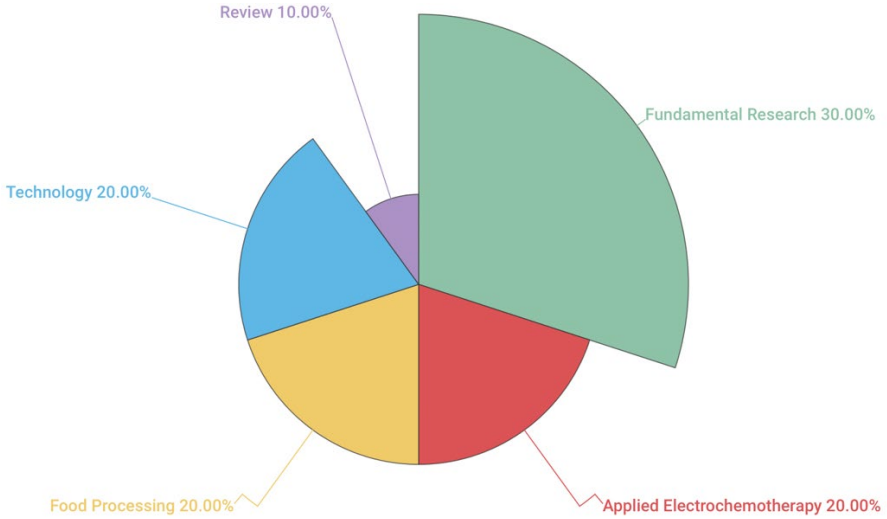

Figure 2. A summary of published articles in the Special Issue based on the covered sub-topics**.**

It can be seen that this SI covers many different sub-topics, which supports the interdisciplinarity of electroporation-based technologies. The paper by Rakoczy et al. [8] provides a comprehensive review of the mechanism of electroporation in the context of gene delivery and electrochemotherapy, overviews prospective applications in medicine and describes novel possibilities for further research. The study by Chiaramello et al. [9] describes a computational approach for the assessment of electric field enhancement using highly conductive gold nanoparticles (Au NPs) in time-varying electromagnetic fields for cell membrane permeabilization, which may be a further evolutional step from conventional electroporation to contactless treatment. The paper by Šalaševičius et al. [10] analyzes the feasibility of electroporation for efficient milk pasteurization while preserving nutrient value, and compares bacterial inactivation efficacy to traditional pasteurization techniques used in the food industry. Novickij et al. [11] present a new bipolar electroporator capable of forming high-frequency pulses in a broad range of parameters (65 ns–100 µs), while Agnass et al. [12] propose an Electric-Potential Estimation (EPE) method for the accurate prediction of electric-potential distribution in the vicinity of cylindrical electrodes during electroporation-based treatments. Matys et al. [13] employ electroporation as a pretreatment step for hybrid drying of apples, while Potočnik et al. [14] explore, evaluate and demonstrate the potential use of different pulse durations for introducing plasmid DNA (pDNA) into cells in vitro; they also compare the efficiency and dynamics of transgene expression after gene electrotransfer. Perminaitė et al. [15] propose a proof of concept for the development of novel clinical procedures based on electroporation to fight drug-resistive microorganisms responsible for wound contamination and chronic wounds, and Palepšienė et al. [16] provide insight into the importance of Ca2+ in the process of gene electrotransfer. Finally, Tunikowska et al. [17] highlight the applicability of Indocyanine Green (ICG) for

electrochemotherapy with bleomycin, which enables the control and detection of drug distribution.

3. Future of Electroporation-Based Technologies

Although the Special Issue has been closed, the rapid evolution of the electroporation field towards clinical and biotechnological applications indicates the high relevance of the topic and the emergence of new PEF-based technologies. Recently, the potential of pulsed field ablation in the context of atrial fibrillation was highlighted, as it is currently a serious focal point for scientists [18]. Additionally, the feasibility of high-frequency bipolar pulses to minimize muscle contractions and improve the homogeneity of electric fields is being analyzed [19]. Finally, the possibility of a transition to contactless electroporation via the application of a high pulsed electromagnetic field is being researched [20], indicating the good development dynamics of this scientific field and this method.

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