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Editorial

Current Advances in Fuel Cell Technology

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1. Introduction

Fuel cell technology is a significant contributor to the global push towards clean energy, offering high efficiency and low emissions ideal for applications such as electric vehicles and stationary power systems. This Special Issue of *Energies* entitled "Current Advances in Fuel Cell Technology" collates pioneering research in this field, exemplified by nine highly regarded papers that highlight the importance and impact of research into this technology. This editorial showcases key contributions from this Special Issue, including recent advances and potential future directions for fuel cell research.

2. Contents of the Special Issue

This Special Issue covers several critical aspects of fuel cell research, from enhancing efficiency and durability to improving environmental sustainability. Below, we examine some of the notable contributions of the studies presented here.

2.1. Optimising PEMFC Flow Field Designs

In the study by Rosli et al. [1], the researchers investigated the effects of channel geometry on the performance of proton exchange membrane fuel cells (PEMFCs). Using computational fluid dynamics (CFD) models, they explored configurations such as single-channel, seven-channel, and multi-channel setups. Their findings revealed that the single-channel designs provide high current density due to streamlined reactant flow; in contrast, multi-channel designs help to improve reactant distribution, which is beneficial for larger cells. This study provides valuable insights into the balance between efficiency and scalability when tailoring PEMFCs to specific applications.

2.2. Sustainable Corrosion Protection Solutions

Durability is a major challenge for fuel cells, as metallic components are prone to corrosion, a process that can significantly reduce their lifespan. To address this issue, Arwati et al. [2] explored the use of chitosan—a biodegradable compound derived from natural sources—as an environmentally friendly corrosion inhibitor for aluminium alloy components. Their experiments showed that chitosan coatings reduced corrosion rates by up to 95% in acidic environments. This approach would not only enhance the longevity of fuel cell components but also offer an eco-friendly alternative to traditional inhibitors like chromate, in line with ongoing efforts to promote the more widespread usage of sustainable materials.

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2.3. Advanced Modelling and Validation Techniques

Modelling and simulation play crucial roles in understanding the behaviour of fuel cells and predicting their performance under a range of conditions. Multiple studies in this Special Issue, including one by Śreniawski et al. [3], combine CFD models with real-world experimental data to validate the accuracy of these models. This integration of simulation and empirical testing can help accelerate the design process, allowing researchers to evaluate concepts virtually before progressing to the physical prototyping stage.

2.4. Effective Water and Thermal Management

Efficient water and thermal management are essential for maintaining stable fuel cell operations, particularly in high-performance applications where water accumulation and heat build-up can compromise cell integrity. This Special Issue includes studies that propose innovative solutions to these problems, such as multi-layer diffusion media and optimised flow channels, which can help to maintain ideal water and temperature levels within the cells. These approaches are critical to prolonging PEMFC lifespan and ensuring consistent fuel cell performance.

3. Challenges and Future Opportunities

While substantial progress has been made in fuel cell research to date, various challenges remain, and there are still many opportunities for further improvement.

3.1. Enhancing Material Durability

While chitosan and other eco-friendly corrosion inhibitors show significant promise, there is also a need for materials that can withstand long-term use under harsh conditions. The development of hybrid materials that combine corrosion resistance, durability, and environmental sustainability could provide a transformative solution to this challenge.

3.2. Scaling for Industrial Applications

Transitioning fuel cell technology from research laboratories to industrial production requires both scalability and cost-efficiency. Smaller cells can benefit from single-channel designs, but larger cells require multi-channel configurations to ensure the uniform distribution of reactants and water. Research focused on developing scalable and cost-effective designs will be crucial for the widespread adoption of fuel cell systems.

3.3. Mastering Water and Thermal Control in Large-Scale Applications

Water and heat management become increasingly complex in large fuel cell stacks, where even small fluctuations in these parameters can disrupt the stability of the output power. Future studies could focus on flow channel designs and material selection to help facilitate heat dissipation and prevent water accumulation, thus ensuring stable performance even under demanding conditions.

4. Conclusions

In summary, this Special Issue of *Energies* entitled "Current Advances in Fuel Cell Technology" highlights key advances in channel design, corrosion protection, and water management. The studies presented in this Special Issue address critical challenges in fuel cell technology and provide a solid foundation for future innovations. In the future, a continued focus on sustainable materials, sophisticated modelling, and effective water and thermal management will be essential for fuel cell development beyond the laboratory. This Special Issue serves as a valuable snapshot of current progress and a guide for future research in this evolving field.

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