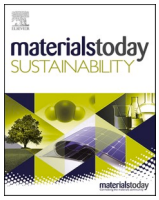
Materials Today Sustainability 26 (2024) 100709

Contents lists available at ScienceDirect

Materials Today Sustainability

journal homepage: www.journals.elsevier.com/materials-today-sustainability



A class of promising fuel cell performance: International status on the application of nanofluids for thermal management systems

A.G.N. Sofiah [a,*], J. Pasupuleti [a,**], M. Samykano [b], A.K. Pandey [c,d], Reji Kumar Rajamony [a,e], Nur Fatin Sulaiman [f], Zatil Amali Che Ramli [a]

[a] Institute of Sustainable Energy, Universiti Tenaga Nasional (The Energy University), Jalan Ikram-Uniten, Kajang 43000, Selangor, Malaysia
[b] Centre for Research in Advanced Fluid and Processes, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia
[c] Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya, 47500 Selangor Darul Ehsan, Malaysia
[d] Center for Transdisciplinary Research (CFTR), Saveetha University, Chennai, India
[e] Devision of Research and Development, Lovely Professional University, Phagwara, 144411 Punjab, India
[f] Institute of Informatics and Computing in Energy, Universiti Tenaga Nasional (The Energy University), Jalan Ikram-Uniten, Kajang 43000, Selangor, Malaysia

ARTICLE INFO

Keywords:
Fuel cell
Nanofluids
Energy
Thermal management
Heat transfer

ABSTRACT

Fuel cell technologies are developed due to their positive impact on the environment and their ability to empower sustainable energy compared to other power generators. The operating temperature of fuel cells influences the maximum capacity of the devices, with higher heat generation resulting in a lower theoretical maximum voltage and affecting the system's efficiency. The utilization of nanofluid systems in this kind of energy-related application is employed at lower costs but with higher efficiency. This review article investigates the recent development of nanofluids for the thermal management system of fuel cell technologies to enhance sustainable energy in the future. Nanofluids serve as coolants and create excitement among researchers due to their excellent behavior in thermal conductivity. This article, therefore, reviews the cooling approaches that have been commercialized for fuel cell devices and reports recent progress in the thermal management system and the employment of nanofluids in different types of fuel cell technologies. Important properties of nanofluids are critically discussed, and recent case studies (2018–2023) are recorded to provide a comprehensive understanding to the readers. Finally, the advantages and disadvantages of nanofluids as coolants for fuel cell operation are discussed. It is reported that these nano-enhanced coolants provide improvements to fuel cell technology in terms of smaller system dimensions, eliminating deionizing components, and exhibiting higher heat transfer behavior compared to conventional coolants. Progressively move towards cleaner energy, including nanofluids into fuel cell design offers a viable way to achieve higher energy efficiency, less environmental impact, and a more sustainable future.

1. Introduction

Recently, the application of nanofluid system in various devices has been vigorously developed. Numbers of research has been completed and published on their fundamental study and nowadays, researchers are focusing to thermal application of nanofluid system due to its promising behavior in thermal conductivity enhancement [1–3]. Other than that, nanofluid system are very convincing in renewable energy application such as solar thermal devices, fuel cell, and photovoltaic instruments [4]. By using nanofluid, this kind of energy-related application can be employed at lower costs but higher efficiency [5–7]. However, a good formulation of nanofluids must obtained an outstanding thermal conductivity property at lower viscosity. Using those considerations, most researchers in nanofluid research area are evaluating fundamental study of nanofluids including their heat transfer properties [8,9] and rheology behavior [10,11]. Nevertheless, publications in nanofluid study have also focused on the application of nanofluid in many devices, such as heat exchangers as many researchers have attempt to enhance the efficiency of these kind of devices to achieve the demand of energy worldwide and to overcome the depletion of fossil fuel sources issue [12–14] The efficiency of these devices can be improve

* Corresponding author.
** Corresponding author.
E-mail addresses: nurhanis.sofiah@uniten.edu.my (A.G.N. Sofiah), jagadeesh@uniten.edu.my (J. Pasupuleti).

https://doi.org/10.1016/j.mtsust.2024.100709
Received 6 December 2023; Received in revised form 26 January 2024; Accepted 10 February 2024
Available online 14 February 2024