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Review Article

Direct liquid fuel cells: A review

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ABSTRACT

Direct liquid fuel cells (DLFCs) are one of the most promising types of fuel cells due to their high energy density, simple structure, small fuel cartridge, instant recharging, and ease of storage and transport. Alcohols such as methanol and ethanol were the most common types of fuel used, although glycols and acids are also used. The main problem that arose in direct liquid fuel cells (DLFCs) was the high cost of the catalyst and the high catalyst loading. Other issues, such as fuel crossover, cathode flooding, the generation of various side products, fuel safety and unproven long-term durability, must also be solved to improve the performance of DLFCs. More research studies were required to increase its performance and foster commercialization. Currently, there were some commercial products using direct methanol fuel cells (DMFCs) and direct ethanol fuel cells (DEFCs), but the other types of DLFCs were generally still in the research stage. This paper aims to review the different types of liquid fuels directly used in fuel cells and identify their properties, challenges and applications.

Contents

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Introduction

DLFCs are one type of fuel cell that is currently under intense study, due to their advantages over hydrogen-fed polymer electrolyte membrane fuel cells (PEMFCs). PEMFCs, which use hydrogen as their fuel, are considered to be a pioneering type of fuel cell that performs well in many applications, such as the automobile industry. However, hydrogen fuel usually needs to be stored under high pressure during operation. This may lead to accidents such as explosions if the hydrogen is not being handled properly, and it is the main safety issue related to PEMFCs. Furthermore, hydrogen fuel is highly flammable and poses transport and storage problems [1]. DLFCs appear to be an alternative type of fuel cell because of their liquid fuel and easy handling of the fuel [1–5].

In this modern era, the increased demand for high-tech portable electronic devices such as cellular phones and laptop computers that require high power output and long operation times has driven the need for better sources of power. DLFCs are considered the most suitable candidates for mid-size powers ranging from a few hundred watts to around 3 kW and very specialized applications of military purposes [5,6]. Furthermore, lithium ion battery operated devices have mobility limitations, in that they are not suitable for use in remote places that lack an electrical power supply, whereas DLFCs can operate without an electrical power supply [7]. Additionally, liquid fuels generally have a higher energy density than lithium ion polymers, approximately 600 Wh kg^{-1}. This shows that DLFCs can provide longer conversation times when using a mobile phone, longer usage times for laptop computers, more power available to meet consumer demand, and convenient refuelling that is instantaneous compared to that of a rechargeable battery, which needs hours for charging when depleted [8]. In DLFCs, liquid fuel is fed directly to the anode, at which an oxidation reaction occurs, while air or oxygen gas is sent to the cathode for the reduction reaction. The charged ions pass through the electrolyte, and electrons travel via an external circuit. There will always be some side product produced in the anode due to incomplete oxidation of fuel, whereas, at the cathode, the waste product will be mostly water [9]. Fig. 1 shows a diagram outlining the general operation of DLFCs.

Dermici [10] presented a review on different type of direct liquid-feed fuel cells focussing on thermodynamic-energetic data and toxicological–ecological hazards of the chemicals used as liquid fuels. Later Soloveichik [11] presented a review on Liquid Fuel Cell focussing different types of organic and inorganic fuel as an anode material for LFCs. While this paper aims to present a detail review on Direct Liquid Fuel cell considering acid and alkaline type of fuel cell. It focuses on

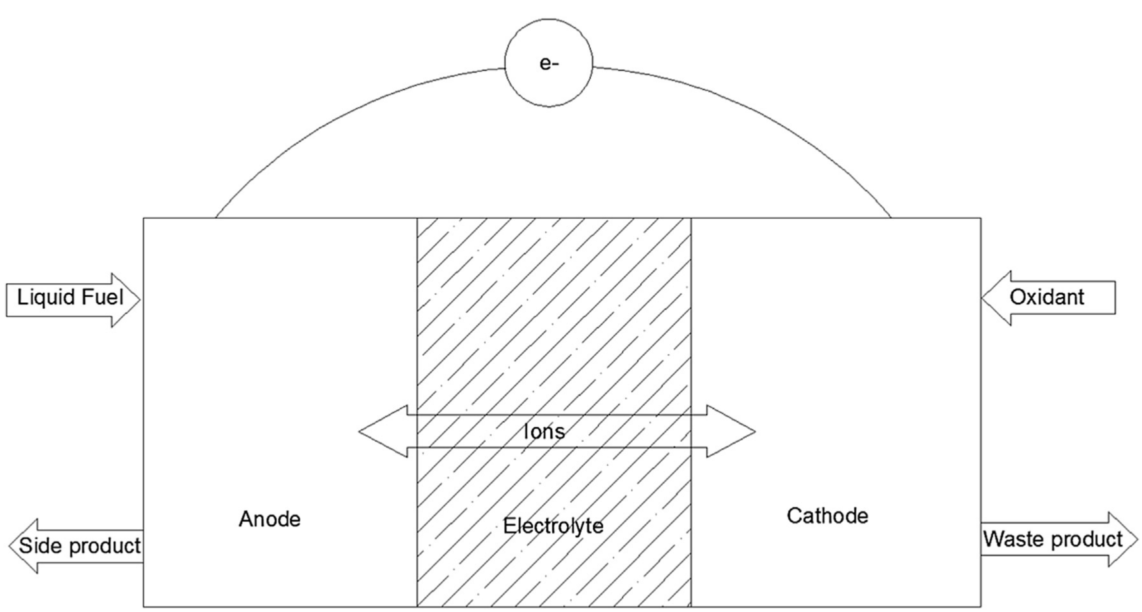

Fig. 1 – General operating principle of DLFCs.

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