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# Wire mesh current collectors for passive direct methanol fuel cells

Naveen K. Shrivastava [a,*], Shashikant B. Thombre [a], Ramani V. Motghare [b]

[a] Department of Mechanical Engineering, Visvesvaraya National Institute of Technology, Nagpur 440010, India
[b] Department of Chemistry, Visvesvaraya National Institute of Technology, Nagpur 440010, India

## HIGHLIGHTS

- Feasibility of stainless steel wire mesh as current collector (CC) in passive DMFC is investigated.
- A novel single cell fixture is designed and fabricated.
- Five different wire meshes are used as CC.
- Wire mesh CC exhibited better fuel distribution at anode catalyst layer compared to conventional CC.
- Identifies the wire mesh as promising material to be used as CC.

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## ABSTRACT

This paper examines the feasibility of the stainless steel wire mesh as current collector in the passive direct methanol fuel cell (DMFCs-W). A novel single cell fixture is designed and fabricated. The cell performance is evaluated and compared with five different wire mesh current collectors. The supporting plates are optimized for every mesh. The performance of DMFCs-W is compared with the conventional passive DMFC which uses perforated metal plate as current collector (DMFC-P). The polarization tests and electrochemical impedance spectroscopy are performed to investigate the different aspects of the cell performance. The results reveal that the DMFCs-W yield better performance than the DMFC-P. Also, more uniform fuel distribution at catalyst layer and higher cell temperature is achieved with wire mesh current collectors. It is found that the wire mesh geometry has significant effect on the cell performance and the mesh made of relatively thick wires gives better cell performance. This study identifies the stainless steel wire mesh as promising material to be used as current collector and potential substitute to the perforated plate current collectors in the passive DMFC.



## 1. Introduction

The passive direct methanol fuel cells (DMFC) have emerged as potential source for powering portable electronic devices such as mobile, laptop, i-pod, etc. The passive DMFC does not have energy consuming auxiliary devices such as pumps, fans, blowers etc. and rely on passive means such as diffusion, natural convection and capillary action for supply/removal of the reactants/products [1,2]. Hence, the passive DMFCs have low parasitic power losses, high energy density, high efficiency, simpler and more compact structure and are considered as a great alternative to the rechargeable batteries [1–4].

The passive DMFC is primarily composed of methanol solution reservoir, membrane electrode assembly (MEA), anode and cathode current collector, anode and cathode end plate. The current collectors are one of the most important components of the passive DMFC. These are used to collect the current generated in the MEA and provide passage for transportation of the reactants (methanol and water on the anode and oxygen on the cathode) and products (carbon di-oxide on the anode and water on the cathode). The current collectors are expected to have good mechanical strength, high electrical conductivity, low thermal conductivity, high corrosion resistance, uniformly distributed transport area, light weight, low cost, easy machining and wide availability [1,2,4]. Typically, the 1 mm–3 mm thick metal plate with the array of drilled holes (known as perforated current collector) or with rectangular parallel channels (known as parallel current collector) are used as current collectors [3–25]. Different materials such as stainless steel (SS) plate [5,9–11], gold coated SS plate [13], platinum coated SS plate [16], titanium nitride (TiN) coated SS plate [21], gold coated printed circuit board (PCB) plate [22] and graphite plate [19] are used as current collectors.

* Corresponding author. Tel.: +91 712 2801535; fax: +91 712 2223230.
*E-mail address:* shri.nav@gmail.com (N.K. Shrivastava).

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Several studies related to the structural aspects of perforated plate (hole-array or parallel channels) current collectors have already been performed. The effect of non-uniform parallel channels on the performance of passive DMFC has been studied by Gholami et al. [11]. They showed that the current collector with non-uniform parallel channels is more effective in removing $CO_2$ gas than the current collector with parallel channels. Yuan et al. [9] investigated the effects of structural diversity on the performance of a liquid-fed passive DMFC. They recommended the use of circular hole-array pattern with a lower open ratio at the anode but parallel-fence pattern with a higher open ratio at the cathode. A passive DMFC with its cathode current collector made of porous metal foam has been investigated experimentally by Chen & Zhao [26]. They showed that the passive DMFC having the porous current collector yielded much higher and more stable performance than the cell having the conventional perforated-plate current collector with high methanol concentration operation.

Metal mesh provides an excellent alternate or substitute to the perforated metal plate current collectors. As compared to the perforated metal plates; the metal meshes are lighter in weight, cheaper, involves low fabrication cost and offers high open ratio. The metal mesh can be categorized mainly into two types; expanded metal mesh and wire mesh. The expanded metal mesh is produced by simultaneously slitting and stretching a metal plate or sheet. In this process the cuts are expanded into diamond shaped holes. The expanded metal mesh has been used as current collector in many of the previous studies [27–37]. Platinum coated niobium expanded mesh, platinum coated stainless steel (SS) expanded metal mesh, 304 SS expanded mesh, SS expanded mesh with gold coating were used as current collector in several passive DMFC stacks and single cells. The expanded metal mesh can be characterized by opening dimensions, strand width, strand thickness and open ratio etc. Not much research efforts regarding structural optimization of the expanded metal mesh as current collector have been found. Guo and Faghri [36] compared the single cell performance with gold coated SS expanded mesh and platinum coated niobium expanded mesh as current collectors which was either put directly on the diffusion layers (DL) or hot-pressed on the diffusion

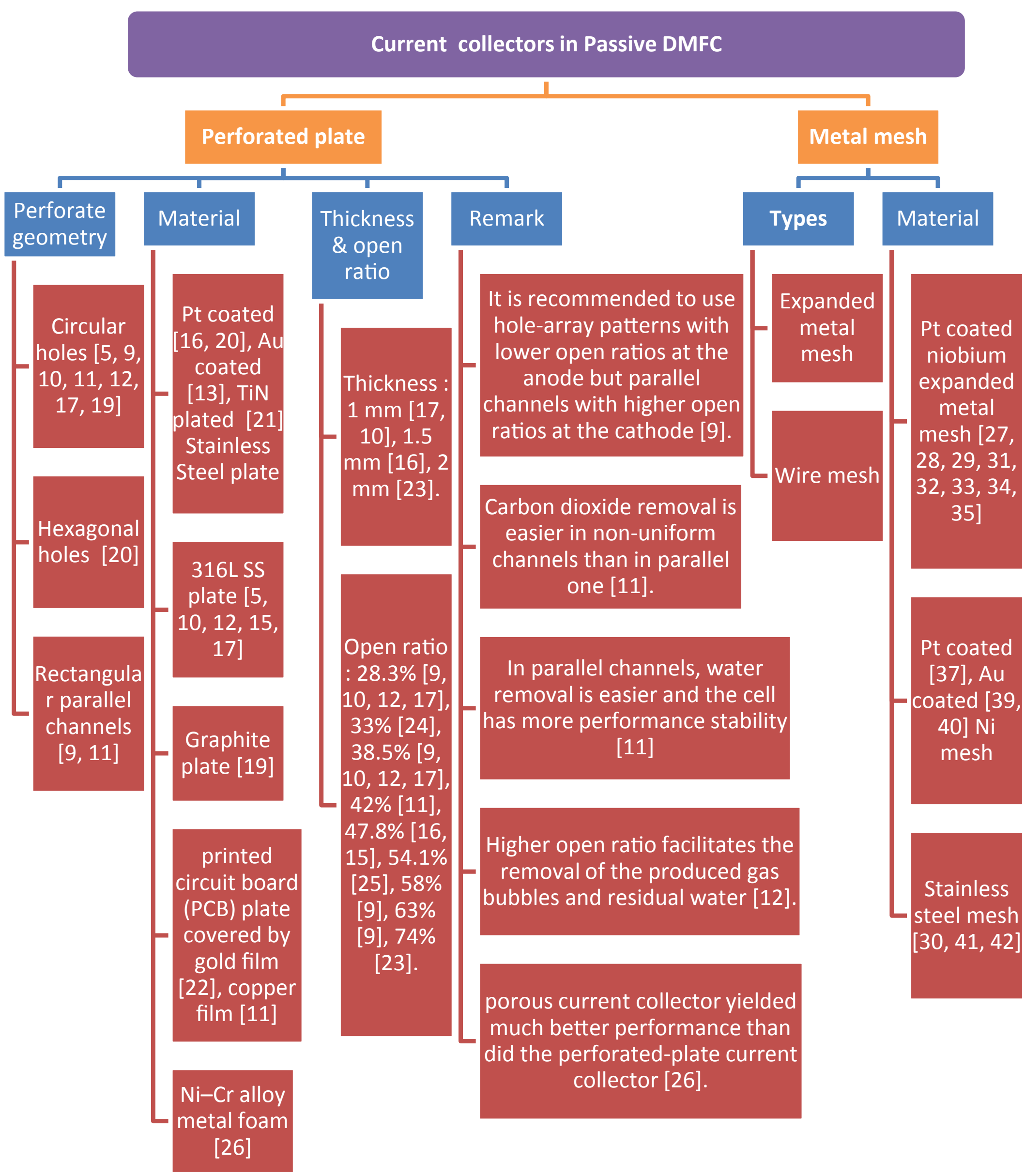


**Fig. 1.** Current collectors in passive DMFCs.