A New Concept of Zero Emission for Solid Oxide Fuel Cell System*

MA Wen hui, YANG Bin, YU Jie, WANG Hua, DAI Yong nian
(Faculty of Materials and Metallurgical Engineering, Kunming University of Science and Technology, Kunming 650093, China;
//Key Laboratory of Vacuum Metallurgy of Non-ferrous Metals of Yunnan Province, Kunming 650093, China)

Abstract: A new concept of zero emission for solid oxide fuel cell system was proposed, which has some advantages such as high power generation efficiency, zero emission of greenhouse gas, carbon dioxide recycling, and reusable material with environmental benign for carbon dioxide capture. In addition, the component materials of solid oxide fuel cell and reusable material of carbon dioxide capture were reported and prepared. The maximum volume absorption ratio could be 993 and the optimum capture temperature is 700 ℃ for new absorption material, and carbon dioxide captured could desorb completely if the temperature is higher than 800 ℃ in 2 hours.

Key words: zero emission; solid oxide fuel cell; carbon dioxide recycling; Li_4SiO_4

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1 Introduction

In order to reduce costs, particularly of interconnect, manifolding and sealing materials of solid oxide fuel cells (SOFCs), one promising way is to decrease operating temperature, that is, intermediate temperature solid oxide fuel cells (ITSOFCs), using hydrocarbon as fuel with internal fuel reforming function[1]. It could eventually decrease the emission of greenhouse gas such as carbon dioxide and increase the efficiency of fuel compared to conventional internal combustion engine because of the limit of carnet cycle. However, carbon dioxide emits into the atmosphere and the efficiency is also relative low to electricity generation in some special applications. Therefore, it is necessary to design and research new system for intermediate temperature solid oxide fuel cell with higher power generation efficiency and zero emission for the operation system.

In this paper, a new concept of zero emission for solid oxide fuel cell system was proposed. In addition, the relative materials research about it and the capture property of carbon dioxide with new reusable material with environment benign were also reported simultaneously.

2 New concept of zero emission

Fig. 1 shows the schematic diagram of new concept of zero emission for solid oxide fuel cell system. For this system, there are some advantages.

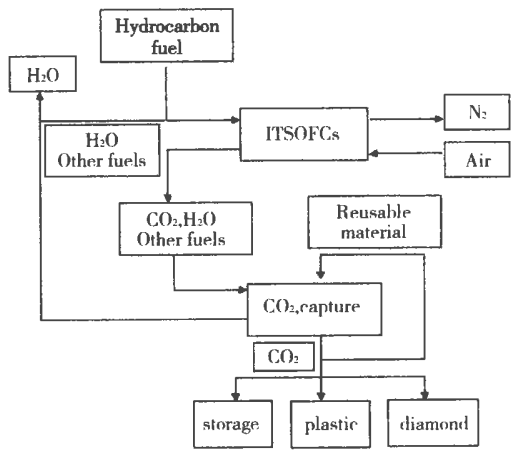

Fig 1 Schematic diagram of new concept of zero emission for SOFC system

(1) High efficiency of electricity generation. For traditional system, the flue gas from anode in fuel cells containing unreacted gas such as carbon monoxide, hydrogen and other type of hydrocarbon combust completely in the second fire chamber for heat recovery leading to heat production that excesses the demand in some regions. For example, Kunming city named spring city is relative warm in the winter, it is better to generate more electricity with solid oxide fuel cells installed in such city in the future.

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作者简介: 马文会 (1973 年生), 男, 副教授; E-mail: mwhui@kmust.edu.cn

Therefore, it could be realized if we recycle the unreacted gas to anode after separation of carbon dioxide and some part of steam because of additional water needed for internal reforming of hydrocarbon fuel at anode side in solid oxide fuel cell system. Among them, the most important aspect is the separation of carbon dioxide from the flue gas.

(2) Zero emission could be realized. For this system, the production at anode is only steam, carbon dioxide and others combustible fuels. If we could capture carbon dioxide from the production and then pure water could also be obtained, which realizes the zero emission for this system.

(3) High purity carbon dioxide obtained and easy to recycle. After desorption of carbon dioxide captured in material, gas with high purity could be used as raw material for production of plastic and diamond or put under the deep sea after compress and package.

(4) Material for carbon dioxide capture is reusable with environmental benign. The operation principle of this novel material for carbon dioxide absorption is shown in Fig. 2.

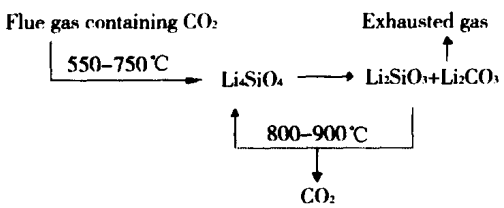


Fig 2　Working principle of reusable material for carbon dioxide capture

3　Preparation of component materials

Component materials for solid oxide fuel cells have been researched and synthesized successfully via solid reaction or sol-gel methods by authors[2,3], such as anode material $La_{1-x}Sr_xMn_{1-y}Cr_yO_3$ (LSMC), cathode material $La_{1-x}Sr_xFe_{1-y}Co_yO_3$ (LSCF) and electrolyte material $La_{1-x}Sr_xGa_{1-y}Mg_yO_3$ (LSGM), which is not discussed in detail in this paper. For example, the SEM and TEM photographs are shown in Fig. 3 (a) and (b), respectively.

In addition, Li_4SiO_4 could be used as reusable material for carbon dioxide capture proposed by authors was also prepared using solid reaction method without other secondary phase via X-ray diffraction measurement. This material has some advantages for carbon dioxide capture such as cheap raw materials, reusable with environment benign, high capture volume ratio and so on.

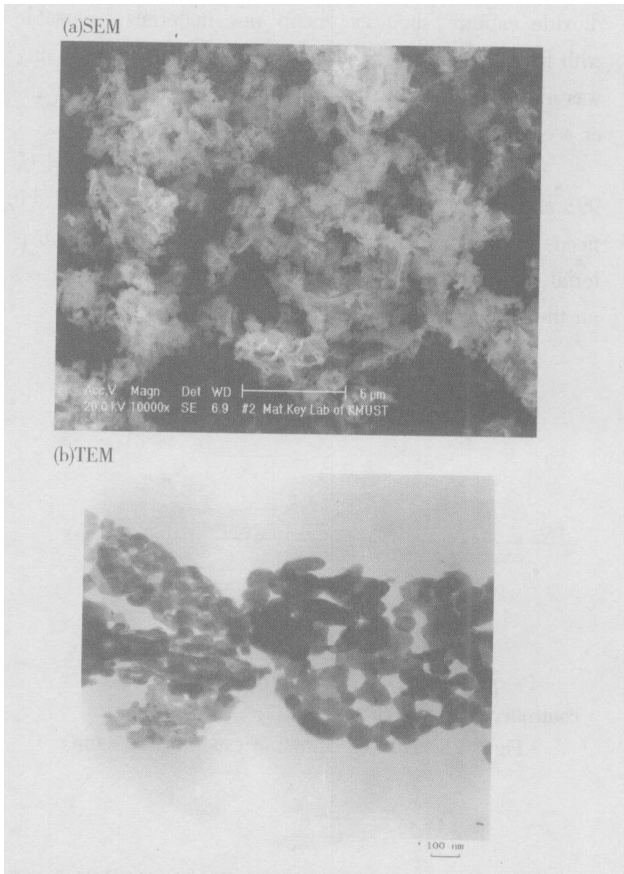


Fig 3　SEM (a) and TEM (b) photographs of $La_{0.8}Sr_{0.2}FeO_3$

4　Capture property of carbon dioxide

Fig. 4 shows the schematic diagram of experimental setup for property measurement of carbon dioxide absorption. The rate of carbon dioxide is 1L/min for capture stage, and the absorption and desorption time is 2 hours, respectively.

Fig. 5 shows the relationship between absorption capacity of carbon dioxide for reusable material and capture temperature, which indicates that the maximum volume absorption ratio could be 993 and the optimum capture temperature is 700℃, and carbon dioxide captured could desorb completely if the temperature is higher than 800℃ in 2 hours. It needs to further research the effects of particle size of material, porosity of sample and compositions in the flue gas on the capture capacity in detail.

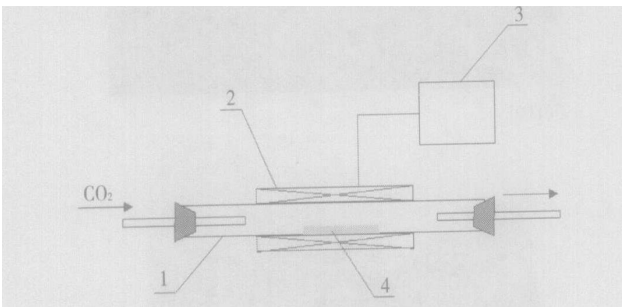
5　Conclusions

(1) A new concept of zero emission for solid oxide fuel cell system was proposed, which has some advantages such as high power generation efficiency, zero emission of greenhouse gas, carbon dioxide recycling, and reusable material with environment benign for carbon dioxide capture.

(2) Li_4SiO_4 could be used as reusable material for carbon dioxide capture, which has some merits for carbon

dioxide capture such as cheap raw materials, reusable with friendly benign, high capture volume ratio and so on, was also prepared using solid reaction method without other secondary phase via X-ray diffraction measurement.

(3) The maximum volume absorption ratio could be 993 and the optimum capture temperature is 700 ℃. It needs to further research the effects of particle size of material, porosity of sample and compositions in flue gases on the capture capacity in detail.



1— **quartz tube**, 2— **heat furnace**, 3— **temperature controller**, 4— **sample**

Fig 4 **Schematic diagram of experimental setup**

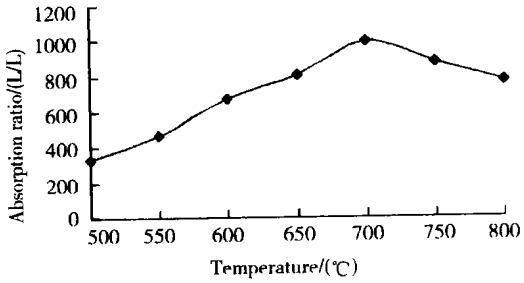


Fig 5 **Capture property of carbon dioxide for reusable material**

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固体氧化物燃料电池系统零排放新思路研究

马文会, 杨 斌, 于 洁, 王 华, 戴永年

(昆明理工大学 材料与冶金工程学院 //云南省有色金属真空冶金重点实验室, 云南 昆明 650093)

摘 要: 提出了固体氧化物燃料电池零排放新思路设计, 该设计具有高发电效率、温室气体零排放、回收利用二氧化碳以及使用环境友好的可再生循环二氧化碳吸收材料等优点。此外, 还介绍了电池构件材料以及二氧化碳吸收材料的制备, 最后测试了材料的二氧化碳吸附性能。结果表明最大体积吸收比可高达 993 倍, 最佳吸收温度为 700 ℃, 同时可实现在 800 ℃以上 2 h 内将所吸附的二氧化碳完全解析。

关键词: 零排放; 固体氧化物燃料电池; 二氧化碳循环利用; Li_4SiO_4

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