Study of Catalyst Layer of Low Temperature Proton Exchange Membrane Fuel Cell

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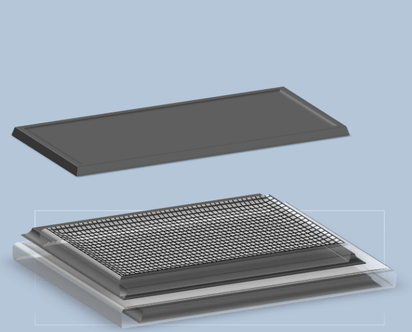
Introduction

Catalyst layers (CLs) have been regarded as one of the most crucial structures in proton exchange membrane fuel cell (PEMFC), especially the cathode CLs. It is responsible for the main electrochemical reaction. MEAs were manufactured with the catalyst coated membrane method. To improve efficiency of fuel cell, we add various carbon materials into the CLs to enhance the electric conductivity. Three materials, **carbon fiber (CF)**, **carbon nanotube (CNT)** and **vapor grown carbon fiber (VGCF)**, have similar excellent properties, such as electrical conductivity. However, apart from the electronic resistance, contact resistance and ionic resistance are required to be under consideration. Therefore, this study aims to investigate the effect of various carbon materials on fuel cell performance and find out the optimal percentage of them.

Property	Diameter (nm)	Length (μm)	Density (g/cm^3)
CF	5000~10000	5~10	1.75~1.93
CNT (MWCNT)	5~20	＞1	1.3~1.4
VGCF	100 ~ 500	1~250	1.8 ~ 2.0

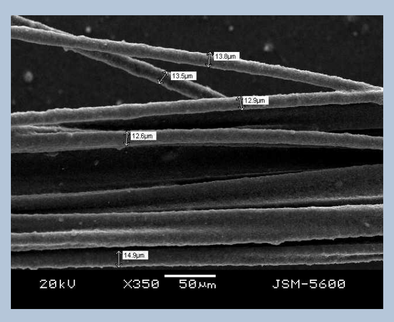
Model description and surface analysis of electrodes

CF

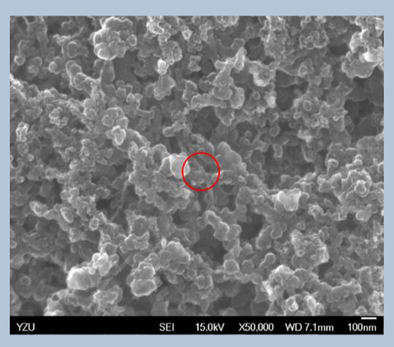


Cathode

Anode



CNT



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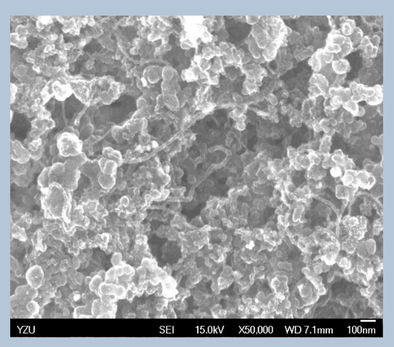

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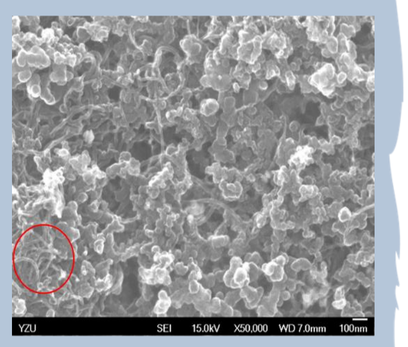
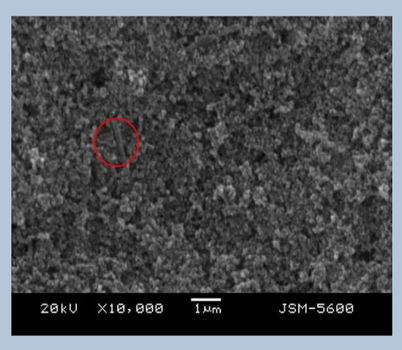


6%

VGCF



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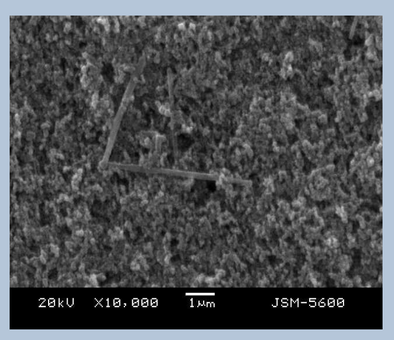

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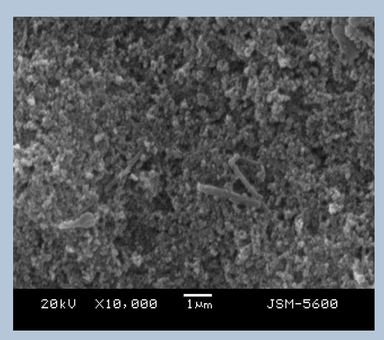
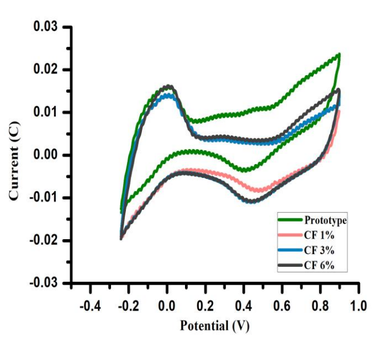
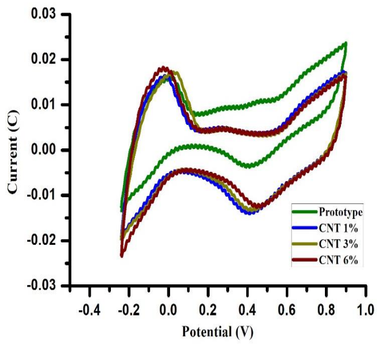
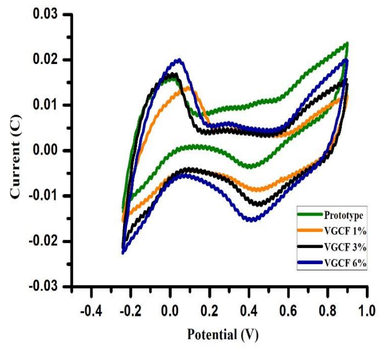


6%

Electrochemical analysis of electrodes







Electrochemical active surface area(ECSA)	0%	1%	3%	6%
CF	41.95	43.44	41.85	43.73
CNT	41.95	43.41	46.94	49.70
VGCF	41.95	43.14	47.00	56.49

Unit: hydrogen adsorption of Pt per unit (m^2/g)

- **Increment of the porosity** in catalyst layer extends the uncovered Pt surface area after adding CNT and VGCF into it.

Electronic resistance analysis of electrodes

Resistance (Ohm)	0%	1%	3%	6%
CF	46.60	31.40	13.90	9.26
CNT	46.60	30.75	24.60	19.57
VGCF	46.60	39.00	38.60	35.15

- All additions noticeably **decrease electronic resistance** on catalyst.
- Although CF is not evenly dispersed into the catalyst, areas containing CF have startlingly high electrical conductivity because its **perfect continuity does not interrupt transportation of electron**.

Results and discussion

Operation condition

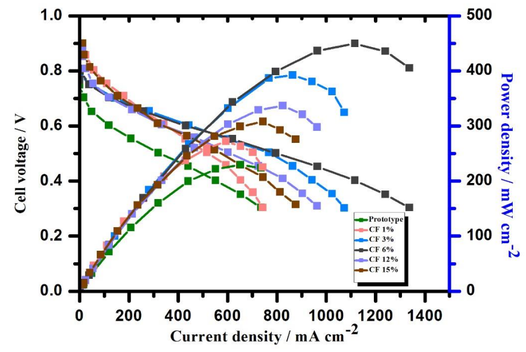
Surface Area (cm^2):6.25 Cell Temperature (℃): 80

	HGL Temperature	Minimum Flow (c.c./min)	Stoichiometry (6.93 sccm H, 17.5 sccm Air)
Anode	80.0	≧200.0	1.5
Cathode	80.0	≧1000.0	2.0

Activation method

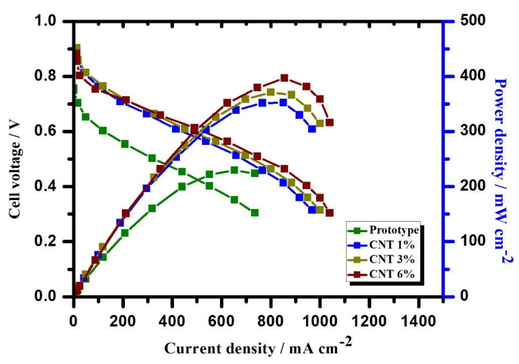
Scan control: Potential (Volt) Potential (Volt) : 0.6 Total time: 8 hours

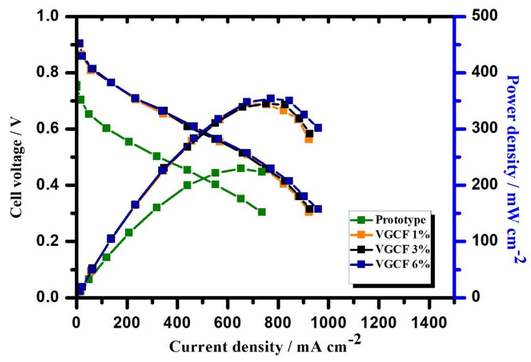
I-V curve of CF



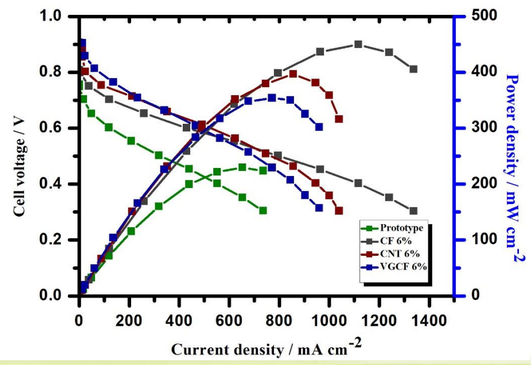
- As proportion of CF increasing, the performance significantly escalates **until CF 6%**.
- Due to high concentration and high viscosity of ink, including CNT and VGCF, sprayer cannot spray it out.

I-V curve of VGCF and CNT





Optimal I-V curve of CF, VGCF and CNT



- In activation polarization, the CF is faster in potential loss than the VGCF and CNT are. However, it remains **less the loss in ohmic polarization**.

Conclusions

- According to the CV result, it suggests that CNT and VGCF do not negatively interfere ability of Pt for hydrogen adsorption, but strengthen the ability instead.
- It effectively reduces the electronic resistance of catalyst layer by adding these three different kinds of materials into it.
- Compared to the control sample (only Pt/C), all three materials would substantially increase performance of the fuel cell.
- **Continuity**: CF (longer length) ＞ CNT (hollow material, lower density) ＞ VGCF
- Around **6 w.t%** of the additions in the cathode catalyst layer have optimal performances.
- As a result, the increment of electron paths is the most prominent factor to improve the efficiency in this study.

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