Iron sulfide loaded carbon nanotube –graphene composite (FeS/CNT-GR) for Oxygen reduction reaction

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Abstract: The development of highly active and stable non-precious metal catalysts is a very important issue in the field of electrocatalysts. There is an active research on non- precious metal catalysts for replacing expensive noble metal catalysts. Herein, Iron sulfide loaded carbon nanotube –graphene composite (FeS/CNT-GR) was synthesized by modified urea-glass route. Owing to active FeS particle and CNT-GR possessing large mesopores and high electrical conductivity, FeS/CNT-GR exhibits excellent ORR activity and durability in alkaline media.

Keywords: Iron sulfide, carbon nanotube –graphene composite, Oxygen reduction reaction

1. Introduction (11-point boldface)

Polymer electrolyte membrane fuel cell(PEMFC) are attractive devices among next-generation eco-friendly generators due to high energy conversion efficiency, high power density and eco-friendly. High cost platinum catalysts are used as the cathode and anode catalysts, which is a major weakness of the fuel cell. Further, oxygen reduction reaction(ORR) in cathode reaction PEMFC is sluggish and corrosive. This cause large amounts of Pt needed and stability is also problematic. In order to commercialize a fuel cell, it is essential to develop catalysts which are stable in Oxygen reduction reaction and can be substituted for a noble metal catalyst. Accordingly, many non-Pt catalyst is reported for ORR including transition metal-nitrogen-carbon electrocatalysts(MN_x/C) [1][2][3], heteroatom-doped carbon based catalysts, transition metal carbides, nitride and oxynitrides catalysts, Metal chalcogenides.

Recently, Shuai Wang at al. [4] was reported that raisin bread-like iron sulfides/nitrogen and sulfur dual-doped mesoporous graphitic carbon spheres ($Fe_{1-x}S$/N, S-MGCS). $Fe_{1-x}S$/N, S-MGCS exhibited greatly enhanced electrocatalytic activity and stability towards ORR.

Here, we report an efficient ORR electrocatalysts composed of FeS/CNT-GR. By a simple synthetic method called urea-glass route was applied to FeS. Through the synthesis, FeS/CNT-GR was prepared well, and it was confirmed through various analysis synergistic effect between active FeS particle and CNT-GR possessing large mesopores and high electrical conductivity were attributed to increased ORR catalytic activity. Especially, 3-D like CNT-GR structure assembled between 2-D GR and 1-D CNT provides large mesopores, it can be easily accessed by electrolyte

2. Experimental

Iron chloride tetrahydrates were used as iron precursors for synthesis. Graphene oxide (GO) was synthesized by Hummer's method. CNT was used Nitric Acid treated CNT, which is commercial CNT (Hanwha nanotech, CMP-301F) was reacted with Nitric acid at 393K for 3hr to eliminate metal. Iron chloride tetrahydrate was dispersed in ethanol. The solution was dispersed ultrasonically in ethanol solution containing carbon supports (CNT: GO = 1: 1 weight ratio). The resulting solution was dried in oven to evaporate the ethanol. The mixture was moved to furnace and calcined under Nitrogen atmosphere. As a

control experiment, bare FeS, FeS/CNT and FeS/GR were prepared by carrying out the procedure without carbon support, GO and CNT.

3. Results and discussion

Fig.1 display the XRD patterns of prepared catalysts. All of the catalysts exhibited FeS peaks. The peaks were well matched to the reference XRD patterns of FeS (JCPDS No 01-089-6927). It shows clean picks without any other impurities or metal oxides excepted of carbon peaks. FeS/CNT, FeS/GR and FeS/CNT-GR have carbon peaks came from their carbon support. Using the Scherrer equation, the average particles size of the FeS were estimated to be 27.7nm, 35.8nm, 24.5nm for FeS/CNT, FeS/GR and FeS/CNT-GR. Follow the XRD patterns, Fe2S were well formed on each carbon support through our simple synthetic method.

Electrochemical properties of FeS/CNT-GR catalysts were revealed by LSV in Fig 2. Carbon supported FeS catalysts estimated onset potentials of 0.97V for FeS /CNT, 0.96V for FeS /GR and 0.99V for FeS /CNT-GR. Carbon support material is considered that it plays a large role to enhance in the ORR reaction of the FeS. CNT-GR hybrid having increased large mesopores and number of active sites. Furthermore, FeS /CNT-GR reach the commercial Pt/C activity.

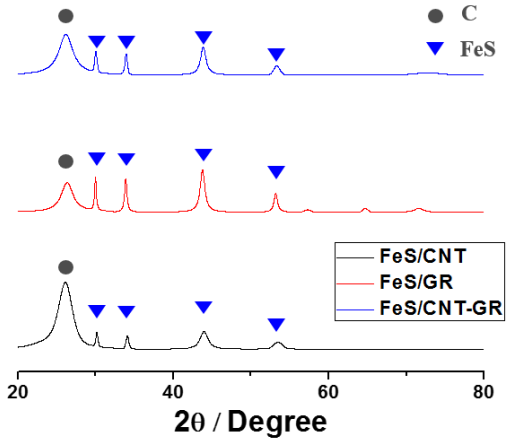

Figure 1. XRD data of FeS

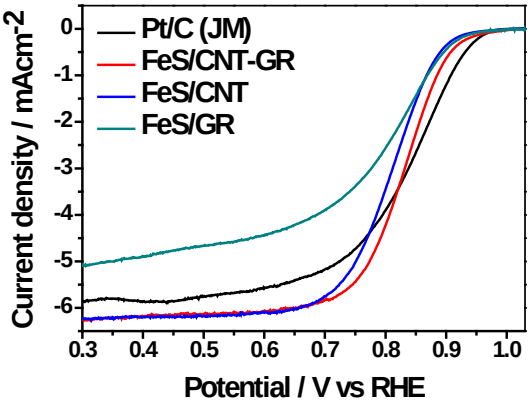

Figure 2. ORR polarization curves 0.1M KOH with O2

4. Conclusions

In summary, FeS/CNT-GR were successfully prepared by simple synthetic method called urea-glass route. Through the synthesis, FeS/CNT-GR was prepared well, and it was confirmed through various analysis. Synergistic effect between active FeS particle and CNT-GR possessing large mesopores and high electrical conductivity were attributed to increased ORR catalytic activity. Especially, 3-D like CNT-GR structure assembled between 2-D GR and 1-D CNT provides large mesopores, it can be easily accessed by electrolyte. For these reason, FeS/CNT-GR has comparable ORR activity to commercial Pt/C.

References

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