"Sandwich-structure" Nanocomposites of Graphene Nanosheets and Alkaline Exchange Ionomer as Superior Catalyst Supporting Materials for Alkaline Exchange Membrane Fuel cells

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Anion exchange membrane fuel cells (AEMFCs) using alkaline ionomer membranes have been attracting significant attention recent years. [1] The reasons are that the enhanced reaction kinetics for oxygen reductions and the improved stability of the catalysts in alkaline media. However, the state-of-art performance of AEMFCs is much lower than that of proton exchange membrane fuel cells (PEMFCs) (0.6 A cm^{-2}@0.6V vs. 2.3 A cm^{-2}@0.6V). [2] Considering that the ion-mobility ratio of hydroxide to proton (0.57:1, 20.50 vs. 36.25 cm^2 V^{-1} s^{-1}, 25ºC), the performance of AEMFCs is inherently lower than that of PEMFCs, but it also indicates that there should be much room to improve the present performance of AEMFCs. In order to improve the fuel-cell performance, not only the development of the high hydroxide conductive ionomers and superior electrocatalytic non-platinum catalysts are required, but also a strategic design of the catalyst layer with well establishment triple-phase-boundary (TPB) to transfer the ions as well as electrons is highly needed. [3]

In this regard, we here developed a "sandwich-structure" nanocomposites, containing graphene nanosheets and alkaline exchange ionomer, as the catalyst supporting layer to further deposit the catalysts. The schematic diagram for the preparation of nanocomposites is illustrated in Fig. 1. Contrary to the conventional catalyst-layer preparation, graphene nanosheets are firstly wrapped with a thin layer of alkaline ionomer through π–π stacking interaction or hydrophobic interactions, namely AI/Graphene. Due to the thickness of wrapped ionomer is nano-scale, the obtained nanocomposite preserves the intrinsic electronic and structural properties of graphene. More importantly, the nanocomposite is facile for ion conductivity, resulting from the well hydroxide conductivity of DAPSF, i.e. homemade cross-linked polysulfone-based ionomer. The platinum catalyst, using chloroplatinic acid as the precursor and ethylene glycol as the reducing agent, was deposited onto the nanocomposite to form Pt/AI/Graphene, as shown in Fig. 2. The existence of nitrogen element was confirmed by EDS analysis, indicating that graphene nanosheets were successfully wrapped by the alkaline ionomer. The TEM results showed that Pt particles uniformly distributed on the wrapped graphene nanosheets with the average particle size of 1.88 ±0.03 nm. The uniform size distribution and highly dispersed nanostructure is favorable toward oxygen reduction reaction (ORR).
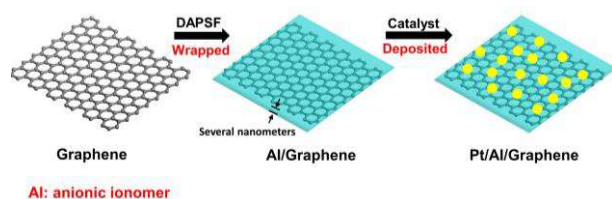

Figure 1 Schematic diagram for the preparation of Pt/AI/Graphene

Further physicochemical analysis and electrochemical characterizations will be presented at the meeting. The fuel-cell performance employing this type of sandwich-structure catalysts will also be presented at the meeting.
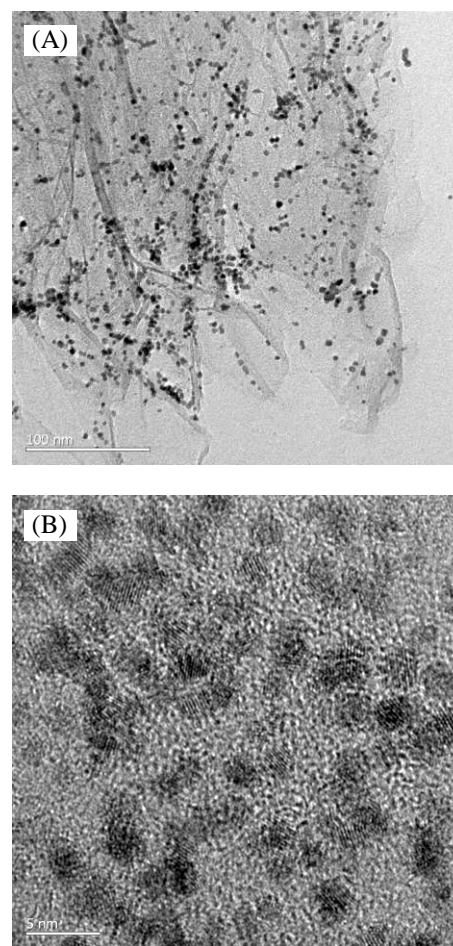

Figure 2 a representative TEM image of the Pt/AI/Graphene (A) and high resolution TEM image (B)

References
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