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Synthesis of durable Nb-TiO_2 support for PEMFCs by electrospinning

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Polymer Electrolyte Membrane Fuel Cell (PEMFC) is a power generation system to convert chemical energy of fuels and oxidants to electricity directly by electrochemical reactions. As a catalyst support for PEMFCs, carbon black has been generally used due to its large surface area and high electrical conductivity. However, under certain circumstances (start up/shut down, fuel starvation, ice formation etc.), carbon supports are subjected to serve corrosion in the presence of water.

Therefore, it would be desirable to switch carbon supports to corrosion-resistive support materials such as metal oxide. TiO_2 has been attractive as a support with its stability in fuel cell operation atmosphere, low cost, commercial availability, and the ease to control size and structure. However, low electrical conductivity of TiO_2 still inhibits its application to catalyst support for PEMFCs.

In this study, electrospun TiO_2 nanofibers as a catalyst support with high electrical conductivity in different calcination temperature for PEMFC. Moreover electrospun Nb-doped TiO_2 (Nb-TiO_2) nanofibers as a catalyst support for cathode in the fuel cell is prepared. Electrochemical properties of Nb-TiO_2 supported cathode catalyst are evaluated and compared with those of carbon supported catalyst.

Fig 1 was SEM images of synthesis Nb-TiO_2 nanofibers with different contents of niobium. The surface of pure TiO_2 nanofibers (Fig 1 (a)) was rough. The Nb doped TiO_2 nanofibers which contained niobium (Fig 1 (b)-(d)) was decreased the fiber diameter and smooth surface. The reason for this result was maybe the viscosity of the electrospinning solution which was decreased as increasing the content of niobium.

Fig 2 shows the rotating disk measurements, at 1600 rpm, for the ORR on 20 wt% Pt/Nb-TiO_2 catalysts, along with the commercial 20 wt% Pt/C catalyst for comparison. As can be seen in Fig 2, the activity of the Pt/Nb-TiO_2 at 0.9 V (4901 ㎂/㎠) was similar to that of the Pt/C (4870 ㎂/㎠).

To estimate the effect of the ADT on the oxygen reduction activity, Fig 3. The ORR activity of 20 wt% Pt/Nb-TiO_2 was found to be 3127 ㎂/㎠ after 6000 cycles, whereas the 20 wt% Pt/C lost ~90 % of its initial activity (from 4570 ㎂/㎠ to 400 ㎂/㎠) due to carbon corrosion and subsequent catalyst particles agglomeration. Additionally, the Pt/Nb-TiO_2 showed nearly 10 times higher ORR activity than the Pt/C catalyst after the potential cycling experiment.

In summary, Pt/Nb-TiO_2 catalyst shows enhanced activity and stability compared with the commercial Pt/C. This means that the Nb-TiO_2 catalyst supports is a promising replacement for carbon supports and improvement of the durability in PEMFC.

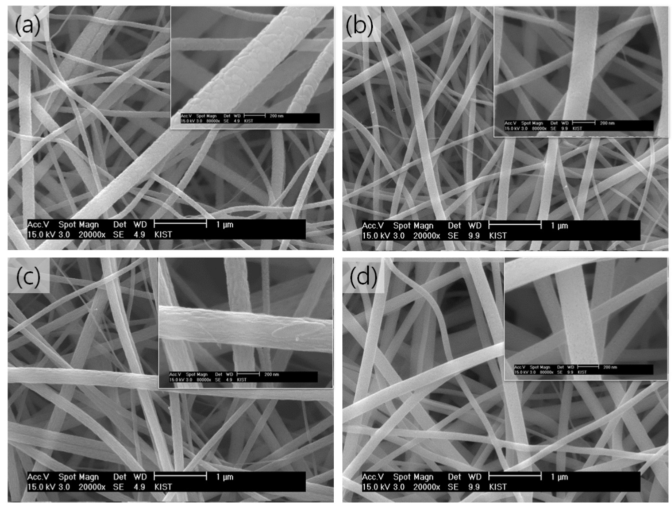

Fig 1. SEM images of synthesis Nb-TiO_2 nanofibers with different contents of niobium. (calcination in air at 700 °C for 1 h) ; (a) 0 at.%, (b) 10 at.%, (c) 25 at.%, (d) 50 at.%

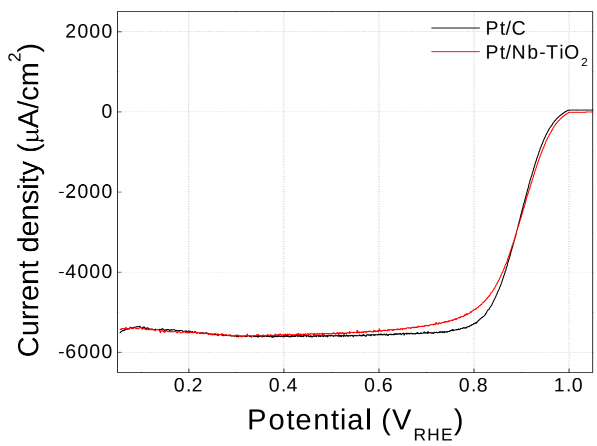

Fig 2. ORR polarization curves for commercial Pt/C catalyst and Pt/Nb-TiO_2 catalyst.

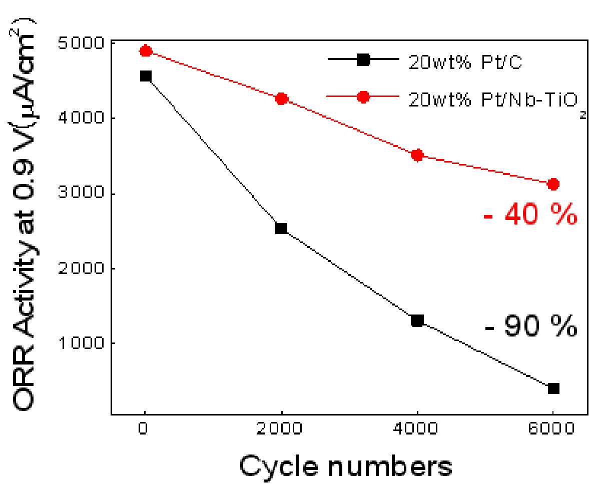

Fig 3. ORR activity as a function of cycle number for commercial Pt/C catalyst and Pt/Nb-TiO_2 catalyst.