

Antimony Doped Tin Oxide Modified Carbon Nanotubes as Catalyst Supports for Methanol Oxidation and Oxygen Reduction Reactions

Junyuan Xu et al.

Electronic Supplementary Information

1. Thermal stability of the composite support

To evaluate the thermal stability of the composite support, TG analysis was done in air with heating rate of $10\text{ }^{\circ}\text{C min}^{-1}$. The results are shown in Figure S1 below. As shown in the figure, the onset oxidation temperature for pure CNT was $400\text{ }^{\circ}\text{C}$ and a complete oxidation was reached after $750\text{ }^{\circ}\text{C}$. However, the thermostability was improved immensely in the composite due to the introduction of ATO. The onset oxidation temperature was increased to $590\text{ }^{\circ}\text{C}$ and the oxidation rate was also significantly decreased.

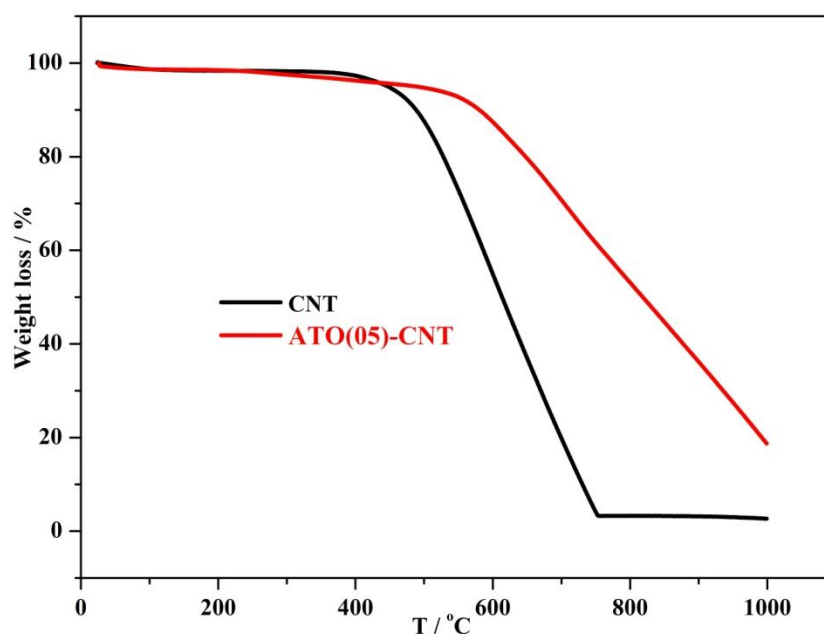


Fig. S1. TG analysis of the CNT and ATO(05)-CNT as measured in air at a heating rate of $10\text{ }^{\circ}\text{C min}^{-1}$.

2. Koutecky-Levich (K-L) analysis

Further discussion on RDE data of the Pt/CNT (Fig. S2a) and Pt/ATO(05)-CNT (Fig. S2b) is made using the Koutecky-Levich (K-L) approach, embodied by equation (1), where I is the measured current, I_K and I_L are the kinetic and the diffusion limited currents, respectively, B is the Levich slope, n is the number of electrons transferred per O_2 molecule, F is the Faraday constant. The diffusion coefficient of oxygen D_{O_2} , is taken as $1.93 \times 10^{-5}\text{ cm}^2\text{ s}^{-1}$ and the solubility of oxygen in the bulk solution is C_{O_2} , ω is the angular velocity and ν is the kinematic viscosity of the solution.

$$\frac{1}{I} = \frac{1}{I_K} + \frac{1}{I_L} = \frac{1}{I_K} + \frac{1}{B\omega^{1/2}} = \frac{1}{I_K} + \frac{1}{0.62nFA_{geo}D_{\text{O}_2}^{2/3}\omega^{1/2}\nu^{-1/6}C_{\text{O}_2}} \quad (1)$$

The K-L plots for the Pt/CNT and Pt/ATO(05)-CNT catalysts are shown in Fig. S2c and Fig. S2d. The number of electrons transferred per O₂ molecule (n) can be deduced from the experimental value B obtained from the slope of the K-L plot. The calculated values of n were 3.96 and 3.97 for the Pt/CNT and Pt/ATO(05)-CNT catalysts, respectively, which supported a 4 electron pathway of oxygen reduction.

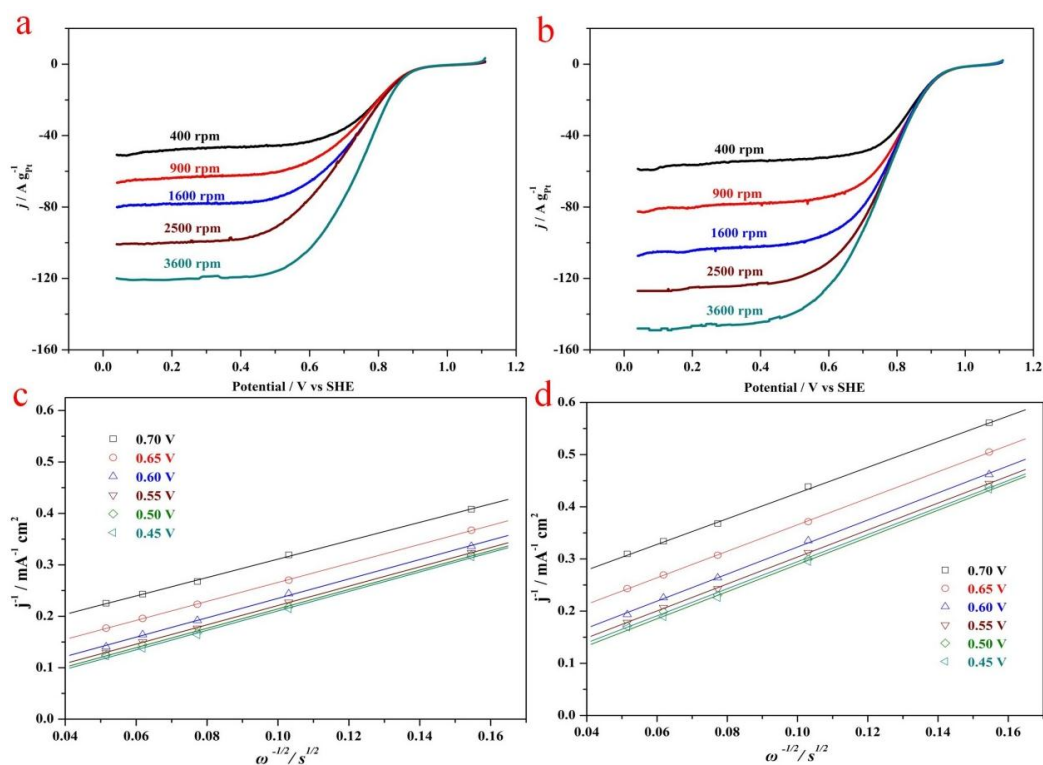


Fig. S2 Mass normalized ORR polarization curves of Pt/CNT (a) and Pt/ATO(05)-CNT (b); Koutecky-Levich (K-L) plots at different potentials for Pt/CNT (c) and Pt/ATO(05)-CNT (d).

3. Effect of antimony on the electroactivity of platinum

To illustrate the effect of antimony on the electroactivity of platinum towards ORR and MOR, pure SnO₂ modified CNT support (SnO₂, 5 wt%) was synthesized, onto which 20 wt% Pt was loaded. The electrochemical activity of platinum supported on SnO₂(05)-CNT and ATO(05)-CNT was investigated towards the MOR and ORR. The ECSA value was first calculated from the hydrogen desorption peak. And the activity was evaluated by comparing the peak currents for the MOR and ORR. As shown in Fig. S3, the activity of Pt/ATO(05)-CNT was much better than that of Pt/SnO₂(05)-CNT.

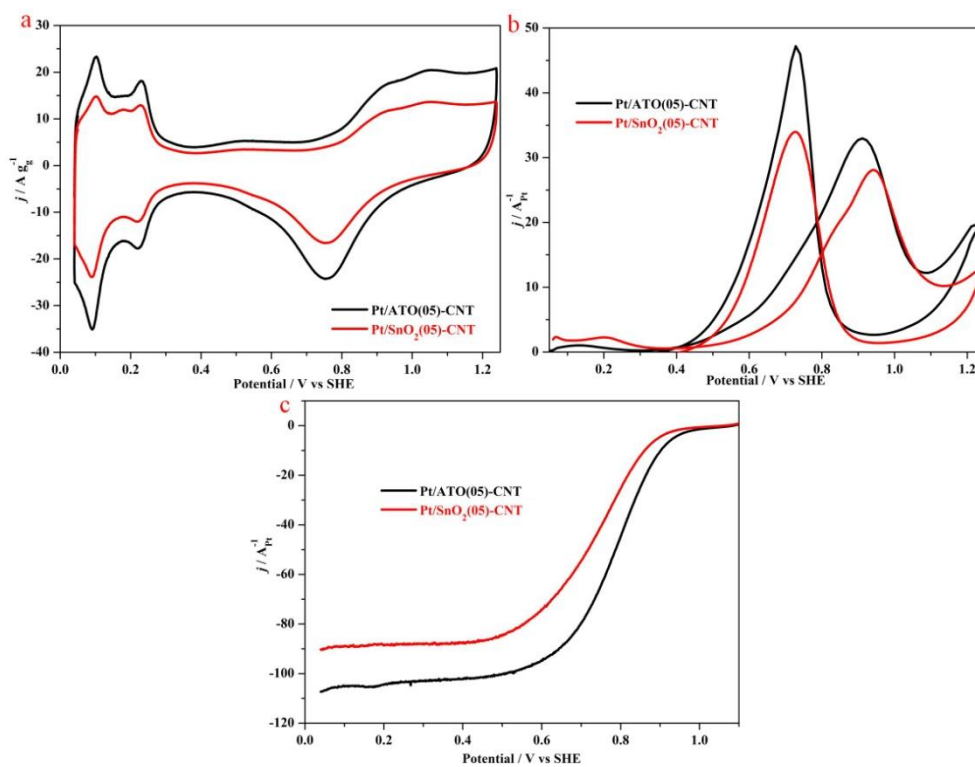


Fig. S3 (a) CVs of catalysts in N₂-saturated 0.5 M H₂SO₄ solutions at a scan rate of 50 mV s⁻¹; (b) Mass normalized CVs of catalysts in 0.5 M H₂SO₄ + 1 M CH₃OH solution; (c) Mass normalized ORR polarization curves of catalysts at 1600 rpm.