Preparation of high catalytic activity SnO$_2$ nanoflower for electrochemical reduction of CO$_2$

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The electrochemical reduction of carbon dioxide (CO$_2$) has been seen as a potential solution to address global climate change. Converting CO$_2$ into simple molecules such as formic acid and methanol, which are useful fuels and feedstock for fuel cell, will largely settle these problems. In the electrochemical reduction of CO$_2$, metal electrodes such as In, Sn, Pb has high faradic efficiency in aqueous media. Sn metal was chosen from the metals because of its high activity and relatively low toxicity. However, the deactivation of Sn metal electrodes during CO$_2$ reduction is very fast in aqueous solutions. Considering these difficulties, developing new electrode material with good electrochemical performance of high catalytic activity and sufficient stability is of great importance.

In order to improve electrochemical performance of catalyst materials, two significant aspects are to be taken into account, which are oxide materials and nanostructures. Tin dioxide has been extensively studied as an advanced electrode material with high capacity and stability. The nanoscale materials provide a high specific surface area which can increase catalytic activity and selectivity, as well as the productivity. Herein, we report the synthesis of SnO$_2$ nanoflowers, and its catalytic activity toward CO$_2$ reduction is investigated.

The flower-shaped SnO$_2$ nanostructures were prepared by Tin dichloride dehydrate (SnCl$_2$·2H$_2$O), sodium citrate (Na$_3$C$_6$H$_5$O$_7$) and sodium hydroxide (NaOH), using a simple hydrothermal method. The crystal structure of the product was characterized by XRD and SEM. The catalyst electrode was prepared by SnO$_2$ powder, also bonded with Nafion solution and isopropanol, and spread over the gas diffusion layer (GDL). The catalytic activity of SnO$_2$ nanoflower supported on GDL as the cathode electrode was measured using cyclic voltammetry (CV) and linear sweep voltammetry (LSV).

Figure 1 shows the SEM image of flower shaped SnO$_2$ nanostructures. It can be seen that the product consists of spherical nanoflowers with a porous structure in an average size of 200nm in diameter. It provides a high surface area which has a positive effect on promoting catalyze of CO$_2$ electro reduction to HCOOH. The unique properties of these nanostructures were measured using LSV curves in both N$_2$ and CO$_2$-saturated aqueous solutions, which are shown in Figure 2. Clearly, the SnO$_2$ reduction peak displays a more positive potential when the solution saturated with CO$_2$ than with N$_2$. Moreover, when the current density exceeds 0.09 mA cm$^{-2}$, the potential occurred at -0.59V for SnO$_2$ nanostructures in CO$_2$-saturated aqueous solution which is about 100mV more than in N$_2$-saturated aqueous solution. This was due to the competition at electrode between hydrogen evolution and CO$_2$ reduction.

Reference

Figure 1: SEM image of spherical SnO$_2$ nanoflowers.

Figure 2: Cyclic voltammograms in 0.5M KHCO$_3$ on the SnO$_2$ nanoflowers-decorated GDL saturated with N$_2$ and CO$_2$ at scan rate 5mVs$^{-1}$. Electrode area 4.0cm$^2$. 