Catalysts Based on TiO_2-Au Hybrids Supported on Carbon for the Electrogeneration of H_2O_2: Investigating the Effect of TiO_2 Shape

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Introduction

In this work, we describe a facile strategy for the synthesis of well-defined TiO_2 morphologies (colloidal spheres and wires) decorated with Au nanoparticles displaying monodisperse sizes and uniform distribution over the TiO_2 surface, followed by the investigation of their electrocatalytic activity towards the electrogeneration of H_2O_2 by the oxygen reduction reaction (ORR) using the rotating ring disk electrode technique (RRDE).

Results and Discussion

The TiO_2 colloidal spheres and wires were synthetized according to previously reported protocols[1,2] and were employed as physical templates for the nucleation and growth of Au NPs over their surface. Our approach employed water or EG as solvent, ascorbic acid as a reducing agent, PVP as a stabilizer, and $AuCl_4^-{}_{(aq)}$ as the Au precursor. Figures 1A and B show SEM images of the hybrid materials.

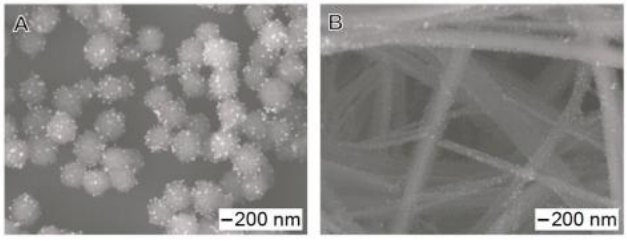

Figure 1. SEM images for TiO_2 colloidal spheres (A) and wires (B) decorated with Au NPs.

The electrocatalytic activity of TiO_2-Au materials towards the ORR as a function of the TiO_2 shape was investigated. For this purpose, the TiO_2-Au materials were supported on Vulcan XC-72R carbon to prepare TiO_2-Au/C catalysts with 1, 3, and 5 % w/w loading. Figure 2A and B shows the polarization curves for the ORR promoted by TiO_2-Au/C. To obtain information to which extend the addition of both TiO_2-Au/C 3% electrocatalysts influences the local structure of the Vulcan XC-72R support, and consequently the catalytic activity of the system, XPS C 1s and O 1s high-resolution core-level spectra were recorded as depicted in Figure 2C.

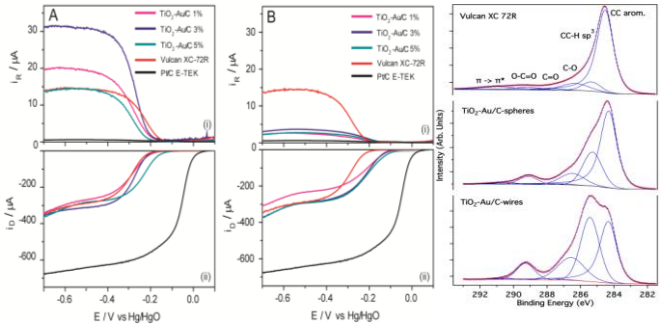

Figure 2. (A) Steady-state polarization curves for the ORR of different proportions of TiO_2-Au colloidal spheres or (B) wires supported on Vulcan XC-72R carbon. (C) Deconvoluted C 1s XPS spectra of the Vulcan XC 72R support and of the TiO_2-Au/C 3% based materials.

Regarding the TiO_2 colloidal spheres decorated with Au NPs, our results show that the TiO_2-Au/C 3% loading had the highest ring currents, indicating higher H_2O_2 electrogeneration. The hybrid materials prepared by using TiO_2 wires decorated with Au NPs presented current values significantly lower than pure carbon. The quantitative XPS analysis showed that the morphological difference between TiO_2-Au nanomaterials and the strong reduction of the conductivity of the carbon support might be the principal cause for the reduced electrocatalytic activity TiO_2-Au/C wires based material.

Conclusions

According to the presented results, TiO_2-Au/C with 3% colloidal spheres supported on carbon XC-72R is a promising material to be used in H_2O_2 electrogeneration.

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