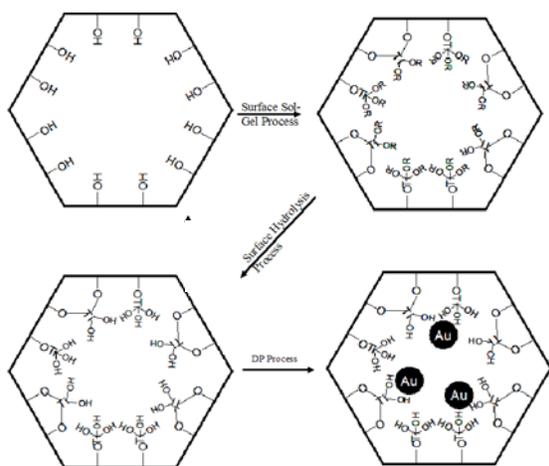


# Lined Nanopores: A Novel Method For Controlling Au Catalyst Particle Growth And Catalyst Activity

PIs: Sheng Dai and Steven H. Overbury  
Chemical Science Division  
Oak Ridge National Laboratory

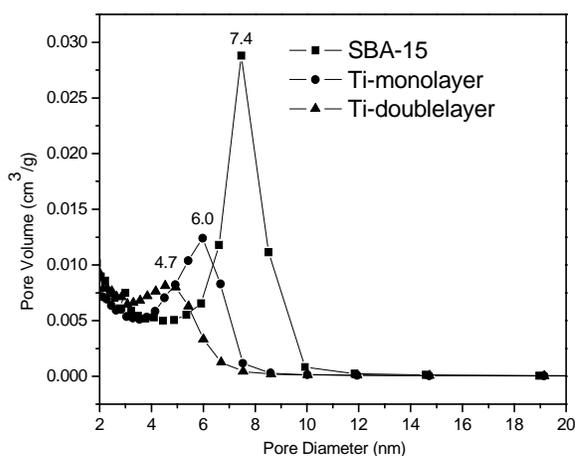
Developments during the last decade have resulted in synthesis of a rich variety of meso- and microporous silica materials with variable pore sizes and structure. These materials are very stable and have a rich variety of morphologies useful as a scaffold for synthesis of nanowires, nanoclusters or new classes of highly dispersed catalysts. However, the chemical properties of the silica pore walls limit their application. A team of ORNL researchers have for the first time exploited a novel method<sup>1</sup> to functionalize silica pores with a single layer of titanium dioxide, thereby preparing a support for a highly active Au catalyst (Scheme 1). Non-aqueous synthesis conditions permit a self-limiting reaction of titanium precursors onto the silanol feature endemic to all silica surfaces, resulting in a single layer

**Scheme I**



deposition. Alternating with an aqueous rinse, a two step procedure may be repeated to permit layer-by-layer lining of the silica pores with titanium oxide. The technique has been demonstrated by successful deposition of single and double layers of titania into the long hexagonally ordered pores of SBA-15. Gas adsorption methods confirmed that the pore diameter was diminished with each deposition (Figure 1), by an amount consistent with the expected thickness of a titanium layer. Subsequently, Au was added by deposition-precipitation, resulting in a catalyst demonstrated to have very high activity for CO oxidation reaction. A catalyst prepared in this way was not only highly active but also was more stable to deactivation by high temperature treatments than Au catalysts prepared by the same methods on conventional titania supports.

This layer deposition method can be extended to other precursors besides titanium. It should be possible to deposit single molecular layers of a variety of active oxides into any silica host material, giving huge flexibility in the surface chemical properties of the resulting oxide support without using potentially deactivating organic functionalizers. Methods to mask external silica surface area can be used to limit the active oxide layer growth only to internal, pore wall surfaces. Subsequent deposition and reduction of Au (or other metal) nanoparticles would then also be confined to the active oxide pore lining. Since pore size can be tailored by layer deposition, it may be possible to control the size and growth of the confined Au nanoparticles. The approach is applicable to dispersed powders or to porous films and monolithic structures such as membranes.



**Figure 1.** Pore size distribution as function of the number of TiO<sub>2</sub> layer.

<sup>1</sup> Ichinose, I., H. Senzu, T. Kunitake, *Chem Mater* **1997**, 9, 1296.