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In-situ Thermal Stability Analysis of Au Nanoparticles in a Metal Oxide Framework Based on a Sacrificial Fiber Template

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Nanoparticles encaged within a high surface area nanoporous material provides an opportunity toward enhanced catalytic active devices. Toward their successful use, it is essential to maintain thermal stability and spatial separation of nanoparticles (NP's) within the nanostructure. This work demonstrates the entrapment of gold nanoparticles (NP's) embedded in an alumina porous inorganic matrix through the use of a facile organometallic vapour exposure to sacrificial polymer fiber templates. Initially, gold NP's are decorated on fibrous nylon-6, followed by inorganic modification using a novel exposure technique, referred to as sequential vapour infiltration (SVI). The SVI technique, is defined by the reaction of the organometallic vapour and the polymer, the choice of which allows for unique tailoring of the degree of hybrid material formation. For example, an alumina-hybrid materials is formed by exposure of trimethyaluminum to the fibrous nylon-6 via the reaction with the C=O bonds in the polymer. Synthesis of porous nanoflakes after calcination of the alumina hybrid-modified nylon-6 yields a porous aluminum oxide framework surrounding the disconnected NP's with a surface area of 250 m^2/g. A unique feature of this work is the use of a transmission electron microscope (TEM) equipped with an in-situ annealing sample holder to explore the underlying nanoscopic stability of NP's embedded in these frameworks in a single step. TEM analysis indicates thermal stability up to 670 deg C and agglomeration characteristics thereafter. The vapour phase processes developed in this work will facilitate new complex NP/oxide materials useful for catalytic platforms.

Keywords: Nanoparticle; sequential vapour infiltration; fibrous template; porous frameworks; alumina