

Combustion Synthesis of Gold Nanoparticles using a
Multi-Element Diffusion Flame Burner
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Gold (Au) has interesting and unique optical, physical, and chemical properties that change as the gold particle size approaches the nano-scale. Gold nanoparticles have been shown to have potential for considerable impact on sensor technology, electronics materials, biomedical, and catalysis applications¹. Gold nanoparticles have been fabricated using such methods as sol-gel, self-assembly, deposition, sputtering, laser ablation, reduction, and flame spraying (2, 3, 4, 5, 6, 7, 8). The objective of the present work is to demonstrate the synthesis of gold nanoparticles using a combustion synthesis technique. The work is based on the hypothesis that solid-phase particle precursor materials can be injected into the combustion environment of a multi-element diffusion flame burner in order to produce gold nanoparticles. Specifically, the technique uses a novel particle feed system to inject gold acetate ($\text{Au}(\text{O}_2\text{CCH}_3)_3$) into hydrogen/oxygen/argon flames.

The experimental facility used to generate the Au particles is of a multi-element diffusion flame burner and a particle injection system (see Figs. 1 and 2). Details of the burner description are provided in Wooldridge et al.⁹ Briefly, the burner produces a steady, laminar, one-dimensional flame sheet. It consists of an array of fuel tubes and oxidizer channels arranged in a 2.54 cm square honeycomb matrix. This matrix is surrounded by an additional 1.0 cm wide inert gas co-flow region, which provides flame stability and minimized room-air entrainment. A secondary fuel tube, located in the center of the burner surface, is used to supply the particle precursor materials, in this case gold acetate particles entrained in argon. The particle injector entrains the precursor particles from a reservoir into argon via an induced pressure drop in the glass particle injector. The fluidized particle feed is either directly injected into the flame sheet or directed through the secondary fuel tube and into the burner. The particle injector allows for a range of flow rates and a steady feed of precursor materials.

All experiments consisted of a $\text{H}_2/\text{O}_2/\text{Ar}$ primary flame with N_2 serving as the inert co-flow gas. Equivalence ratios were nominally kept at a ratio of one. Particles were collected above the surface of the burner for bulk and microscopic material analysis (e.g. x-ray diffraction, and transmission electron microscopy) to determine both composition and particle size. The effects of the gold nanoparticles on the sensor properties of SnO_2 -based gas sensors were also examined.

Acknowledgements

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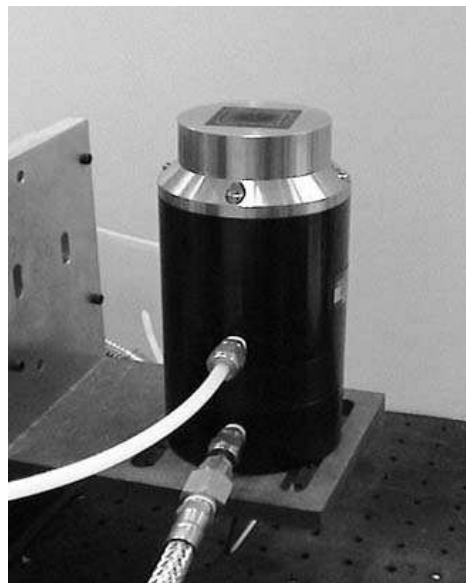


Figure 1: Multi-Element Diffusion Flame Burner

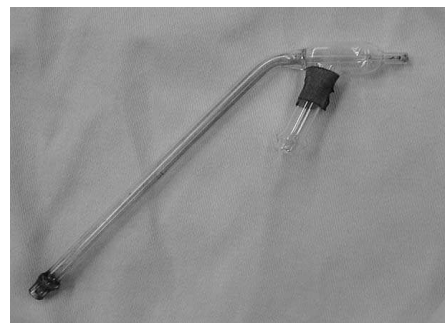


Figure 2: Glass particle injector used to inject the gold nanoparticle precursor materials; nozzle is at top right of image and the gold acetate reservoir is placed at bottom left of image.

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⁹ M. S. Wooldridge, P. V. Torek, M. T. Donovan, D. L. Hall, T. A. Miller, T. R. Palmer, and C. R. Schrock, *Combust. Flame*, 131, 5, 2002.