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SPATNANOPARTICLES OF GOLD ON GRAPHITE PRODUCED BY DE MAGNETRON SPUTTERING AND THE OXIDATION OF GLYCEROL

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Nanoparticles of Gold on Graphite Produced by dc Magnetron Sputtering and the Oxidation of Glycerol

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Introduction

The discovery of catalytic activity from gold nanoparticles towards the oxidation of carbon monoxide in 1989 by Haruta et al. [1] initiated a great deal of research to explore and understand the unique properties of a material previously thought to be chemically inert. As a result there is a growing body of scientific literature detailing the synthesis and reactivity of Au nanoparticles towards a variety of reactions. However, as Wolf and Schüth pointed out in 2002, "the reproducibility of highly active gold catalysts is typically very low"[2]. This lack of reproducibility is due to the large number of synthetic preparation methods and the subsequent treatments of the catalysts (i.e. annealing, aging) which subtly affect the catalytic properties [2]. In addition, most of these techniques are not industrially feasible due to the large amount of water required or the prohibitive cost of reagents.

This presentation describes a one-step magnetron sputtering technique for the preparation of supported catalyst particles that has a number of advantages over existing methods. For example, there is no contamination from solvent or precursor molecules on the surface, and no heating is required to decompose the precursors. The process is economical and environmentally friendly since the excess gold is recoverable from the chamber and there is no liquid waste. Finally, it is also adaptable to a wide range of catalyst materials and catalyst support powders. Most importantly, this technique could easily be scaled up to industrial production.

Materials and Methods

A schematic of the set up used for these experiments is shown in Fig 1. A 2-inch diameter magnetron sputter source was located 12 cm above a stainless steel (SS) cup. Graphite powder was loaded into the angled SS cup and rotated. Gold nanoparticles were prepared via direct current (dc) magnetron sputtering of a gold target (Englehard, 99.99%) in a high purity Ar (99.9995%) atmosphere onto the tumbling graphite support. The gold loading was determined using an Inductively Coupled Plasma (ICP) Optical Emission Spectrometer. The catalytic oxidation of glycerol was used in order to determine the activity of the catalyst [3]. X-ray photoelectron spectroscopy (XPS), scanning transmission electron microscopy (STEM) [4], and powder X-ray diffraction (PXD) were used to further investigate these materials.

Results and Discussion

This technique is shown to produce gold nanoparticles with an average diameter of 1.5 nm (from STEM). XPS results show that the gold is Au^{o}. The particles are highly active towards the oxidation of glycerol (99% conversion in 4 hours, 1,000 Glycerol:1 Au). There is a significant difference in selectivity between the sputtered catalyst and ones prepared by gold Sol techniques (4-5 nm particle sizes) [3] that will be discussed.

Significance

This talk describes an industrially viable technique for the preparation of Gold nanoparticles that is environmentally friendly and produces no liquid waste.

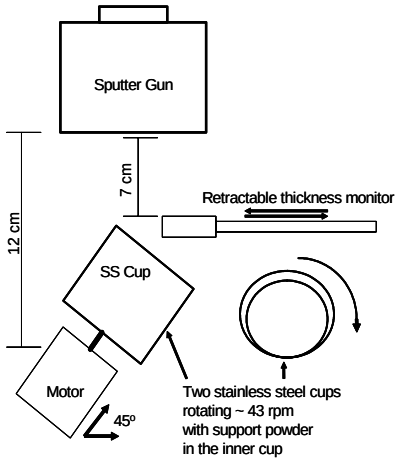

Figure 1. Schematic of deposition set up.

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