# CO Catalytic Oxidation Using Laser-Assisted Gold Nanoparticles Supported on Activated Carbon

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## Abstract

Gold nanosparticles (AuNPs) that have been extensively studied over the last decade will supporte activated carbon (AC) for efficient Co catalytic oxidation. To avoid oxidation and well-controlled size and shape distribution (<10 nm), AuNPs were be synthesized in pure acetone using not more than 4.8 J/cm$^2$ of Fiber laser power density to ablat a gold target surface. The prepared AuNPs were indicated by UV-Vis spectroscopy and Zeta potential measurments. The laser ablation method (LAM) released uniform and homogenous AuNPs with a Gussian curve of UV-Visible absorption peak at 530 nm. Large negative Zeta potential of AuNPs showed a good stability without using any additives/surfactants. In this paper, design and fabrication results of `in-plane' type AuNPs/AC catalyst were characterized by FESEM. According the results, characterized AuNPs with mean diameter of 7±1 nm were successfully supported onto AC. Finally the catalytic activtity of AuNPs/AC catalyst for CO oxidation were studied.

**Keywords:** Gold nanoparticles, activated carbon, catalyst, CO oxidation, laser ablation method

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## 1- Introduction

Superior conductivity, easy transfer of electrons, adjustable optical and electrical properties, biocompatibility and high catalytic activity have increased attraction of AuNPs for various applications [1-5]. The immense efforts of researchers have been focused on gold nanoparticles-based catalysts due to the high activity of AuNPs for low temperature hetreogeneous oxidation ractions [6]. In order to obtain high catalytic activity, AuNPs are generally dispersed on support materials, among which activated carbon (AC) are commonly used. The main reasons to use of activated carbon as a catalyst support are that the stability of AC in acidic or basic environments and catalyst recycling. Moreover, from a perspective of microscopy studies, carbon is an almost ideal support because of its low atomic number [7].

Numerous studies based on Au catalysts were performed on the CO oxidation [8,9], oxidation of alcohol and suger [10,11] and ozone decomposition at room temperature [6].

The overall performance of a supported AuNPs catalyst highly depends on the size and shape of the AuNPs, the structure and properties of supports, and gold-support interface interactions [12]. Several methods have been proposed to attach AuNPs onto the activated carbon (AC). Coprecipitation (CP), deposition-precipitation (DP), co-sputtering and liquid-phase grafting [8] can be basically attended. Although these techniques have been developed to prepare AuNPs/AC catalyst, they do not allow precise control over these parameters. Pulsed laser ablation (PLA) method in pure liquid medium is an alternative and returnable physical technique to fast prepare noble metal nanoaprticles due to well-controlled size and shape of NPs absolutely without helping the specific catalyst [13,14].

The present study is aimed at investigation the fabrication, characterization and catalytic activity laser assisted AuNPs in spherical shape on AC for CO oxidation. Subsequently a sol immobilization method provides coated AC surface by Au NPs.

## 2- Materials and Methods

### 2-1- Synthesis of AuNPs

To synthesize pure Gold NPs of the target material (1 $cm^3$ Au cubic), a fiber pulsed laser (wavelength ($\lambda$=1.07 nm)) was used by (PLA) method. Componential, dimensional and structural studies of AuNPs are availabled in our published articles [13,14].

A commercially Au bulk cubic of 99.99% was immersed in 30 mL of pure acetone and stirred for 5 min while the laser beam was focused on its surface in regular condition (at room temperature and one atmosphere of air pressure). An extra irradiation of 20 min could be a benefit apportunate to more reduce sizes of the AuNPs synthesized.

The fiber pulsed laser power and spot size were 0.4 W and 72 µm of the laser beam on the sample surface respectively. To avoid scattering the laser beam and disturbance of the ablation process, the laser power density did not exceed 4.8 $J/cm^2$.

### 2-2- Preparation of AuNPs/AC catalyst

The proposed procedure for preparation of the AuNPs/AC catalyst is followed in pretreatment the carbon for 12 h in a 6 M HCl solution, filtering and washing several times with distilled water carry on until the washing pH between 6 and 6.5 be obtained. The preteated AC was dried for ~6 h at 150℃ in air. To preparing the AuNPs/AC sensors, with highly sensitive, fast responding and high active gold catalysts, briefly the nanogolds colloidal solution of 0.3 g/ml was mixed with the AC of 0.1 g while were stirred in continure by a stirring speed of 800 rpm in 2 h. Finally, the supported AC was then dried in air until the acetone evaporated.

### 2-3- Characterization of AuNPs/AC catalyst

The UV-Vis measurements were completely discussed in the noted refrences. The Zeta potential of prepared AuNPs was measured on a Nano ZS (red badge) ZEN 3600 device (Malvern Instruments, Malvern, UK). Morphology and average size of AuNPs in spherical shape, supported on AC were characterized by field emission scanning electron microscopy (FESEM, MIRA TESCAN operating at 15 kV). The catalytic activity of AuNPs/AC was determined using a custom built flow reactor to monitor the conversion of carbon monoxide to carbon dioxide.

## 3- Results and Analysis

### 3-1- UV-Vis of fabricated AuNPs by laser ablation

The formation of gold nanoparticles was confirmed by using UV-Visible spectra (Figure 1). Gaussian curve with absorbance peak was obtained 530 nm, reveals the hemojenous NPs of with the average size of less than 10 nm.

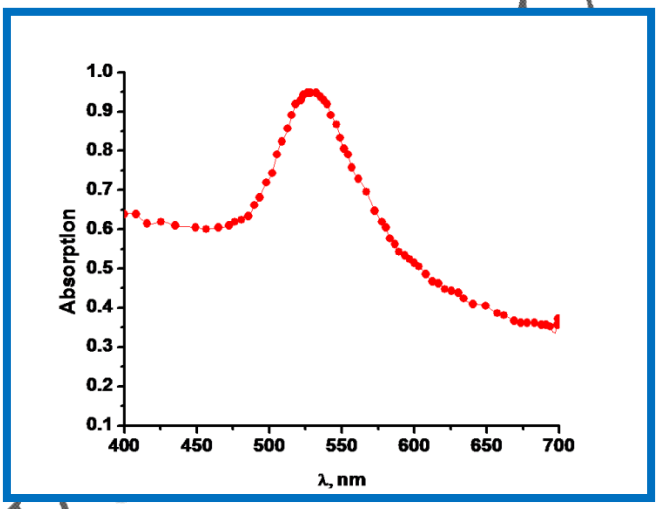


**Figure 1. An absorption spectra of Au NPs using LAM.**

### 3-2- Zeta potential of fabricated AuNPs by laser ablation

Figure 2 shows the Zeta potential histogram of the ablated AuNSs which have -39.5±11.2 mV. The general dividing line between stable and unstable suspensions is generally taken at aither +30 mV or -30 mV. Particles with Zeta potentials more positive than +30 mV or more negative than -30 mV are normally considred stable. Therefore the synthesized AuNPs by laser ablation have large negative Zeta potential which no tendency to flocculate.

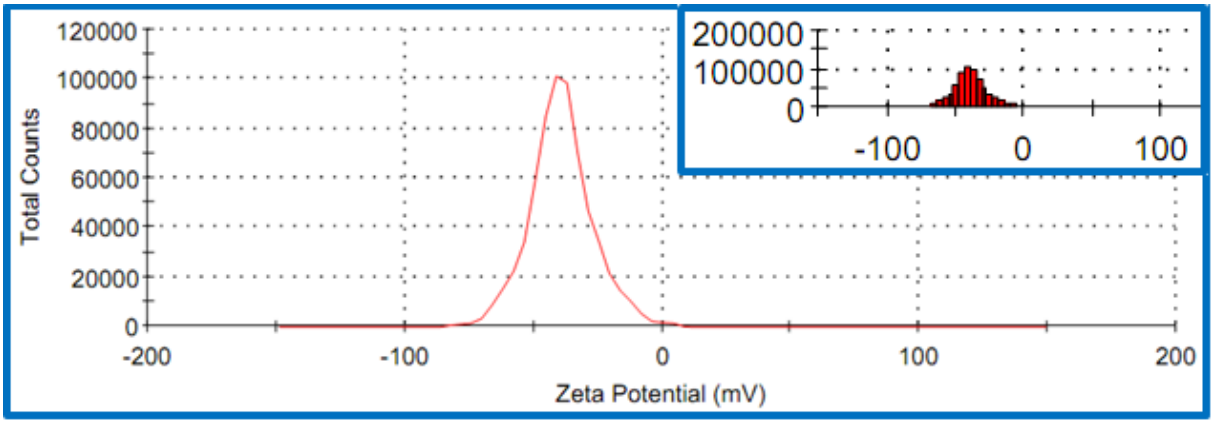


**Figure 2. Zeta potential (mV) of fabricated AuNPs by laser ablation.**

### 3-3- FESEM image of AuNPs supported on AC

Morphology and particle size of the AuNPs supported on AC were characterized by FESEM. Image analysis was done by "Image j" software. Figure 3 illustrates the characteristic shperical AuNPs, which shown with arrows, are succusfully supported onto AC. However, the agglomerated particles with larger sizes, which shown with circles, can be seen onto AC. The size distribution of characteristic AuNPs with mean diameter of 7±1 is available in Figure 3.

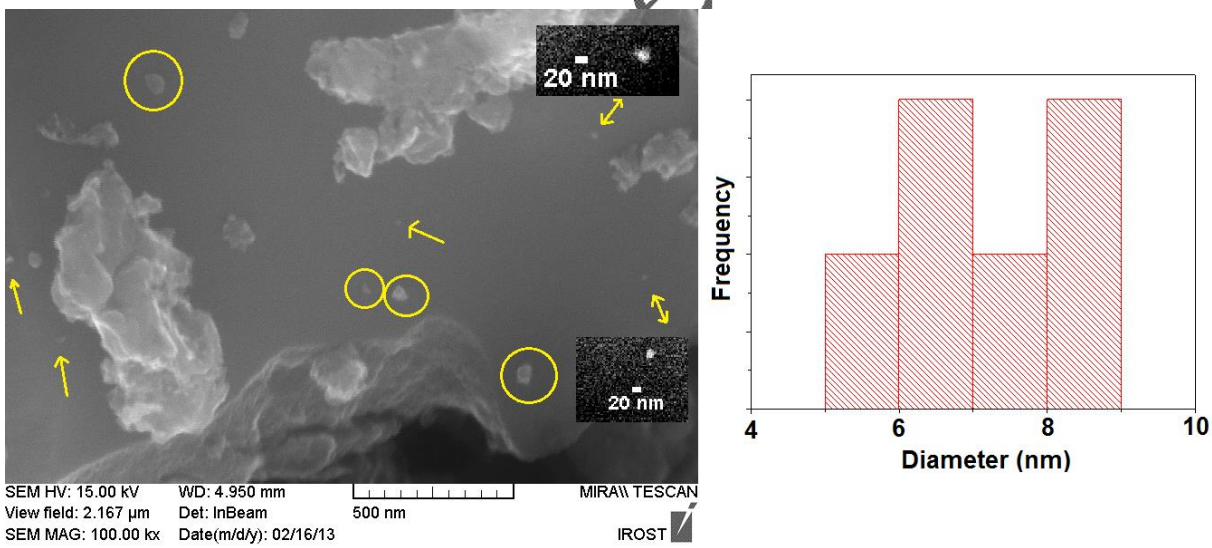


**Figure 3. FESEM image and size distribution of AuNPs supported on AC.**

### 3-4- AuNPs/AC catalyst formation

In order to evaluate the activity of the AuNPs supported onto AC, we performed a simple carbon monoxide oxidation reaction. Figure 4 shows a plot of the conversion ratio versus temperature. AuNPs dispersed onto AC active for CO oxidation at temperature below 500℃.

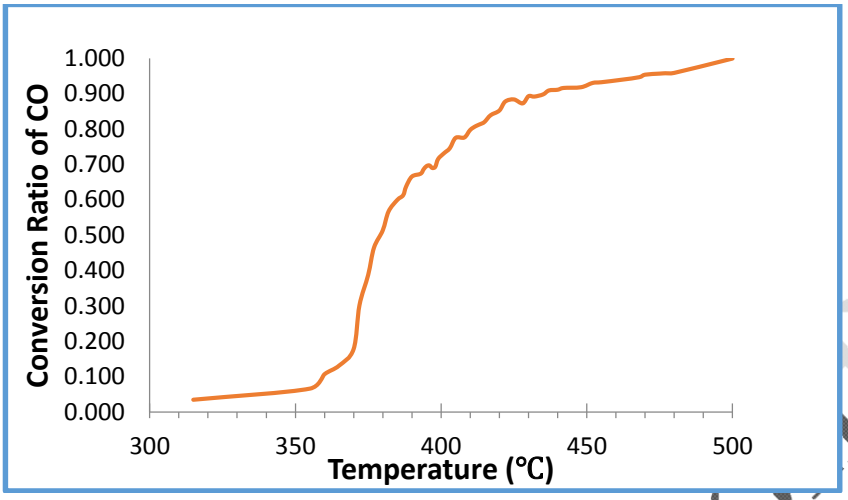


**Figure 4. Plot of catalytic activity (CO conversion ratio) versus temperature (℃).**

## 4- Conclusion

This study shows the utility of laser ablation method towards the formation of supported catalytic gold nanoparticles. On the basis of the results, the higher pure small-sized Au nanoparticles with dimension less than of 10 nm were fabricated. In the present work has empirically been demonstrated, this approach is catalytically active for the oxidation of carbon monoxide.

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