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# Enhanced cyclic voltammetry using 1-D gold nanorods synthesized via AAO template electrochemical deposition

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**Abstract**

Gold nanorods were successfully fabricated by using polycarbonate membranes and anodic aluminum oxide (AAO) membranes as growing templates under electrochemical deposition. The as-synthesized gold nanorods were polycrystalline with unidirectional direction along [111], having a uniform diameter around 100–200 nm and length of 5–6 μm. These gold nanorods were deposited on the gold-coated working electrode of cyclic voltammetry, where an enhanced current-voltage voltammograms were obtained. The enhanced sensitivity is achieved with the large electrocatalytic signals at amplified surface area using nanorod-modified working electrodes. Current-voltage voltammograms using ordered gold nanorod arrays are enhanced more than those using disordered gold nanorods. The results strongly suggested that the 1-D nanorods facilitated the electrocatalytic reactions due to enhanced diffusion occurring around these nano-structures.

*Keywords:* Gold nanorods; Cyclic voltammetry; Electrocatalytic reaction

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## 1. Introduction

One-dimensional (1-D) metallic nanorods have attracted considerable attention in recent years because of their novel physical properties and potential applications as interconnects in nanometer-scale electronics [1–2]. A general method for preparing 1-D nanomaterials called template synthesis attracts intensive attentions. This method entails synthesis or deposition of the desired materials within the cylindrical and mono- dispersed pore channels of a nanoporous membrane followed by removal of the template. Template synthesis has the advantages of flexibility (both nanotubes and nanorods of a broad range of materials can be prepared) and precise size control. Both polycarbonate (PC) membranes and anodic aluminum oxide (AAO) membranes well serve this purpose as the suitable templates for growing one-dimension (1-D) gold nanorods and many other novel multicomponent nanorods [3–4] or nanotubes [5]. The progress in this field has been accelerated by advances in both synthetic methods of preparing the nanoporous templates, and development of techniques capable of filling the pores of such membranes [6]. Filling of the pores of such membranes with long aspect ratio nanorods has been accomplished by electrochemical or electrophoretic deposition [7]. Single crystalline as well as polycrystalline metal nanorods (such as Au, Ag, Cu etc.) have been synthesized using this template method [8–13]. Miniaturized structures or electronic elements were successfully synthesized by template growth in channels of AAO and PC membranes [14–15]. The electrochemical response of gold deposited in the pores of aluminium oxide membrane has been studied [16]. Electroanalytical detection limits of such gold-deposited membranes were found to be lower than that of the macro size electrode.

Gold nanorods are unique class of metal nanostructures that have been found to be very useful for biomedical and biological applications such as cancer diagnostic marker [17], and electrocatalytic DNA detection system [18]. The application of arrayed gold nanorods as a novel and useful platform for electrochemical DNA detection has been reported by Kelley et al. [18–20]. The gold nanoelectrode ensembles (NEEs) synthesized using the electroless plating gold within the polycarbonate (PC) membranes and subsequently exposed outside PC membranes by oxygen plasma etching away a thin layer of PC membrane are attractive substrates for biosensing applications, where enhanced cyclic voltammograms could be obtained [19,20]. In their study, the gold nanowires are approximately 15–20 nm in diameter and approximately 150–250 nm in exposed length [19]. Thiolated DNA is deposited, and films similar to those obtained with bulk gold surfaces are generated. The NEEs exhibits background-subtracted cathodic peak currents ($i_{pc}$) of 8 μA, while the macroelectrode $i_{pc}$ is only 1 μA [19].

In this study, gold nanorods were synthesized using template-growth electrochemical deposition method and deposited on a flat Au-coated stainless steel plate as the working electrode for cyclic voltammetry. Disordered gold nanorods and 1-D arrayed gold nanorod-modified (3D nanostructure) working electrodes were fabricated. Enhanced current-voltage voltammograms were observed for both gold nanorod-modified working electrodes. In addition, ordered 1-D gold nanorod-modified electrodes exhibit more enhanced CV signals than that of disordered gold nanorod-modified electrodes. The enhanced diffusion occurring around these structures and the materials have different affinities to the different nanostructures are discussed.

## 2. Experimental

### *2.1. Preparation of gold (III) solutions*

1 wt.% gold (III) solutions for the electrochemical deposition were prepared by dissolving

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