



ELSEVIER

Contents lists available at SciVerse ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/matlet

Facile deposition of gold nanoparticle thin films on semi-permeable cellulose substrate

Ndabenhle Sosibo^a, Phumlani Mdluli^a, Philani Mashazi^{a,b,*}, Robert Tshikhudo^a, Amanda Skepu^a, Sibulelo Vilakazi^a, Tebello Nyokong^b

^a Nanotechnology Innovation Centre, Advanced Materials Division, Mintek, Private Bag X3015, Randburg, South Africa

^b Nanotechnology Innovation Centre—Sensors, Chemistry Department, Rhodes University, PO Box 94, Grahamstown, South Africa

ARTICLE INFO

Article history:

Received 4 January 2012

Accepted 13 August 2012

Available online 21 August 2012

Keywords:

Gold nanoparticles

Thin film

Cellulose membrane

ABSTRACT

This study reports the facile method for the deposition of gold nanoparticle thin film onto a monoporous semi-permeable cellulose membrane through the diffusion of borohydride ions leading to the reduction of $AuCl_4^-$ ions. The synthesis of gold nanoparticle thin film was deposited on one side of the membrane that was exposed to $AuCl_4^-$ ions while the other side containing a reducing agent remained clear. The gold nanoparticle thin film exhibited a broad surface plasmon resonance (SPR) peak at 529 nm. Various characterization techniques were employed and all demonstrated the presence of gold thin film. The reported method represents a simplistic method for the deposition of gold nanoparticle thin films and various other metal nanoparticles may be deposited following this method.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Metal nanoparticles and their preparation have attracted much attention due to their interesting physico-chemical properties and potential applications [1–4]. Thin films of metal nanoparticles deposited onto solid substrates represent an important class of materials with wide potential applications from energy to electronics [5]. Nanometer size particles with different shapes, sizes and varied optical and electrical properties are a subject of international interest [4,6–8]. The applications of the metal nanoparticles, especially gold nanoparticles ranges from basic research to applied research in biology (sensors), catalysis and nanotechnology [4]. The use of cellulose as a substrate or support for preparation of metal nanoparticles has been described in literature [9,10]. This technique takes advantage of the porosity of cellulose and metal ions are impregnated and subsequently reduced to form nanoparticles within the cellulose matrix. This is however limited to the pore size and an overall porosity of cellulose fibers as the support for the formed nanoparticles. Such synthesis of metal nanoparticles impregnated onto cellulose fibers have been reported with multiple immersion and rinsing steps [9]. Dong and Hinestroza [11] reported the synthesis of cationically charged cellulose substrates by grafting positively charged (2,3-epoxypropyl)trimethylammonium chloride (EPTAC) and used as templates for the deposition of negatively charged

nanoparticles and negatively charged metal complexes. The difficulties of the previous studies, were scaling-up and reproducibility of these types of reactions which were generally impractical. This is due to the fact that the immersion and cleaning steps involved result in altered stoichiometric amounts absorbed which cannot be precisely defined.

In the present study, we report a facile synthesis of nanogold thin films onto monoporous, semi-permeable regenerated cellulose membrane. Regenerated cellulose membranes are commonly used for dialysis of biological molecules and are composed of uniform pore sizes allowing for potentially consistent deposition of metal nanoparticles.

2. Experimental

A basic synthetic protocol was followed to form the gold nanoparticle thin film on cellulose. The synthesis was conducted using a cellulose Slide-A-Lyzer Dialysis Cassette (10k MWCO, Pierce Biotechnology, Inc., USA) composed of ~24 Å diameter pores as a reaction chamber. The membrane dialysis cassette was first hydrated by immersing in 40 mL Milli Q water (18 mΩ resistivity) for 1 min. The cassette was then injected with 2 mL of 0.01 M $AuCl_4^-$ aqueous solution. The cassette was then immersed into 500 mL solution of 0.1 M $NaBH_4$ under mild stirring. Within 2 min of stirring the yellowish membrane surface turned red signifying the progress of the reaction. The stirring was continued for an hour. After which the solution was clear in color within the dialysis cassette signifying the complete reduction of gold salt. The membrane changed from clear to grape red color

* Corresponding author at: Nanotechnology Innovation Centre, Advanced Materials Division, Mintek, Private Bag X3015, Randburg, South Africa. Tel.: +27 11 709 4497; fax: +27 11 709 4480.

E-mail address: philanim@mintek.co.za (P. Mashazi).