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Visualizing latent fingerprints by electrodeposition of metal nanoparticles

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ABSTRACT

A novel and simple strategy for visualizing both sebaceous and eccrine latent fingerprints on conductive surfaces (indium/tin oxide-coated glass, gold, platinum and stainless steel coin) has been developed by the use of spatially selective electrodeposition of gold or silver nanoparticles (NPs). In this technique, the fingerprint residue acted as an insulator to the electrodeposition process, so that the metal NPs could only be generated on the areas without residue, which resulted in a negative image of the fingerprint with high contrast. In addition, latent fingerprints could be effectively visualized on various conductive surfaces no matter they were smooth or rough, clean or dirty. The surface morphology of AuNPs was characterized by the field emission scanning electron microscopy (FE-SEM).

1. Introduction

Fingerprints are the key and most widely used evidence in criminal investigations since they are an internationally recognized means of human identification [1,2]. Fingerprints are unique to each person and remain unchanged during an individual's lifetime. When a finger touches a surface, secretions are deposited leaving an impression of the finger's ridge pattern, some of them invisible named as latent fingerprints (LFPs), which require physical or chemical treatments to enhance their visualization. To date, although a great variety of methods have been exploited for the detection of LFPs [1–9], a few works have reported the enhancement of LFPs on metal surfaces [10–15].

Metallic objects have an important forensic relevance, particularly noble metals and stainless steel which are commonly used in handles, tools, weapons, etc. Metals are regarded as smooth, non-porous surfaces which are capable of retaining LFP residue [6]. Among the existing methods, powders, cyanoacrylate fuming, aqueous electrolytes, metal vapor deposition and scanning probe techniques have proved very useful to develop LFPs on metallic surfaces [10–14]. Nevertheless, the detection techniques also have their apparent drawbacks: inevitably destroying some LFP details (powders), suffering from contaminative reagents (liquids, powders and chemical fuming) or requiring relatively expensive purpose-built equipment and protracted imaging time (scanning probe techniques). Recently, Hillman et al. has reported an attractive method involving the electropolymerization of electrochromic polymer on metal surfaces between fingerprint ridges to generate a negative image of the LFPs [16,17]. However, the electrochromic enhancement was prone to be influenced by anionic surfactant and the relatively weak visibility needed to be improved. Herein, we report the first use of electrodeposition of metal nanoparticles (NPs) for the effective enhancement of LFPs.

Electrochemical deposition is a powerful method to prepare metal NPs, while AuNPs is normally used [18]. AuNPs have been widely used in the fabrication of different kinds of biosensors since they have the ability to enhance the electrode conductivity and facilitate electron transfer [19–21]. Previously, electrodeposition of AuNPs on indium/tin oxide (ITO) film coated glass [22,23], gold electrode [24] and glassy carbon electrode [25,26] has been reported and it provides a easy, rapid and low cost tool to modify conducting surfaces [27,28]. LFP enhancement by AuNPs suspended in aqueous medium, followed by a silver physical developer, has been used in a process known as Multi-Metal Deposition (MMD), which suffers from the poor repeatability and complicated experimental conditions with many immersion baths required [29–31].

Herein, we describe a simple and efficient strategy for visualization of both sebaceous and eccrine LFPs by spatially selective electrodeposition of gold or silver NPs. The electrodeposition process can only occur on the valleys between fingerprint ridges and on the free conductive surfaces to generate an enhanced contrast with the undecorated ridge details. It presents the great advantage of being a relatively simple, rapid, high resolution and non-hazardous technique for the LFPs on smooth and rough, clean and dirty conductive surfaces.

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2. Experimental

2.1. Substrates

The ITO film coated glass (KYKY Technology Development Ltd.) was cut 15 mm × 15 mm pieces form by a glazing knife. Samples of 10 mm × 10 mm × 0.5 mm gold and platinum (99.9% purity) were obtained from Beijing Mountain Technical Development Center for Non-ferrous Metals. The stainless steel coin (the fifth set of RMB) was also studied. All the substrates were washed in acetone, ethanol, deionized water, and left to dry in the air.

2.2. Fingerprint samples

Both sebaceous and eccrine LFPs were studied here. Prior to fingerprint deposition, the volunteer's hands were thoroughly washed with soap, rinsed with water, and dried. Sebaceous fingerprints were donated by the volunteer by rubbing his fingertip over forehead or nose and then stamping on the substrates gently. To produce an eccrine fingerprint, a PE glove was worn for 15 min. All of the fingerprint samples got from one donor. The LFP sample was employed as the working electrode (Fig. 1) in a conventional three electrode cell, with a platinum foil as counter electrode and an Ag/AgCl (saturated with KCl solution) as reference electrode.

2.3. Chemicals and apparatus

$AgNO_3$, KNO_3, H_2SO_4 (Sinopharm Chemical Reagent Co., Ltd.) and $HAuCl_4$ (Alfa Aesar) were used as received. All aqueous solutions were prepared with deionized water (conductivity of 18.2 μS cm^{-1}) purified by a Milli Q plus 185 (Millipore). The electrodeposition of metal NPs was performed under potentiostatic condition by a CHI 660D (CH Instrument, Inc.) electrochemical work station. After electrodeposition, the LFP samples were dried by nitrogen and captured using a Canon IXUS 210 digital camera. The morphology of AuNPs was further examined by field emission scanning electron microscopy (ZEISS, AURIGA FIB).

3. Results and discussion

3.1. LFPs on ITO surface enhanced by electrodeposition of AuNPs

The electrodeposition potential and time were first optimized for producing high contrast between the ridges and the valleys. The top part of Fig. 2 displayed the cyclic voltammetric (CV) curves

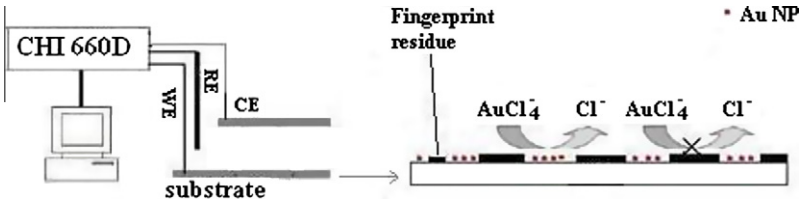

Fig. 1. Schematic representation (not to scale) of the strategy for visualizing latent fingerprints by electrodeposition of gold nanoparticles.

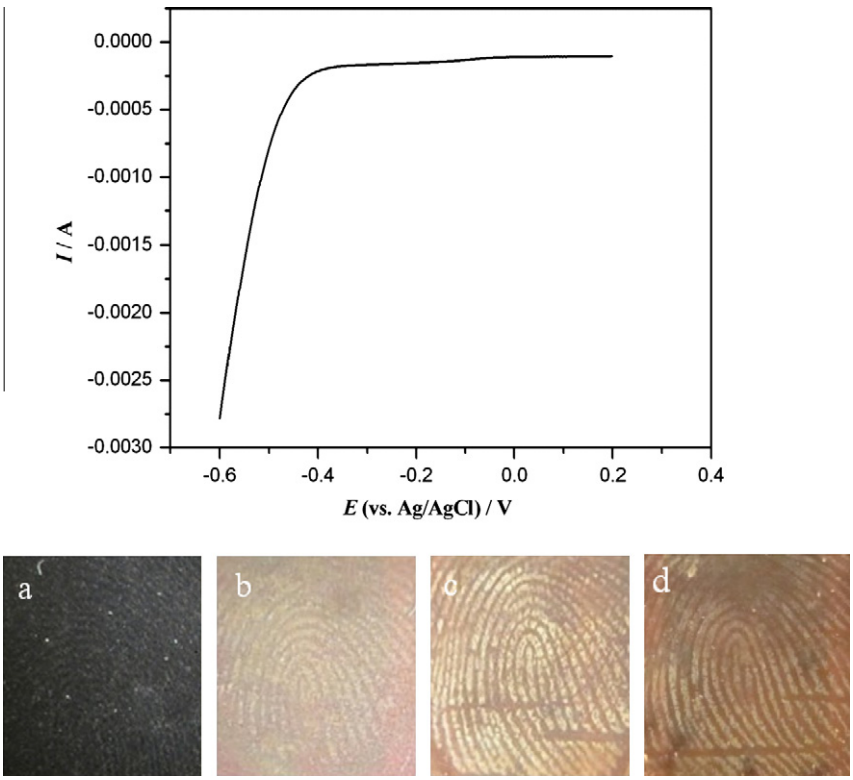

Fig. 2. CV of an ITO electrode in 2.5 mM $HAuCl_4$ + 0.5 M H_2SO_4 recorded at a sweep rate of 100 mV s^{-1}. Latent fingerprints (a–c: sebaceous fingerprint; d: eccrine fingerprint) on ITO substrate developed by electrodeposition of AuNPs with different reaction time at −0.5 V (a) blank control, (b) 1, (c and d) 5 min.