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Surface plasmon resonance based fiber optic dopamine sensor using green synthesized silver nanoparticles

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ABSTRACT

Facile green synthesis of stable silver nanoparticles in flower extract of *Acmella oleracea* and its dopamine sensing properties are reported. UV–visible spectroscopy, Fourier transform infrared (FTIR) spectroscopy, transmission electron microscopy (TEM) and particle size analysis were performed to ascertain the formation of silver nanoparticles. Aqueous dopamine sensing study of green synthesized silver nanoparticles was carried out. Further surface plasmon resonance (SPR) based fiber optic sensor has been fabricated using green synthesized silver nanoparticles as sensing material. The response time of the sensor is 6 min and the detection limit is 2×10^{-7} M.

1. Introduction

Metal nanoparticles have generated a lot of interest in various disciplines over the last decade [1]. Different chemical routes to synthesize silver nanoparticles have been developed over the past few years [2]. The chemicals used for the synthesis of nanoparticles are toxic and harmful for the environment [3]. As a part of developing ecofriendly methods, new synthetic routes based on green chemistry principles are being developed [4,5]. Silver nanoparticles (AgNPs), using plant extract have become a major focus due to their simplicity of procedures and outstanding plasmonic activity [1]. Plant extracts may act as both reducing and stabilizing agents in the synthesis of nanoparticles. The source of the plant extract is known to influence the characteristics of the nanoparticles. A variety of plant and fruit extracts have been used for the synthesis of silver nanoparticles [6–13]. However, *Acmella oleracea* extract has not been explored yet as a reducing and stabilizing agent for AgNPs. Leaves and flowers of *A. oleracea* are used as a local anesthetic to treat toothache [14]. Moreover, this medicinal plant is used for the treatment of stomatitis and cold [15]. Literature survey shows that acmella has different biological effects such as local anesthetic, analgesic, antipyretic, anti-inflammatory, antioxidant, diuretic and vasorelaxant [16].

Dopamine (DA) is an important catecholamine neurotransmitter plays a critical role in the human body and brain [17]. Detection and quantification of DA are important in diagnoses, monitoring, prevention and treatments of several neurological disorders. Therefore, monitoring of dopamine concentration is an essential technique in the clinical diagnosis of neurological diseases. In recent years, different analytical methods have been reported for DA determination. Common DA detection methods utilize electrochemical analysis [18,19], photoelectrochemical [20], chemiluminescence [21,22], chromatography, colorimetricprobes, flurometric [23], visible spectrophotometry, chromatography/mass spectrometry [24], electrophoresis [25] and LSPR sensors using silver nanoparticles [26]. However, most of these methods do not meet the growing requirements. In this regard, further development of simple and more cost-efficient practical sensors for DA is desired. Compared with available techniques for DA analysis, fiber optic spectroscopy is a simple, efficient and sensitive method.

Localized surface plasmon resonance (LSPR) based sensors were widely studied as biosensors [27–29]. LSPR can be tuned based on the properties of capping material, surface modification, particle shape, medium refractive index, surface charge and inter particle interaction, more efficiently than the size of the particle [30].

Currently fiber optic sensors have gained considerable attention in bio-chemical field, the collaboration of surface plasmon resonance (SPR) technique and optical fiber technology have brought a lot of advancements in sensing of various physical, chemical, and biochemical parameters [31]. Sensors based on optical fibers have

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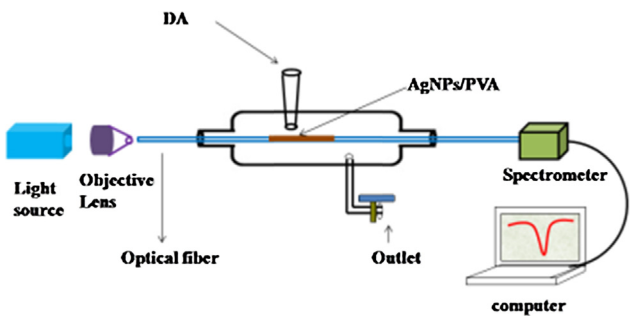

Fig. 1. Schematic representation of experimental setup of fiber optic dopamine sensor.

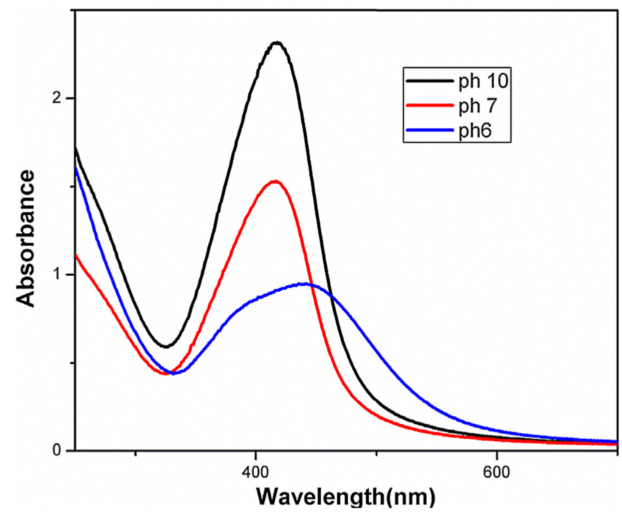

Fig. 2. UV–visible spectrum of AgNPs synthesized at different pH.

been investigated for improving their sensitivity and selectivity. Optical fiber sensors have many advantages over conventional sensors such as immunity to electromagnetic interference, small and compact size, sensitivity, remote sensing, ability to be multiplexed and embedded into various textile structures [32] waveguide based SPR sensing structures have been widely studied. The utilization of optical waveguides offers numerous advantageous features such as small size, robustness, and potential for remote sensing. Various SPR sensors based on integrated optical waveguides and optical fibers have been developed [33]. Fiber-optic SPR sensors have diverse structures that include D shaped, cladding-off, end-reflection, angled fiber tip and taper fiber structures. The typically used metals are gold and silver [31]. Metal thickness is an important parameter in determining sensor characteristics. Many novel SPR fiber sensors using fiber gratings or adopting photonic crystal fiber (PCF) concepts have been proposed recently [34–36].

In this paper, we adopted a novel approach for one pot synthesis of silver nanoparticles and its application in dopamine sensing. LSPR of silver nanoparticles was utilized to sense dopamine by spectroscopic methods, further developed a fiber optic SPR sensor

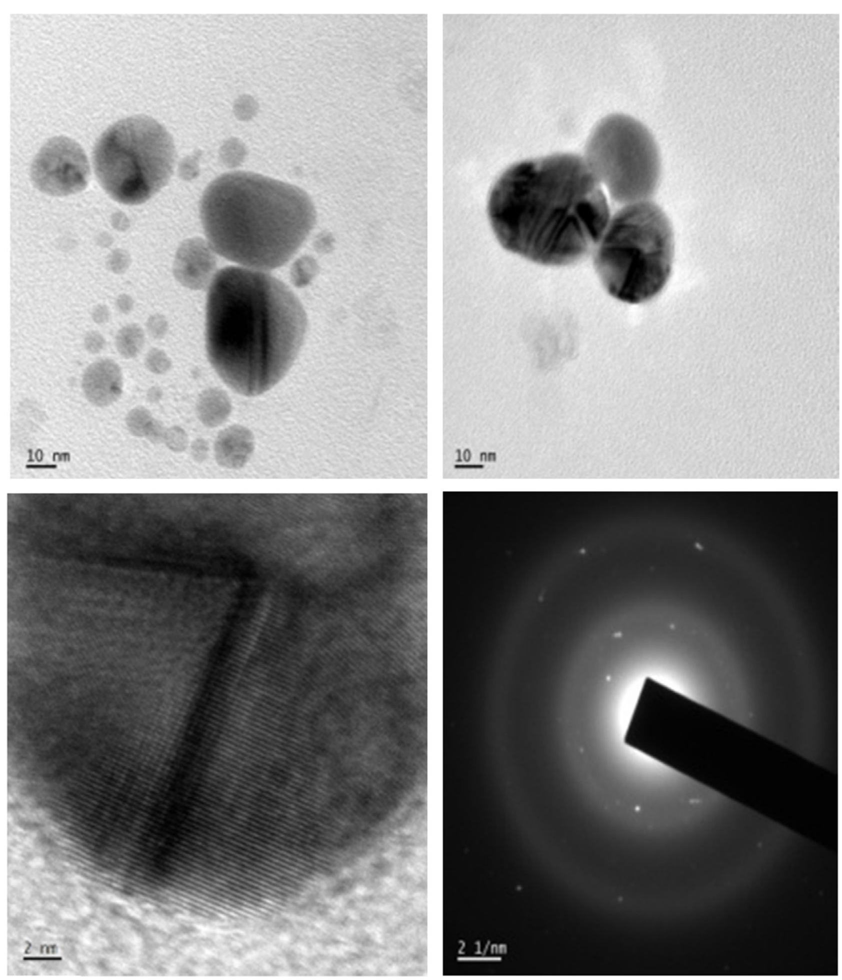

Fig. 3. Transmission electron microscope (TEM) images of green synthesized AgNPs.