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Effects of potentiodynamic electropolymerization parameters on electrochemical properties and morphology of fabricated PANI nanofiber/graphite electrode

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ABSTRACT

In this study, aniline nanofibers were fabricated through cyclic voltammetry electropolymerization on graphite electrode in the acidic solution of Aniline, in two different conditions. In the first condition aniline was electropolymerized in a potential range from −0.2 to 1 V and at different scan rates, while in the second condition; electropolymerization was done at a fixed scan rate of 25 mV s^{-1} and with different switching potentials. The effect of scan rate and switching potential on electrochemical properties and the morphology of produced polyaniline film was investigated by different electrochemical tests such as cyclic voltammetry, electrochemical impedance spectroscopy, and also scanning electron microscopy. The electrochemical investigations indicated that an optimum condition of 25 mV s^{-1} scan rate and a −0.2 to 1 V potential range can be reached where electropolymerized polyaniline could be at its peak of electroactivity, electrical and ionic conductivity and apparent diffusion coefficient (*D*), which is ideal for electrocatalytic applications. The SEM micrographs also confirm the formation of polyaniline with nanofibrous morphology at this optimum condition.

1. Introduction

Conducting polymers are modern materials with various applications whose synthesis and properties have been studied extensively due to the growing interest in the mechanism of their polymerization and redox transformation between conductive and passive states [1]. Among numerous known electroconducting polymers, polyaniline and its derivatives are probably the most investigated because of their unique properties among which one can make mention of having various oxidation states, electrical and optical activity, low cost monomer, red/ox reversibility and environmental stability [1,2]. The great interest in this area of research is connected to the discovery of polyaniline's conductivity in the form of emeraldine salt and the existence of different oxidation forms [3]. These diverse and important features seem to be promising in a wide range of practical application from rechargeable power sources [4], sensors [5], magnetic shielding, electrochemical capacitors [6], to electrochromic devices [7] and corrosion protection [8].

It is clear that the morphology of produced polymer affects its properties to a large extent. Among different morphologies that may be obtained from the polymerization of PANI, the formation of fibrous morphology has various important applications—namely in the domain of sensors—due to effective increase in its surface area.

Aniline nanofibers are usually manufactured by chemical polymerization methods, while little research has been done in fabricating aniline nanofibers by electropolymerization method. Furthermore, it is found that among different electrochemical methods, due to its non-continuing growth of polymer, cyclic voltammetry is a preferred method in producing controlled nanofibers with excellent electrochemical properties. Chemical polymerization is used when large quantities of polymer are requested. However, electrochemical polymerization is more preferable, since in most cases the polymer is directly deposited on the electrode and is especially useful if polymer film electrode is needed. Also through designing the electrochemical experiment properly, polymer thickness and conductivity can be easily controlled [9].

Electrochemical polymerization of conductive aniline is routinely carried out in strongly acidic aqueous electrolytes and through a generally accepted mechanism which involves the

Abbreviation: EIS, electrochemical impedance spectroscopy; CV, cyclic voltammetry; SR, scan rate; SP, switching potential; PANI, polyaniline; SEM, scanning electron microscopy.

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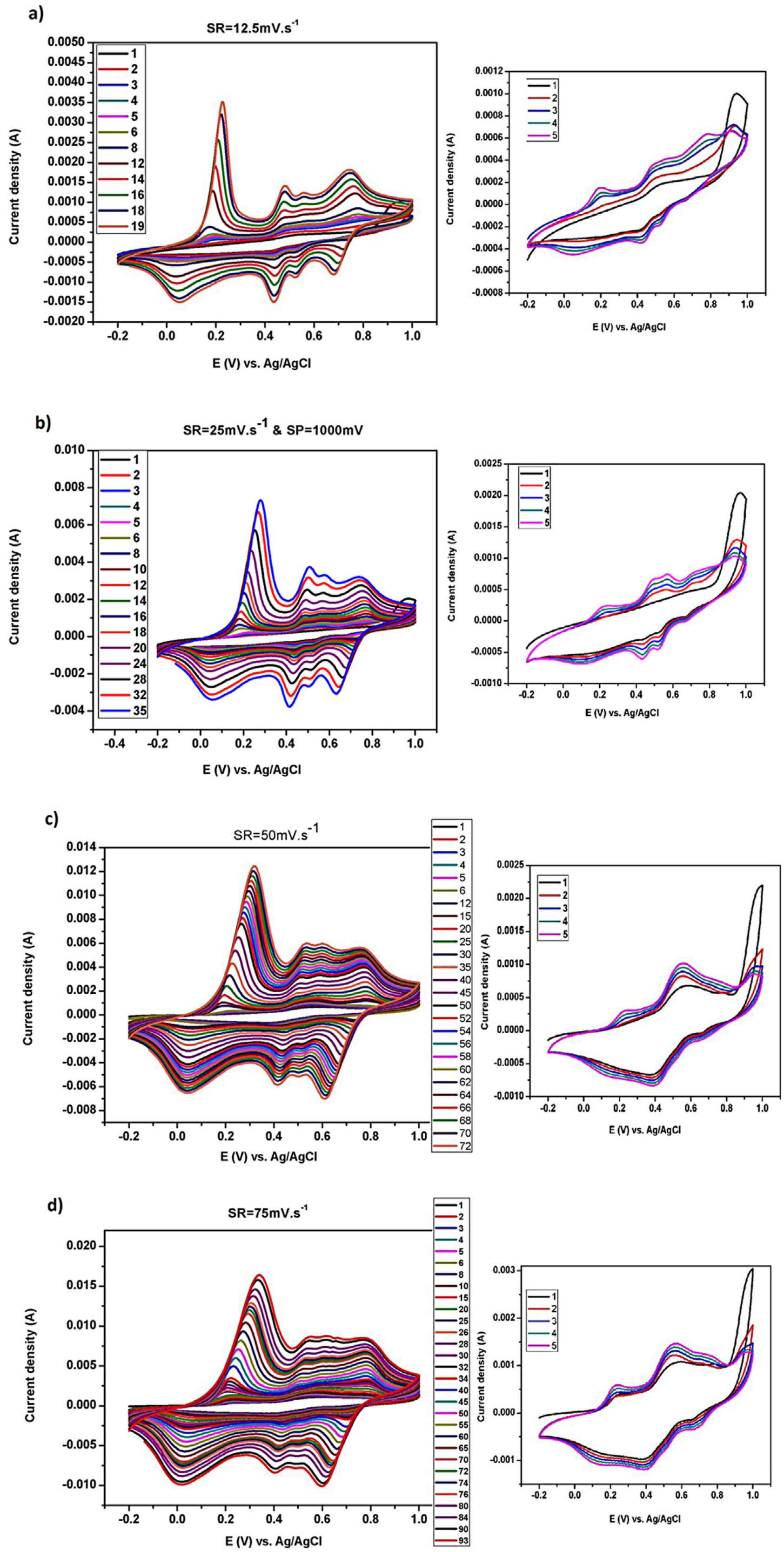

Fig. 1. Cyclic voltammograms (CVs) recorded for aniline electropolymerization in different conditions: (a) SR: 12.5 mV s^{-1}, (b) SR: 25 mV s^{-1}, (c) SR: 50 mV s^{-1}, (d) SR: 75 mV s^{-1}, (e) SR: 100 mV s^{-1}, (f) SP: 900 mV, (g) SP: 1100 mV.