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Short Communication

Eletrospun Polymer Composite to be Used in Cardiology

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Abstract

In order to restore the cardiac damaged tissues cardiac patches have been employed Electrospinning technique has been adopted to design cardiac patch and the same has been assessed with regard to its physicochemical characteristics. Polyurethane coated with cobalt nano particles has been used to prepare the patch and has been synthesized using green approach by means of green tea containing polyphenols. Nanoparticles with varied morphology have been obtained using different concentrations of cobalt salt concentrations mixed with green tea solution. Also, cobalt nanoparticles so synthesized CoNPs with specified concentration has been applied on the polyurethane adopting electrospinning technique. Studies using SEM have revealed that the developed patches having greater concentration of cobalt nano particles showed smaller diameter in comparison with polyurethane. The polyurethane cobalt nanoparticles patch rendered hydrophilic surface with lower ratio of cobalt nano particles. Whereas, greater ratio of cobalt nano particles have shown improved strength compared to the pristine polyurethae. Patches with the improved physicochemical properties and mechanical strength can be exploited for cardiac applications.

Keywords: cardiac patches; electrospinning; cobalt nanoparticles; green tea; nanocomposite

1.Introduction

Higher surface area increases materials functionality. Nanofibres are widely undisputed choice for many engineering applications and it is also used in biomedical applications like tissue engineering scaffolds, drug delivery, medical textiles etc [1]. Electrospinning allows the fabrication of nanometer scale tubules and fibrils from different materials like electronically conducting carbons, metals, polymers and semiconductors in a simple and facile manner [2]. The main setup of electrospinning comprises of 5 to 50 kV high voltage power supply which is connected to a spinneret. A grounded collector is used to harvest the nanofibre at a distance. High voltage is conducted to the polymeric solution droplet at the spinneret's tip causing the electrostatic repulsion to occur which allows the stretching of droplets from charged solution and accelerate it towards the collector of opposite polarity. Before collection, the solvent is evaporated creating the polymeric nanofibres at the collector. Nanofibres are used for the development of the cardiac patch. Cardiac patch is used for post-myocardial infarction application which acts as a scaffold to support and regenerate myocardium. A patch's ability to induce the regeneration of cardiac tissue and heart refunction depends upon the patch's physicochemical properties [3]. Current patch materials are made up of either polymeric material or from a bovine origin. Synthetic polymers used in the manufacturing of cardiac patches and grafts are polyester (most commonly Dacron) and polytetrafluoroethylene (such as Gore-TexVR) [4]. The use of these synthetic polymers in biomedical applications is limited due to certain drawbacks like lack of cell affinity, lack of efficiency due to thrombus formation and low mechanical strength [5]. It is evident that a single material cannot provide the required physicochemical and necessary biological properties which necessitates the manufacturing of composite materials with optimum properties. A composite material is a material made up of more than one constituent materials. As a result of combining different materials, the composite material will have better physicochemical properties. Recently, polymeric composite patches combined with essential oil have been explored for cardiac patch applications. Carotino oil blended with polyurethane possess necessary blood compatible properties for cardiac patch applications [6] (Jaganathan et al., 2018). Further, metallic particles are gaining recognition in cardiac patches since they render conducive mechanical properties. In a recent research, polyurethane added with nickel oxide and titanium oxide has rendered required roughness and mechanical strength than pristine polyurethane [7,8]. This motivated us to explore another widely reputed metallic element like cobalt for cardiac patch. However, instead of directly incorporating the metallic particles as reported in previous studies, for the first time green synthesized cobalt nanoparticles were utilized. Polyurethanes (PU) is chosen as the matrix polymer as it has good mechanical and biocompatible properties. In addition, PU is ideal for membrane applications due to its good barrier properties and oxygen permeability [9]. The filler material that is used along with the PU is cobalt nanoparticles (CoNPs). The main advantage of this work is CoNPs are synthesized with the help of plant extracts that are eco-friendly and cost effective. In this work, green tea extract is utilized due to its rich and varied composition of phytochemicals which can act as a potential reducing agents [10]. The synthesized cobalt nanoparticles were characterized and integrated into polyurethane matrix through single stage electrospinning. Finally, the fabricated electrospun composite patches were subjected to fibre morphology analysis, wettability, functional group changes and mechanical strength in comparison with pristine polyurethane patch.

2. Technical details

The materials include TECO flex EG-80A medical-grade thermoplastic polyurethane (PU), dried green tea leaves, N, N-dimethylformamide (DMF) and cobalt nitrate salt. The following procedures have been followed

a. Preparation of green tea solution
b. green synthesis of cobalt nano particles
c. UV-Vis spectrophotometric absorption
d. Field-emission scanning electron microscopy (SEM) and EDX analysis of CoNPs
e. Preparation of bio composite solution
f. Fabrication of Polyurethane Cobalt nano particles cardiac patch
g. Scanning electron microscopy and EDX analysis
h. Fourier transform infrared spectroscopy
i. Contact angle measurement
j. Mechanical testing

Investigaions have been focused on the following aspects

a) UV-Vi's spectrophotometry [10]
b) EDX data [11]
c) Field emission scanning electron microscopy (FESEM) [12-14]
d) Scanning electron microscopy of PU and PUCONPs patch [15]
e) Fourier transform infrared spectroscopy [16]
f) Contact angle measurement [17,18]
g) Mechanical testing [19-21]

3. Conclusion

For the first time, cobalt nanoparticles synthesized using green tea extract was integrated in the polyurethane scaffold through single stage electrospinning. Synthesized cobalt nanoparticles were visualized using FESEM and its existence were confirmed with EDX. The synthesized cobalt nanoparticles were integrated with polyurethane scaffold rendered smooth morphology mimicking the structure of extracellular matrix. FTIR analysis indicated the interaction between the polyurethane and cobalt nanoparticles. Finally, contact angle analysis revealed that the patch wettability can be tailored successfully by altering the composition of cobalt nanoparticles. Hence, developed patch mimics the structure of the extracellular matrix and exhibit appropriate physicochemical properties. To further anchor the role of the developed composite in cardiovascular application it is necessary to investigate the blood compatibility and cardiomyocytes proliferation and adhesion on the patch material. The tailor-made wettability opens diverse opportunities of the developed material as scaffolds in other tissue engineering scaffolds. However, the developed patch should be experimented further both in preclinical and clinical trials, in order to promote it as a candidate for cardiovascular and other tissue engineering applicationsthe developed patch holds promising potential to be utilized as a cardiac patch.

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