Electrospun Polyaniline Aligned Fibrous Meshes with Conductivity for Cardiac Tissue Engineering

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Heart failure is a public health problem. Normally, it occurs when the vessels supplying blood to the heart suddenly get occluded, known as myocardial infarction (MI), or the cardiac tissue is abnormal in electrical function that severely impair the cardiac performance, known as arrhythmias. Cardiomyocytes are terminally differentiated and do not reenter the cell cycle shortly after birth, causing these cells to lose their ability to divide and lack the ability to regenerate after ischemic injury. Cell-based regeneration therapy has been regarded as one of the most promising methods to repair the damaged heart tissue. In addition to biocompatibility and biodegradability, an ideal biomaterial for heart tissue engineering should encourage the alignment and maturation of cardiomyocytes in vitro or after implantation, improving the contractile properties of the graft. More importantly, a prerequisite for a successful cardiac repair is that the grafted cells electrically and mechanically coupled to the native myocardium. In this study, a conductive and aligned nanofibrous mesh was developed. Conductive polymer, polyanilline (PAni), was blended with poly(lactide-co-glycolide) (PLGA) in a 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP) solution for electrospinning, and a continuous yarn was used to collect the aligned nanofibrs. We investigated the fundamental material properties of this highly oriented PLGA/PAni nanofibrous meshes, including their morphology, surface characteristics, and conductivity. The SEM and conductivity results showed that PLGA/PAni was blended in the ratio of 8%/1% (wt%) gained high conductivity (~10^{-3} s/cm) with uniform, smooth, and aligned morphology. For the *in vitro* study, we cultured neonatal cardiomyocytes on this conductive aligned mesh. Live/dead staining images and LDH assay indicated that the HCl-doped meshes not only supplied a fine adhesion environment, but guided the cells grown as rod shape and oriented into parallel arrays in direction of the oriented fibers. Furthermore, in order to estimate the effect of the PLGA/PAni meshes on the beating behaviors of cardiomyocytes after electrical stimulation, we applied continuously trains of electrical pulses and the results were observed using a fluorescence microscope. We found that before electro stimulation, cardiomyocyte clusters were beat randomly due to the lack of Cx43 between two clusters. However, at the beginning of the stimulation, the applied electrons rapidly transfer from one cluster to another by conductive mesh causing that all of the clusters on the mesh beat synchronized. This study confirms the potential and feasibility of the conductive polymer on heart tissue engineering which maybe can be applied to the repair of myocardial infarction or arrhythmias in the future.

Keywords: conductivity; cardiomyocyte; electrical stimulation; tissue engineering