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Development Of Glaucoma Fibrous Implant Made From PVDF And PEO

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Extended Abstract

Glaucoma, also known as "green cataract," is a series of eye conditions generally caused by high intraocular pressure. This pressure damages the structure and reduces the fibers of the optic nerve, leading to gradual vision loss. One of the causes of the accumulation of intraocular fluid inside the anterior chamber is the clogging of the trabecular meshwork pores, preventing the fluid from draining out of the eye. In current glaucoma therapy, three basic approaches are utilized, based on reducing intraocular pressure: conservative treatment using local or oral medications, laser interventions, surgical treatment, or their combination. Currently used materials in glaucoma management mainly fail due to insufficient drainage of intraocular fluid, hypotony, or inflammatory reactions. Therefore, it is necessary to search for new materials that would reduce the risk of reoperations and improve patients' quality of life. One highly innovative solution currently being explored is nanofiber materials, which can simulate the function of the trabecular meshwork. [1-4]

Therefore, the work focuses on producing a nanofiber implant that would morphologically resemble the trabecular meshwork and thus replace its function when implanted into the eye. The main requirement for the implant is the biocompatibility of the materials used for its production. The materials should prevent cell growth and ensure smooth drainage of intraocular fluid out of the eye. At the same time, the implant must not degrade in the eye to ensure fluid drainage throughout the patient's lifetime. Nanofiber layers can currently be produced in several ways. One of the most common methods is electrospinning. Additionally, nanofiber layers can be produced using methods such as centrifugal spinning, meltblown technology, or phase separation. Electrospinning can be divided into needle and needleless electrospinning. As the name suggests, needle electrospinning uses a needle-shaped electrode. In needleless electrospinning, a metallic rod, roller, or string can be used as the electrode. The last mentioned electrode, the string, was used in the experiment to form nanofiber layers using the Nanospider device. [5-8]

For the production of the nanofiber implant, a biocompatible and non-degradable polyvinylidene fluoride (PVDF, Sigma-Aldrich; Mw: 180,000 g/mol) was selected, combined with polyethylene oxide (PEO, Sigma-Aldrich, Mw: 200,000 g/mol) to ensure sufficient porosity. For electrospinning, a solution of PVDF with a concentration of 26 wt.% in dimethylacetamide (DMAc) was prepared. The solution was stirred and heated at 80°C for 24 hours. Additionally, a solution of PEO with a concentration of 2 wt.% in acetone was prepared. The PEO solution was stirred for 24 hours at a temperature of 55°C. After 24 hours, the PVDF solution was added to the PEO solution, and the mixed solution was stirred for 30 minutes at 55°C. Electrospinning of PVDF with PEO was only possible so far using the needle electrospinning method due to the necessity of heating the solution to 60°C. As part of the experiment, a solution heating system was developed for the Nanospider device, which is used for industrial production of nanofiber layers.

The morphology and fiber diameters of the produced nanofiber layers were examined. Subsequently, the permeability of the nanofiber layers was evaluated using simulated intraocular fluid, and finally, the cytotoxicity of the manufactured materials was monitored. From the results, it was found that the produced materials did not exhibit defects, were non-toxic, and were permeable to simulated intraocular fluid.

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