POLYMERIC NANOFIBER DEVICE CROSSLINKED WITH AN ANTIFIBROTIC AGENT FOR PREVENTING CAPSULAR OPACIFICATION AFTER CATARACT SURGERY

AUTHORS: Thomas Toshio Inoue[1], Ricardo José Alves[1], Silvia Ligorio Fialho[2] and Armando da Silva Cunha Junior[1]

[1]Federal University of Minas Gerais (UFMG), Brazil; [2]Ezequiel Dias Foundation (FUNED), Brazil

ABSTRACT

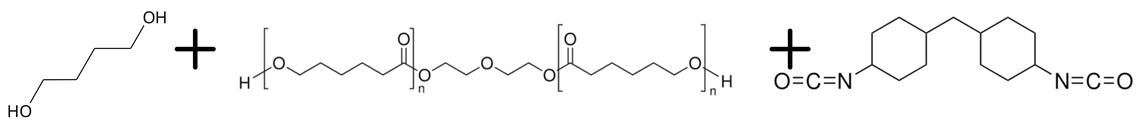
Cataract surgery can result in long-term complications such as secondary cataracts due to capsular opacification. These often lead to YAG laser capsulotomy intervention, with the potential for retinal damage and increased intraocular pressure. This work proposes a novel approach to address this challenge by developing a polymeric nanofiber device loaded with a potent antifibrotic agent peptide (PAAP) to prevent capsular opacification. Polyurethane was synthesized by a one-pot acetone method and nanofibers by electrospinning. The polymer and nanofibers were characterized using nuclear magnetic resonance spectroscopy, infrared spectroscopy, thermal analysis, and electron microscopy techniques. The synthesis yielded a translucent polymer, and electrospinning produced a nanofibrous membrane with fibers in the nanoscale range. Characterization confirmed the successful formation of polyurethane and its thermal stability in both bulk and nanofiber forms. This work demonstrates the successful fabrication and characterization of polyurethane nanofibers, establishing the basis for the development of a drug-delivery device to prevent secondary cataracts. Future work includes crosslinking the PAAP with the nanofibers, further system characterization, and in vitro and in vivo evaluation of its safety and efficacy. This approach holds promise for reducing the need for additional laser procedures after cataract surgery, improving patient outcomes, and potentially transforming the management of this common postoperative complication.

INTRODUCTION

Posterior capsule opacification (PCO) represents a significant complication after cataract surgery. Various strategies have been developed to prevent PCO, including the use of cytotoxic, antiproliferative, and antifibrotic agents. Our approach involves the development of a platform designed to be coupled with an intraocular lens. This platform will carry a potent, crosslinked antifibrotic agent intended to inhibit the formation of fibrosis. To achieve this, the initial step is to develop a biocompatible platform that contains the necessary functional groups to enable crosslinking with the peptide.

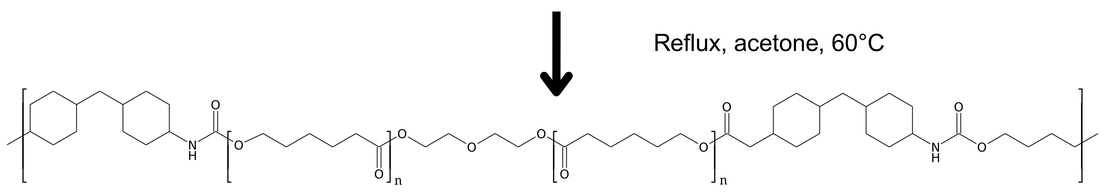
POLYURETHANE SYNTHESIS

Schematic representation of the polyurethane synthesis by one-pot acetone method:



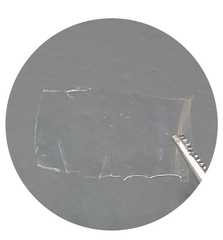
1,4 - butanediol | Polycaprolactone diol | HMDI

Reflux, acetone, 60°C

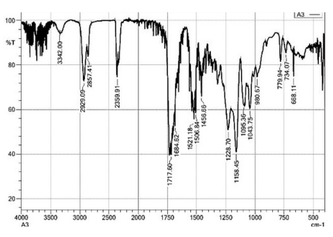


Polyurethane

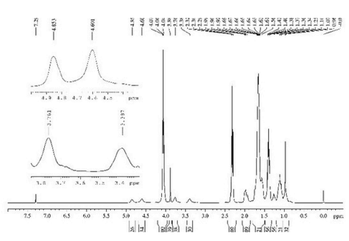
POLYURETHANE CHARACTERIZATION



Polyurethane sample



Infrared spectroscopy analysis



^{1}H NMR spectroscopy analysis

NANOFIBER PRODUCTION

Polyurethane nanofibers were produced via the SBS method, with the pressure differential driving fiber formation. For each membrane, 10 mL of polyurethane solution was utilized:

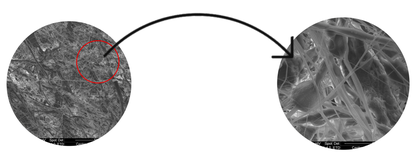
Polyurethane in chloroform 5% w/v

30 bar, 0.5 mm, 300 mm

Polyurethane membrane 100 x 100 mm

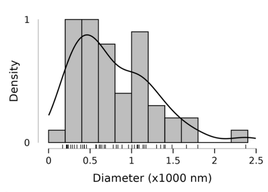
NANOFIBER CHARACTERIZATION

Scanning electron microscopy of the samples:



100x magnification | 1250x magnification

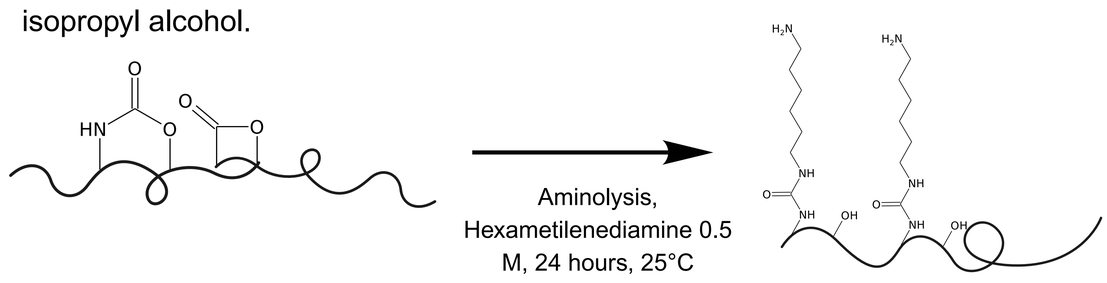
Mean diameter: 779 nm, stdev: 479 nm

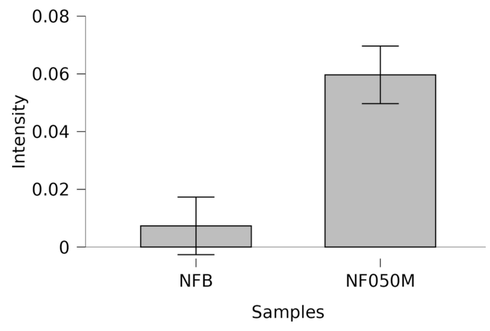


Nanofiber diameter distribution, n = 50

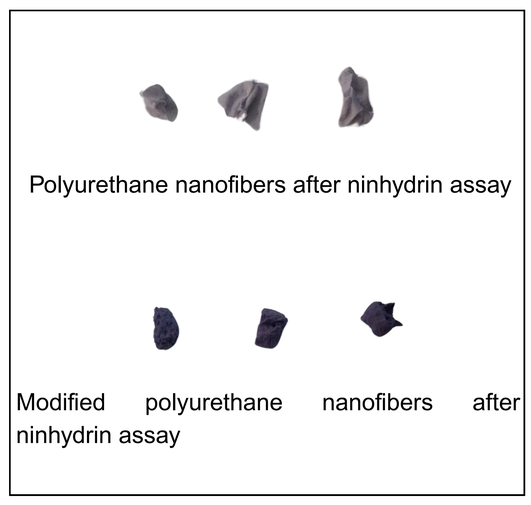
SURFACE MODIFICATION

To introduce reactive groups for peptide crosslinking, the surface was modified by incorporating amine groups via the aminolysis of hexamethylenediamine in isopropyl alcohol.





UV spectroscopy, 570 nm

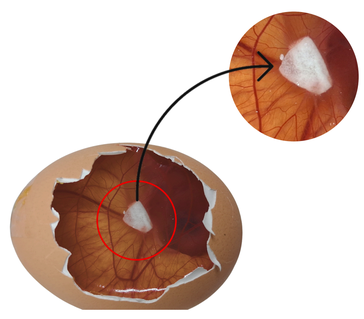


Polyurethane nanofibers after ninhydrin assay

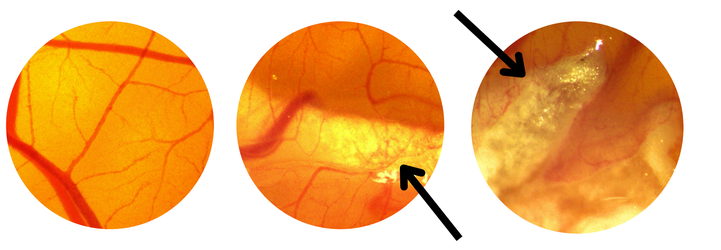
Modified polyurethane nanofibers after ninhydrin assay

IN VIVO EVALUATION

The CAM assay was used to verify the biocompatibility of the membranes. The biomaterial was added onto the membranes on the 7th day of incubation and assessed on the 10th day.



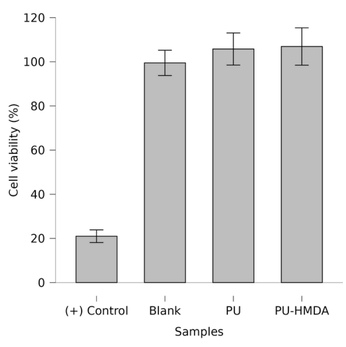
Chorioallantoic membrane assay



PBS solution | Polyurethane nanofibers | Modified polyurethane nanofibers

IN VITRO EVALUATION

To assess the biocompatibility *in vitro*, the samples were prepared following ISO 10993-12 (accelerated degradation, 70°C, 24 hours, 0.1 g/mL in PBS) and evaluated following ISO 10993-5 in ARPE-19 culture:



Cell viability assay (MTT assay) in ARPE-19 cells.
Where the blank is phosphate buffer and (+) control is 40% DMSO solution.

CONCLUSIONS

A biocompatible nanofiber device platform was successfully fabricated from the synthesized polymer. The surface was functionalized through aminolysis, which introduced amine groups capable of crosslinking with a peptide under appropriate conditions. The resulting modified platform maintained its biocompatibility. Consequently, this material demonstrates significant potential for use as a biocompatible device.

ACKNOWLEDGEMENT

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