HYDROGEL BASED INSOLES FOR DIABETIC FEET

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Degree of Master of Philosophy

Department of Electronic and Telecommunication Engineering

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Thesis submitted in partial fulfilment of the requirements for the degree of Master of Philosophy

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Declaration

I declare that this is my own research work and this report does not incorporate without acknowledgment any material previously published submitted for a Degree or Diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

Signature: UOM Verified Signature Date: 20/01/2022

The candidate, whose signature appears above, carried out research for the MPhil dissertation under my supervision

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Name of the supervisor: Dr. Pujitha Silva

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Contributions by others to the thesis

My supervisors Dr. Pujitha Silva and Dr. Thilini Gunasekara, have given the necessary advice, reviewed this thesis, and provided editorial suggestions.

Ms. Chathurani Dias has assisted with getting pressure insole readings.

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Abstract

This research considered an extensive study of double network poly (acrylic acid) and single network polyacrylamide hydrogel as an insole material for the diabetic foot by testing on compression strength, stress relaxation, compression fatigue, shear stress, and shock absorption properties. The previous studies on hydrogel fatigue were mainly focused on fatigue fracture in tension and crack propagation. This study focuses on the mechanical behaviour of hydrogels under diabetic foot-specific loading conditions. The expected testing conditions include minimum 20 000 fatigue cycles under maximum compression stress of 250 kPa at a 200 mm/ min strain rate.

The hydrogel synthesis and testing started with double network poly (acrylic acid) hydrogel. The developed double network poly (acrylic acid) hydrogel displayed fatigue properties up to 3000 loading cycles at maximum stress of 390±30 kPa. Further, maximum average shear stress and shear modulus of 80 kPa and 140 kPa respectively were observed at 84% strain before fracture.

Developed Single network polyacrylamide hydrogel displayed good fatigue properties up to 13,000 loading cycles at maximum stress of 520±50 kPa and 200 mm/min crosshead speed. When the maximum stress condition was reduced to 350±50 kPa, the maximum number of loading-unloading cycles was increased up to 20 000 indicating a single network polyacrylamide hydrogel capable of withstanding more than 20 000 cycles at 250 kPa.

Hydrogels showed superior recoverable and viscoelastic properties when compared with available insole materials. The developed finite element model was validated with pressure insole test data and used to investigate the pressure distribution properties and to optimize the thickness suitable for insole applications

The additional properties of a hydrogel such as high thermal capacity and structural similarity to soft tissues are seen as added advantages when compared to other insole materials to prevent re-ulceration.

Keywords

Hydrogel synthesis, Material characterization, Pressure insole, Finite Element Analysis,

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List of Abbreviations

Abbreviation	Description
AA	Acrylic Acid
AAm	Acrylamide
ATL	Achilles tendon lengthening
BM	Body mass
BMI	Body mass index
CL	Crosslink
DFU	Diabetic foot ulcer
DN	Double network
EVA	Ethylene vinyl acetate
FEA	Finite element analysis
I	Initiator
KPS	Potassium persulfate
M	Mole weight in g/ mol
MBA	N,N'-Methylenebisacrylamide
PAA	Polyacrylic acid
PAAm	Polyacrylamide
PNIPAAm	Poly (N-isopropyl acrylamide)
PU Gel	Polyurethane gel
SN	Single network
SW	Swelling percentage
TCC	Total contact cast