FLOW ENHANCEMENT USING PLANT BASED POLYMERS ADDITIVES IN BRAIN-VESSELS-LIKE MICROCHANNELS

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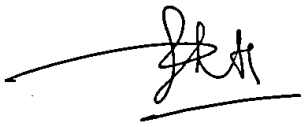

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ABSTRAK

Bahan tambah Polimer organik untuk pengurangan seretan (DRA) yang diperolehi dengan mengekstrak sumber semulajadi telah mula mendapat minat dan perhatian para saintis dalam usaha menggantikan sintetik DRA. Sedikit suntikan (Nano-Molar) bahan pengurangan seretan polimer (DRPs) akan meningkatkan pengaliran darah, pengoksigenan tisu, perfusi dan mengurangkan resistan vaskular darah pada haiwan tanpa mengubah bentuk salur darah mahupun kepekatan darah. Selanjutnya, dalam kajian mikrobendalir menunjukkan dengan penambahan DRPs ini akan menambahkan lagi pengagihan sel darah merah (RBC) pada sistem aliran mikro. Dalam penyelidikan ini, kesan DRA berasaskan tumbuhan terhadap peningkatan aliran cecair dalam mikrosaluran umpama salur darah otak akan dikaji. Selain dari itu, penyedidikan ini juga bertujuan untuk mengkaji kebolehsanan ekstrak polimer dari sumber tumbuhan dalam peningkatan alirancecair di dalam mikrosaluran. Dengan perkembangan teknologi mikrobendalir masa kini membolehkan pelbagai teori dan fenomena di perolehi, ia juga merupakan suatu kaedah ujian itu menjadi lebih jimat dan boleh dipercayai untuk bidang kejuruteraan mahupun perubatan berbanding dengan kaedah secara konvensional yang menggunakan batang paip, banyak bahan kimia dan bahan uji. Polimer organik ini di perolehi dari lendir kacang bendi, lidah buaya dan bunga raya secara kaedah pengekstakan berair. Beberapa surfaktan dan larutan polimer disediakan pada asas nisbah berat/berat dengan menambahkan air nyah ion (DI) yang bertindak sebagai bendalir kerja. Lima set mikrosaluran yang mempunyai ketebalan 200um dengan pelbagai bentuk luas sekatan merupakan simulasi sebagai saluran darah jantung manusia di bina dengan menggunakan kaedah Litografi dan diacukan dengan polydimethylsiloxane (PDMS). Ujikaji ini dijalankan menggunakan sistem gelung buka (open-loop) mikrobendalir yang dihubungkan ke mikrosaluran yang dibuat khas itu. Pretasi peningkatan aliran menggunakan pelbagai kepekatan bahan tambah dari (100, 300, 500, 700 dan 1000ppm) telah dinilai dengan merekodkan kadar aliran yang berpadanan dengan tekanan operasi (50 hingga 500mbar) untuk larutan bendi, lidah buaya dan bunga raya.Adalah dengan ini penting untuk mengambarkan bahawa kajian polimer semulajadi ini mempunyai ciri ciri pengurangan seretan. Hasil dari ujian ini ,suatu hubungan tidak linear diperolehi antara kepekatan bahan tambah dan peratusan kenaikan kadar aliran %FI. Jesteru itu, meningkatnya kepekatan polimer akan meningkatkan %FI sehingga ke satu had yang dipanggil kepekatan kritikal, di mana luar titik ini setiap peningkatan kepekatan mempunyai kesan negatif kepada pengurangan seretan. Dari hasil keputusan ujikaji, lendir lidah buaya memberikan kesan (14.02%) pengurangan seretan %FI yang tertinggi pada kepekatan (100, 300 dan 500ppm) manakala bendi (13.5%) pada kepekatan (700 dan 1000ppm). Dalam kebanyakan kes, dengan Meningkatnya tekanan operasi ini sehingga ke tekanan kritikal 400 mbar, akan meningkatkan %FI. Keputusan ujikaji mengesahkan bahawa bahan tambah ini berpontensi digunakan dalam bidang perubatan untuk menambah aliran darah pada saluran darah yang separa tersumbat dan ini merupakan satu pilihan rawatan alternatif untuk pesakit jantung. Ini adalah disarankan untuk menyelidik dan meneroka polimer semulajadi yang baharu yang mana dapat melarutkan atau menghakis kolestrol yang menyebabkan penyempitan saluran darah.

ABSTRACT

Plant based polymeric drag reduction additives (DRAs) obtained and extracted from natural resources started to gain interest and attention from scientists in an effort to replace the existing synthetic DRAs. The injection of a very small (Nano-molar) concentration of water soluble drag reducing polymers (DRPs) increases the blood circulation, tissue oxygenation and perfusion and decreases vascular resistance in animal models with no effect on blood vessels tone or viscosity. Furthermore, in microfluidic studies, it has been shown that the addition of DRPs will alter the distribution of red blood cells (RBC) in microcirculation. In this study, the effect of plant base DRAs on liquid flow enhancement through brain-vessels-like microchannels is investigated. The present work aims to study the feasibility of the natural polymer extracted from plant sources in enhancing the liquid flow in microchannels. Due to the development of microfluidics technology as an economical and reliable method for testing different theoretical phenomena related to engineering fields and medical fields, microchannel was utilized replacing the conventional method by using pipes which can reduce the usage of the chemical and reagents significantly. Plant base polymers were extracted from Okra, Aloe Vera and Hibiscus leaves using water extraction method. Different polymers solution concentrations were prepared by weight/weight basis after extraction by adding deionized (DI) water which acted as working fluid. Four microchannels which have a thickness about 200 μm with different clogging area simulating the human brain vessel size were fabricated using direct writing Lithography technique approach and then molded with polydimethylsiloxane (PDMS). The experiment was conducted using an open-loop microfluidic system. The flow enhancement performance of different concentration of the additives with different range of concentrations (100, 300, 500, 700 and 1000ppm) were evaluated by recording the flow rate corresponding to the operating pressure (50 to 500 mbar) for Okra, Aloe Vera and Hibiscus solutions. It is important to highlight that the examined plant base polymers have drag reduction properties. A non-linear relationship was obtained from this work between the concentration of the additives and percentage of flow rate increment (%FI). Increasing the polymer concentration increases the %FI until a limit which so-called critical concentration where beyond this point continuous increasing the concentration have an adverse effect on drag reduction. From the experimental results, Aloe Vera mucilage gives highest drag reduction performance (14.02%) by achieving higher %FI as Aloe Vera in lower concentrations (100, 300 and 500ppm) mucilage and Okra (13.5%) for higher concentrations (700 and 1000ppm). Moreover, Hibiscus showed the lowest %FI in this study (-15%). In most of the cases, increasing of the operating pressure up to the critical pressure of 400mbar, resulted in the increasing of %FI. The experimental results validate the potential use of these additives in medical fields to enhance the blood flow in semi-clogged blood streams which can be an alternative treatment for cardiovascular diseases. It was recommended that more new natural polymeric DRAs should be investigated and explored the possibility of these polymers to dissolve the cholesterol which cause narrowing of the blood vessels.

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LIST OF SYMBOLS

m	Meter
ppm	Part per million
ρ	Fluid density
μ	Dynamic viscosity of fluid
D	Internal diameter
μm	Micro meter
mm	Millimetre
mbar	Millibar
g	Gram
C	Concentration
Pa	Pascal
min	Minute
s	Second
a	after drag reducing additive addition
b	before drag reducing additive addition

LIST OF ABBREVIATION

%DR	Percentage of drag reduction
%FI	Percentage of flow rate increment
APG1214	Alkyl Polyglycoside
CMC	Carboxymethylcellulose
DI water	Deionized water
DR	Drag reduction
DRA	Drag reducing additives
DRP	Drag reduction polymer
DSC	Differential Scanning Calorimeter
FI	Flow rate increasement
FTIR	Fourier Transform Infrared
HF	Hydrogen fluoride
HNO_3	Nitric acid
ID	Inner diameter
IR laser	Infrared laser
KOH	Potassium hydroxide
MEMS	Microelectromechanical systems
NaAMPS	Sodium 2-acrylamido-2-methylpropane sulphonic acid
PA	Polyamide
PAM	Polyacrylamide
Poly(AM-co-AA)	Poly(acrylamide-co-acrylic acid)
PCI	Percutaneous coronary intervention
PDMS	Polydimethylsiloxane
PEG	Polyethylene glycol
PEO	Polyethylene oxide
PiB	Polyisobutylene
PIV	Particle Image Velocimetry
PMMA	Polymethyl methacrylate
ppm	Parts per million
Re	Reynolds number
RIE	Reactive-ion etching

SDS	Sodium Doedecyl Suplhate
SEM	Scanning Electron Microscope
Tg	Glass transition temperature
XG	Xanthan gum

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