XXI FMC

XXI Fluid Mechanics Conference

AGH–UST, Krakow, Poland, 15 – 18 June 2014

Book of Abstracts

Editors:
J.S. Szmyd, E. Fornalik-Wajs, M. Jaszczur

AGH University of Science and Technology Press, Krakow 2014
ISBN 978-83-7464-704-5

AGH University of Science and Technology Press
al. Mickiewicza 30, 30-059 Krakow
tel. 012 617 32 28, tel./fax 012 638 40 38
e-mail: redakcja@wydawnictwoagh.pl
http://www.WydawnictwoAGH.pl

BIO-4

MODELLING DRUG DELIVERY FROM NANOFIBERS TO BRAIN TISSUE

P. Nakielski*, T. Kowalczyk, T.A. Kowalewski
Institute of Fundamental Technological Research PAS, Warsaw, Poland

Keywords: *brain, drug delivery, nanofibers, mathematical modeling*

Implantable nanofibrous materials are formed during electrospinning. They offer a wide selection of parameters for control release of various types of drugs. Analysis of influence of initial drug concentration or porosity of the material on the drug transport into the tissue helps understanding release mechanisms. Numerical model avoiding tedious experimental effort was proposed to describe drug release from the surface of nanofibers [1]. Modeling of drug transport and elimination is described by convection-diffusion equation in rigid porous material. It helps prediction of therapeutic efficacy. The drug elimination constant accounts for drug binding, enzymatic metabolism and other processes occurring in intracellular space. Computer simulations of drug delivery from the material to brain tissue segment (with pulsatile cerebrospinal fluid flow) were performed in COMSOL® Multiphysics [2]. Material was considered as a non-degrading in the drug release time scale. Numerical model of the drug release was validated experimentally in setup utilizing optical light sheet method. Poly(vinyl alcohol) hydrogel served as releasing medium mimicking properties of brain tissue. We show that materials with higher porosity release the drug with higher rate. This can lead to adverse effects e.g. exceeding the toxicity level of drug in the tissue. Multilayer material with less porous outer layers exhibited reduced drug release due to slower diffusion in the porous structure.

The aim of the study was to find the optimal composition and geometry of the material used as drug delivery system. Materials containing antioxidants or growth factor prevented neurodegeneration after neurosurgery on animal model [3]. In studies on the healing of brain tissue after surgical brain injury, we found positive impact of the nanofibers structure on tissue remodeling and repair, but there is still a need for additional studies of this phenomenon.

The first author has been supported with a scholarship from the European Social Fund, Human Capital Operational Programme. The support of the National Centre for Research and Development Project grant no NR13008110 is acknowledged.

References

1. Nakielski P., Symulacje numeryczne procesu uwalniania leków z nanowłókien, Modelowanie Inżynierskie, 48:99-111, 2013

2. Nakielski P., Kowalczyk T., Kowalewski T.A., Modeling Drug Release from Materials Based on Electrospun Nanofibers, Proceedings of the Comsol Conference in Rotterdam, 2013

3. Sulejczak D., Andrychowski J., Kowalczyk T., Nakielski P., Frontczak-Baniewicz M., Kowalewski T.A.: Electrospun nanofiber mat as a protector against the consequences of brain injury. "Folia Neuropathologica", 52, 2014, (in press)

* Corresponding author: P. Nakielski
Phone: + (48)-22-8261281, Fax: + (48)-22-8267380
E-mail address: pnakiel@ippt.pan.pl