INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 3 - V7I3-1406)
Available online at: https://www.ijariit.com

Water desalination using P-N sandwiched nanofluidic membranes

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ABSTRACT

In this paper, a novel P-N sandwiched nanofluidic membrane, with two reservoirs connected to the P-N sandwiched nanofluidic membranes is simulated for near 100% multi-ions desalination to result clean water at fast transport of ~ 1 km/hr velocity that keeps the clean water supply going in a city. The P-N sandwiched nanofluidic membrane is electrically driven by Pt electrodes to drive the water and multi-ions similar to reverse electrodialysis (RED) method.

Keywords— *Nano-fluidics, water desalination, nanopores, P-N nanofluidic membranes*

1. INTRODUCTION

Nano-fluidics is the study of transport of fluids less than 100 nm scale. Nano-porous membranes for the applications of nano-fluidics are used in applications like blue energy [1-10], DNA sequencing [11-14], ionic circuits [15-19], seawater desalination [20-23]. Nano-fluidics involves, nano-porous membranes typically integrated with two micro/mm size reservoirs with an electrical voltage applied across the Two Reservoirs + nano-porous membrane unit [24-25] filled with KCl or other multi-ion electrolyte solutions. The ion selective nature of the nano-porous membrane, allows or blocks the ions to transport through the nano-porous membrane, resulting in electrokinetic transport or desalination [20-25].

A pilot scale plant utilizing nanofluidic membranes for water desalination applications is still missing. Here we use P-N sandwiched nanofluidic membranes to simulate the sandwiched membranes with two reservoirs set up and multi-ionic solution to desalinate water and the technology is easy to scale up in city water desalination and supply applications.

2. MATHEMATICAL MODELING

Here, we used OpenFOAM open source, freely accessible software, and an open source package platform, developed in earlier works [1-10], a multiscale multi-physics Two Reservoir + nanoporous membrane unit open source package platform, in which Poisson-Nernst-Planck (PNP) and Navier-Stokes (NS), together hereafter referred as PNP+NS software package are numerically solved using CFD numerical methods, to use for multiscale multi-physics use ***International Journal of Advance Research, Ideas and Innovations in Technology*** [1-10]. The PNP+NS software platform package is available in the GitHub, under free access and download at https://github.com/nandiga/PNP_Navier_Stokes_Foam

3. SIMULATION DETAILS

Here, Two Reservoirs, dimensions, 1 μm long, 100 nm diameter, connected to two nanofluidic membranes of opposite polarity. We designate the positive surface charged nanofluidic membrane as ‘P’ and negative surface charged nanofluidic membrane as ‘N’. The two nanofluidic membranes are sandwiched to form the P-N nanofluidic membrane assembly. Each of the two nano-porous membrane is 500 nm long and 10 nm diameter. The Two Reservoirs+P-N nanofluidic membranes unit is driven by electric field to trigger Reverse electrodialysis (RED) desalination technology with P-N sandwiched nanofluidic membranes. The simulation is carried out at room temperature considering multi-ion electrolyte to showcase the desalination technology. The multi-ion electrolyte considered is $NaHPO_4/Na_2HPO_4$ and its properties are taken at room temperature. The nanofluidic membrane taken is Al_2O_3 (Positive charged) membrane with surface charge density is σ_n= 10 mC/m^2[26] and same Al_2O_3 with intelligent pore creation, breaking oxygen bonds does yield negative surface charge density of σ_n= -10 mC/m^2.

4. RESULTS

Fig. 1. shows the near 100% desalination of multi-ions exiting the P-N sandwiched nanofluidic membrane under electric mediated transport of 40V, providing a reverse electrodialysis (RED) operation for water desalination using P-N sandwiched nanofluidic membranes. Fig. 2. shows the electrokinetic water velocity, transporting from the left reservoir to the right reservoir when the ions are desalinated by the P-N nanofluidic membrane. The water velocity is 0.2 m/s ≈ 1 km/hr water velocity, that is very well admissible and well designed for water desalination in a city area with continuous mode of water desalination operation. Such large flow rates of water with desalination is possible by our novel P-N sandwiched nanofluidic membrane design.

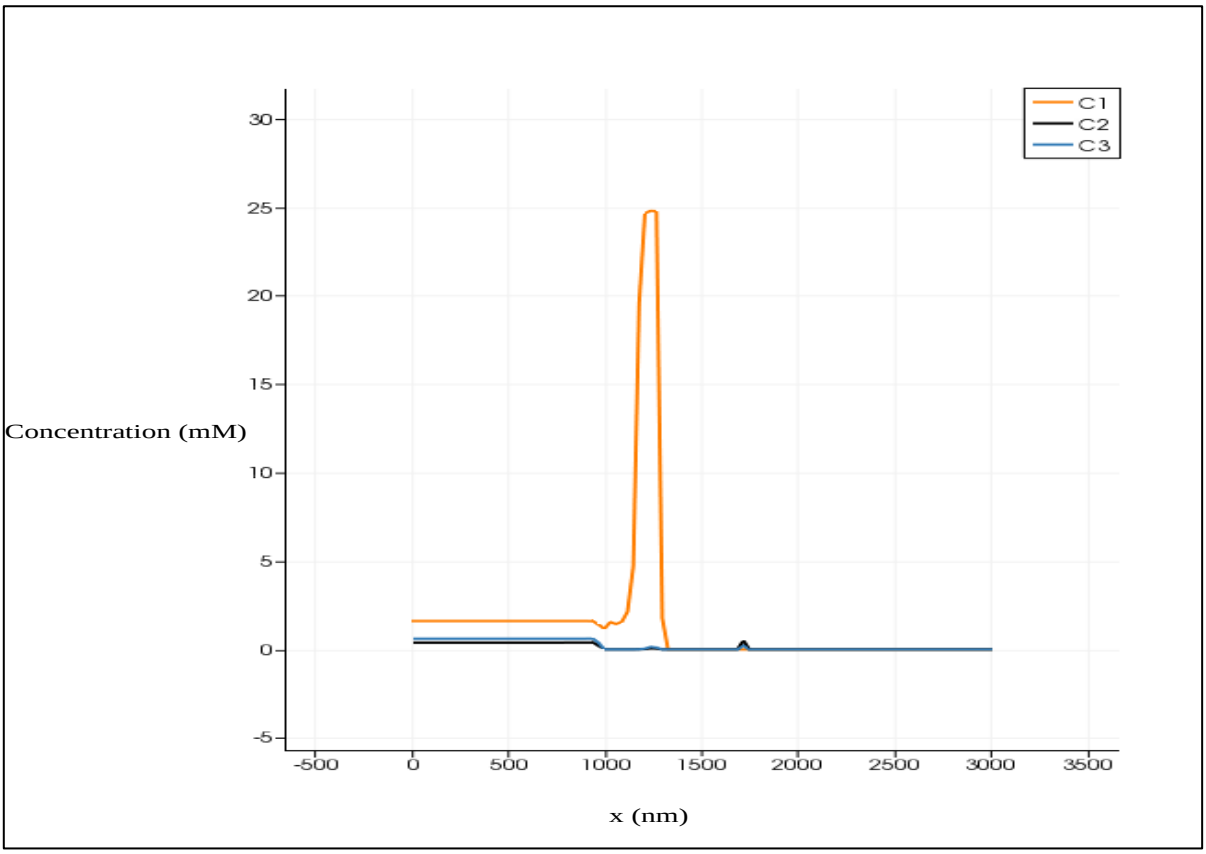

Figure 1. Near 100% multi-ions filtration in P-N sandwiched nanofluidic membrane

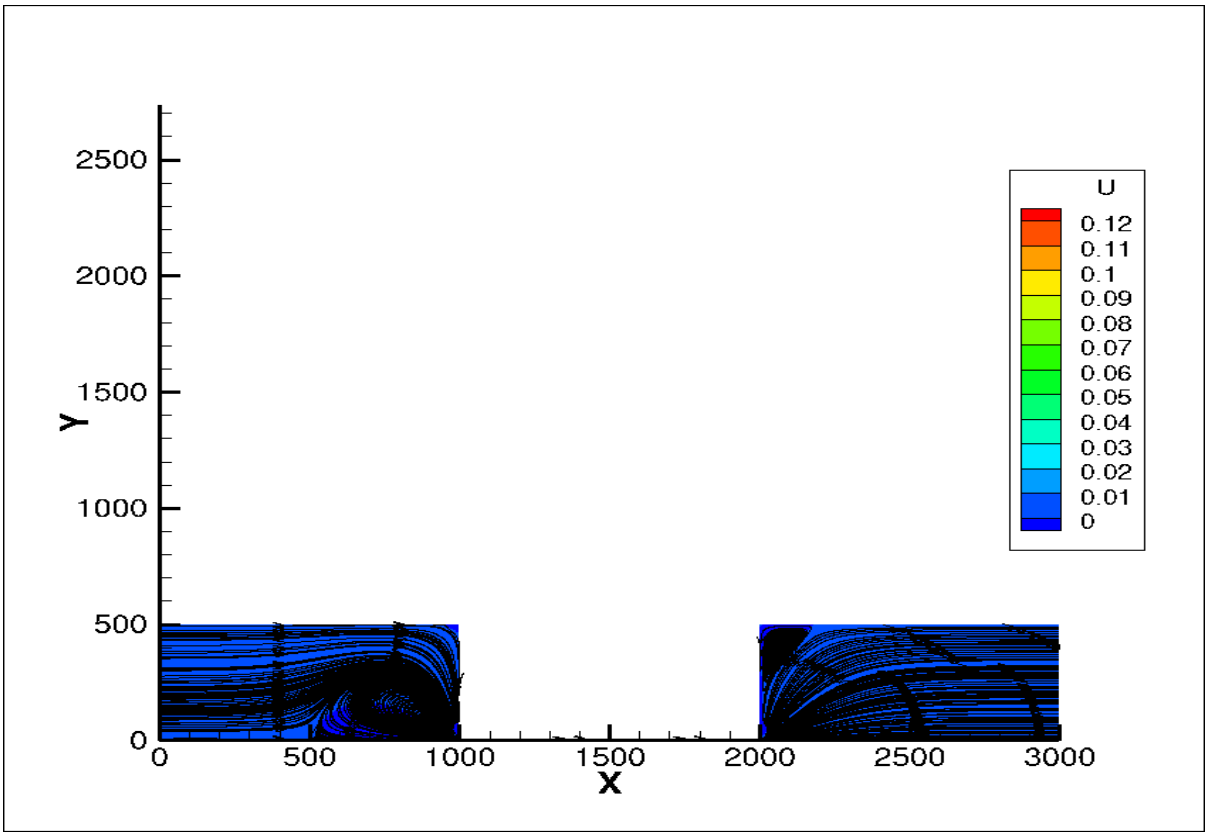

Figure 2. Water velocity in P-N sandwiched nanofluidic membranes

5. CONCLUSION

Here, a novel P-N sandwiched nanofluidic membrane give near 100% desalination for multi-ion desalination working for the first time. Also, the desalted water flows at the rate of ~1km/hr water velocity that is very best for the admissible water desalination velocity for water desalination technology in a city area with continuous mode of water desalination operation and pumping and extracting clean water and supplying new salted water in the water desalination plant.

6. ACKNOWLEDGMENTS

MHRD STARS research grant STARS/APR2019/NS/148/FS., SERB CRG-Exponential technology grant CRG/2020/001684, Support for enterpreneurial and managerial development of MSMEs for Blue Fma PVT LTD, IoE-CoE C-MNBF grant, SB20210808MEMHRD008509.

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