Membrane Performance Evaluation in Water Treatment

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Abstract: Water security is a major objective of the Saudi Arabia's Vision 2030. Dou to the water shortage in the Kingdom, desalination is the primary approach for drinkable water. The current desalination methods are costly and have impact on the environment. The use of membranes technologies increase the efficiency of desalination processes. In this paper, we evaluate the performance of commercial membranes in desalination applications. For example, the FUC 5082 Microdyn Nadir membrane evaluated in material particulate removal by using it as an ultra-filtration membrane (UF) where the evaluation results show that water flux increased noticeably from 19.4 to 48 (Kg/m2*h) within the pressure range from 0.1 to 0.4 bar. Also, the Modified PVDF used as a membrane distillation (MD). The results demonstrate the potential of tested FUC 5082 and modified PVDF membranes for water purification and desalination processes. On the other hand, the membrane SF and modified PVDF evaluated in the material particulate to waste water treatment. Modified PVDF used as a membrane condenser (MC) to control the quality of the recovered water. Moreover, the SF membrane used as a reverse osmosis (RO) where the flux decreased noticeably from 18 to 4.07 (Kg/m2*h) within the time range from 0 to 55 minute. These results show the potential of tested membranes in improving the quality of the final product through the removal of extraneous substances and improvement of the production process.

Keywords: Water, Desalination, Membranes, Purification.

I. INTRODUCTION

As part of Vision 2030, an ambitious economic reform blueprint that outlines Saudi Arabia's future objectives, the Kingdom will fundamentally restructure its resources mainly energy sector and water security. Vision 2030 takes into consideration the impending threat of water shortage in the Kingdom and outlines commitments to ensure "the optimal use of our water resources by reducing consumption and utilizing treated and renewable water." Historically, one of the primary approaches by which water scarcity has been addressed is using desalination processes that transform seawater into potable sources. However, the desalination methods that are currently in use are unsustainable because they are energy intensive, rely on a significant amount of oil, and have a significantly detrimental impact on the environment. According to Global Clean Water Desalination Alliance, desalination plants emit around 76 million tons of carbon dioxide on an annual basis, and it is anticipated that these emissions will increase threefold in the next 23 years. To this end, there is a requirement to identify new novel technologies coupled with renewable energy sources that can adequately support desalination processes and, thereby, address the ongoing water supply and security challenges.

The more recent technologies have gone a long way toward increasing the efficiency of desalination processes, these innovations are still very much in their infancy. The use of membranes technologies could provide a medium-term solution until alternative desalination processes reach maturity.

Membrane technologies are the alternative processes for "molecular separations" due to its optimized energy solutions, efficiency, sustainability and less footprints. Suitably designed membranes and its operability can lead towards simultaneously an efficient removal of particulates and vapours from gaseous streams. This will result in highly pure water without the use of added heat treatment processes.

A membrane is a thin layer of semi-permeable material that can be defined as an "interphase between two close by phases acting as a selective hindrance, controlling the transport of substances between the two chambers"[1-2]. The transport rate of a component through a membrane is determined by driving forces such as concentration, pressure, temperature and electrical potential gradients, the concentration and mobility of the component in the membrane.The most widely used membrane separation technologies are pressure-driven processes : nanofiltration (NF), ulrafiltration (UF), and microfiltration (MF), Reverse osmosis (RO), membrane distillation (MD), pervaporation (PV). Figure 1 compare the characteristtic of these processes. Here we presents the application of the membrane technologies in the water treatment processes which will be a substitute to conventional available technolgoies[3-4].

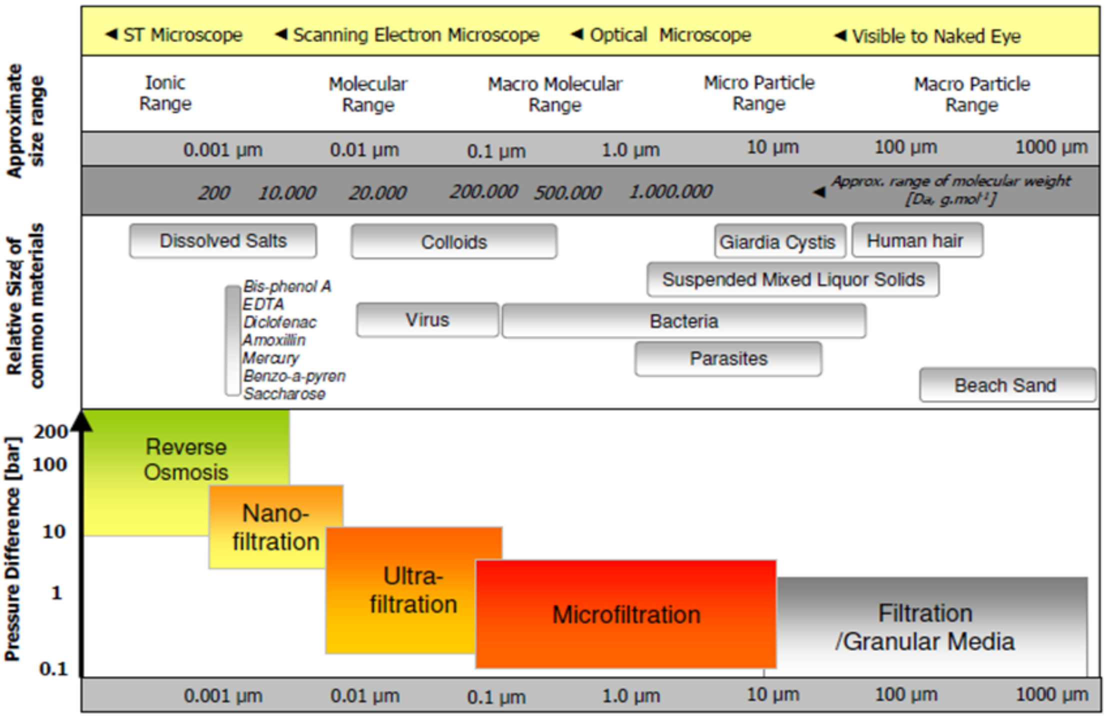

Figure 1. Spectrum of pressure-driven membrane separation processes as a function of size.

II. THE RESEARCH PROBLEM

In light of the requirements set out in Vision 2030, there is an urgent requirement to develop the technologies which can operate effectively across the full value chain, from the manufacturing of the required product through to efficient development of new technologies, and their installation, monitoring, and maintenance. As previously outlined, from both the economic and environmental perspectives, it is imperative that we should identify and actions a sustainable energy efficient water treatment strategy to meet increasing energy demand and diminish fossil fuels.

Membrane technologies currently sits at the core of much of the discourse related to sustainability, energy, and security when comes to separation processes. There is a requirement for a holistic approach to energy management that takes into consideration policy changes, technological developments, and the publics' increasing awareness of environmental concerns. Therefore there is a need to replace the conventional separation techniques with the most advance ones like membranes. The widely used desalination processes in the Kingdom are energy intensive processes. According VISION 2030 directives and protocols, there is much emphasis on the restructuring of water treatment processes with the addition of renewable energy sources like solar to ensure the sustainability and economic viability of water treatment processes. Recently advances in membrane distillation has mobilize the industrial sector to use these alternative energy efficient technologies for desalination. These membrane technology are much efficient as compared to conventional ones as it features the extraction of water vapors from gaseous streams, also when attached with solar energy makes them superior in terms specific energy optimization.

III. Membrane Technologies for Water Treatment

The use of membrane technologies in industrial applications will help in achieving the Vision 2030 energy efficiency program and specifically designed to provide pure water. The main objectives of using membranes as an integral part of the existing industrial processes are to develop energy efficient techniques to reduce the costs of industrial products as per requirement of Vision 2030, to have environmental sustainability by reducing the carbon footprints produced by fossil fuels and to identify suitable membrane technology and its performance for water treatment and to conceptualize the use of membranes for desalination.

IV. RESULTS AND DISCUSSION

A number of commercially membranes were used in this study for different applications. These materials are Modified PVDF (Polyvinylide-neflouride), Cellulose Triacetate UF membrane Module and Silk Fibroin (SF) based Membranes. The results shown at figure 2 and figure 3, demonstrate the potential of FUC 1582 and modified PVDF membranes for water purification and desalination processes. On the other hand, results shown at figure 4 and figure 5 express the potential of the SF and modified PVDF membranes in improving the quality of the final product through the removal of extraneous substances and improvement of the production process.

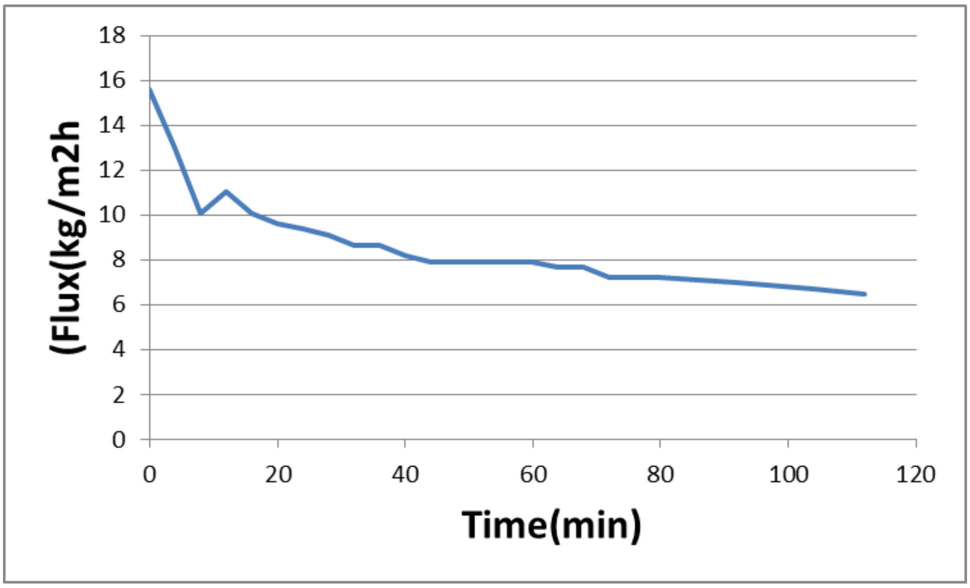

Figure 2. FUC 1582 (filtration)

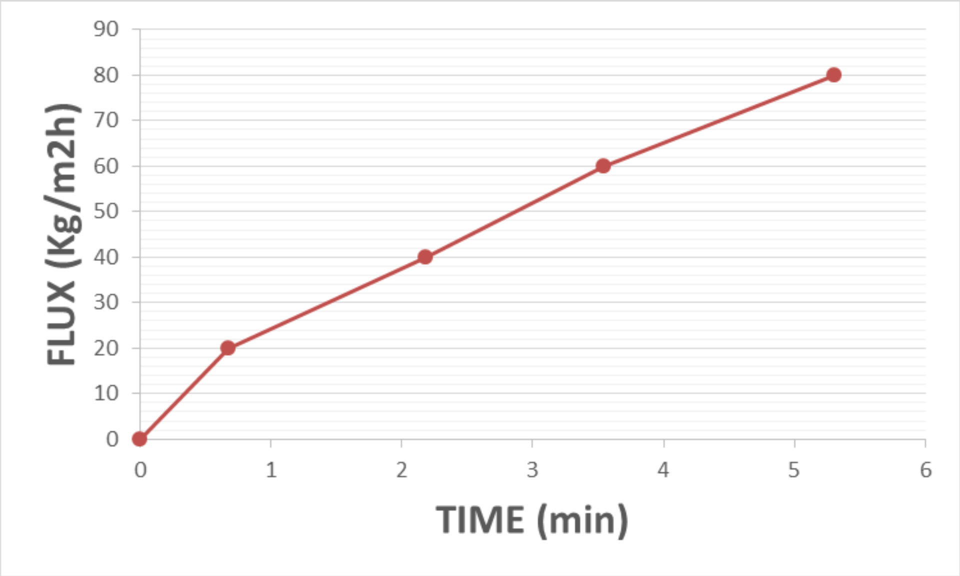

Figure 3. Modified PVDF (distillation)

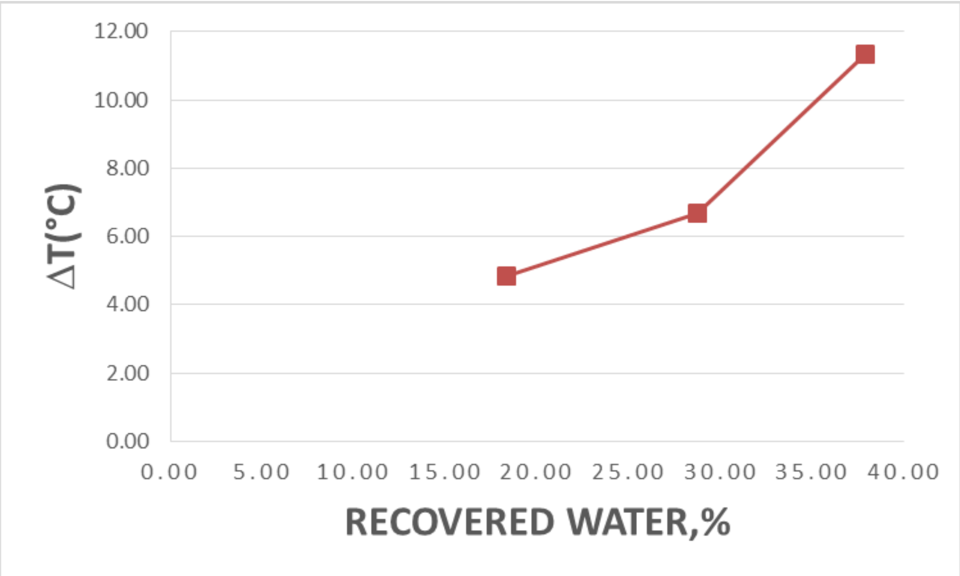

Figure 4. Modified PVDF (condenser)

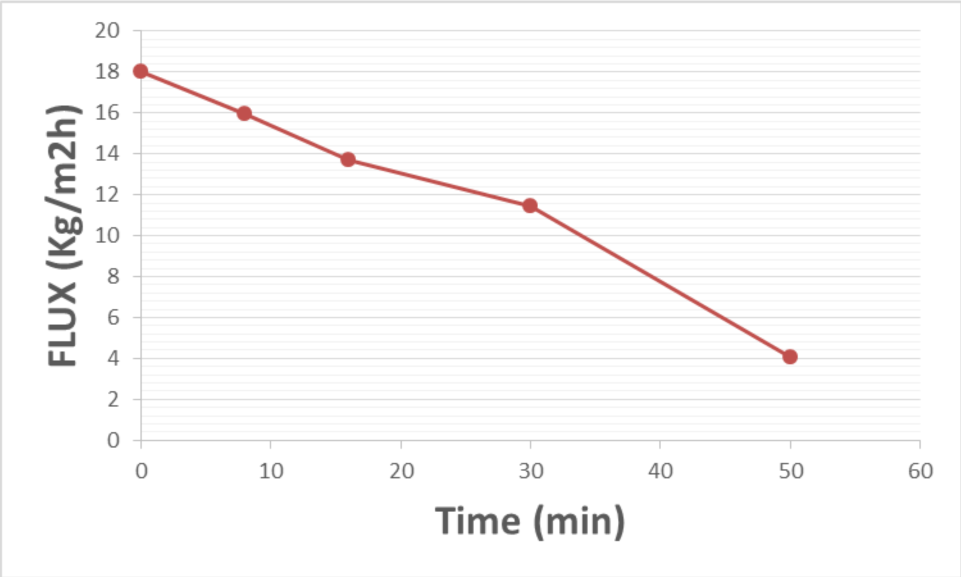

Figure 5. SF membrane (reverse osmosis)

V. Conclusion

The importance of membranes in separation processes was highlighted by assessing their performances. They are mainly evaluated for the removal of particulate matters present in water and recovery of water vapours from industrial processes for process optimization and energy efficiency. The processes uses the hydrophobic-membranes for condenser systems. The performance of commercial membranes in industrial applications was evaluated. The FUC 1582 Microdyn Nadir membrane was assessed in the removal of particulate material by using it as an ultra-filtration membrane (UF), where the evaluation results showed that the water flux was increased noticeably from 19.4 to 48 (Kg/m^2*h) within the pressure range from 0.1 to 0.4 bar. Also, the Modified PVDF was used as a membrane distillation (MD). The results demonstrate the potential of tested FUC 1582 and modified PVDF membranes for water purification and desalination processes. On the other hand, the membrane SF and modified PVDF was evaluated in the material particulate to concentrate juices and waste water treatment. Modified PVDF was used as a membrane condenser (MC) to control the quality of the recovered water. Moreover, the SF membrane is used as a reverse osmosis(RO) where the flux decreased noticeably from 18 to 4.07 (Kg/m^2*h) within the time range from 0 to 55 minute. These results showed the potential of tested membranes in improving the quality of the final product through the removal of extraneous substances and improvement of the production process.

REFERENCES

[1] M. Ulbricht, Advanced functional polymer membranes, Polymer 47 (2006) 2217–2262.
[2] Figoli A., Simone S., Drioli E., Polymeric Membranes, Chapter 1, in Membrane Fabrication, Eds. Hidal N, Ismail F. A., Wright C., CRC, 2015, ISBN-978148221045-3.
[3] E. Drioli, G. Di Profio, and E. Fontananova, Membrane separations for process Intensification and sustainable growth, Fluid/Particle Separation Journal 16 (2004) 1–18.
[4] E. Drioli, E. Curcio, G. Di Profio, F. Macedonio, and A. Criscuoli, Integrating membrane contactors technology and pressure-driven membrane operations for seawater desalination energy, energy and costs analysis, Chemical Engineering Research and Design 84 A3 (2006) 209–220.

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