# Presidential Address
# 22nd Symposium: "**Membranes"**

December 18, 2021

My dear fellow Engineers,
Respected Speakers,
Ladies and Gentlemen

SALAMUN ALA MANIT-TABAUL-HUDA

I am extremely pleased to see you online.

It was forty years back that I came across a detailed write up on "**Membranes"** produced by a German Research Organisation. It covered comprehensively the membranes used by nature and those produced artificially. The membranes produced by nature are intelligent membranes epitomized in sensing and functioning. Our life is well protected by membranes all around. There are about 1 million nephrons in the normal kidney. The kidney is a key component of the body's waste disposal and acid-base regulation mechanism. Our interfacing with the environment is through our skin, which is an intelligent membrane. The biological membrane is able to recognize what the cell needs for its survival and accordingly promote the exchange of matter, information, and energy. Thanks to the membrane Science and Technology that a new field Tissue Engineering has been generated using biochemical transformations and regenerative medicine. In terms of total membrane area produced medical applications are at least equivalent to all industrial membrane applications combined.

There is hardly a subject attracting more wide research interest than Membranes. There is a World Association of Membranes Societies. Globally there is a Conference on Membranes every month. The journal "**Membranes and Membrane Technologies"** annually publishes a whole range of original works and reviews devoted to the synthesis and investigation of new types of membranes, development of the processes of membrane separation and purification, and use of membranes in many other fields.

Membranes are traditionally used for executing the process of separation, purification and concentration of gaseous and liquid media. Research in the field of application of membranes in alternative energy, sensories, biology and medicine is being actively carried out. The creation of hybrid membranes emerged in the late 1980s. It became one of the most actively developing approaches and almost immediately became sought for by the scientific community. The main requirements to membrane materials are selectivity, productivity, strength, stability and cost.

The traditional field of application of pressure driven membrane processes is wastewater treatment, water conditioning and production of drinking water. Today, globally over 100 million $m^3$ of fresh water a day is produced by desalination of seawater with membranes. The share of reverse osmosis is about 60%. The progress in the development of membranes over the last 20 years has decreased the cost of $1m^3$ of produced fresh water from US$ 1.25 to US$ 0.44.

Water usage has increased by 6 times in the past 100 years. The use of water will double again by 2050 driven mainly by irrigation and demands of agriculture. Undoubtedly, sea and brackish water desalination has emerged in the past few decades as the most promising contributor to solve the water-shortage problem. Reverse Osmosis, based on membranes, has emerged as the leader in future desalination installations. At the end of Feb. 2020, the global installed and accumulative capacities for fresh water production stood at 97.2 million $m^3/d$, 114.9 million $m^3/d$ provided by 20,971 projects, with 16,876 new plants. Over the last year, the desalination saw 44% of new capacity awarded in the second half of 2020, while the reuse market reached new heights with 15.4 million $m^3/d$ of awarded new capacity.

Thin-film composite membranes consist of a larger non-woven polyester, and a 100 to 200 nanometre thin-film layer. The membranes are 50-100% more permeable than conventional membranes. The economics of desalination has been changed globally, reducing the price of desalinated water by a third by 2020.

Membrane based RO desalination plants cumulative installed capacity for seawater and brackish water sources is 30.6 million $m^3/d$ and 17.8 million $m^3/d$ respectively. Prices have been brought down to US$ 0.14/$m^3$ with seawater desalination, the cost is approaching the indirect potable reuse, with prices in US$ 0.30-0.40 range.

Water reuse has become of necessity. Membrane Bioreactors have proved to be very efficient and cost effective. Material research is key to enable synthetic membranes for large-scale energy-efficient molecular separations.

Graphene-based membranes have been prepared that are robust enough to withstand strong cross-flow shear for a prolonged period while maintaining Na Cl rejection near 85% and 96% for an anionic dye.

Membrane contactors and membrane reactors have the greatest potential to develop into large-scale commercial processes. Proton-conducting membranes for hydrogen production and fuel cell have emerged successfully and open the road for e-mobility.

Recent years have seen a rapid increase in research using 3D printing for membrane separation, desalination and water purification applications, potentially revolutionizing the field.

In order to enhance membrane performance, stability and antifouling properties, super hydrophilic photocatalytic membranes an produced with nanomaterials added to its surfaces.

Liquid membranes have been developed for separation processes applied to the removal and recovery of heavy metals and rare earth metals from waste streams and process streams, the recovery of antibiotics and biochemical from aqueous solutions and fermentation broths, and the use in

processing nuclear waste, and preconcentration for analytical applications. Their use is expected to grow.

In just one hour, more energy searches the Earth from the Sun than is used by humanity in a whole year. Photocatalytic membrane reactors (PMRs) are efficacious in sustainable hydrogen production. Artificial Photosynthesis fundamentally inspired by nature itself, is the fuels from Sunlight Energy. Scalable technology that converts carbon dioxide, water and sunlight into renewable transportation fuels is being intensely researched.

**Ladies and Gentlemen!**

I fervently hope you will enjoy the quality presentations made by our learned speakers. They will be available to answer your questions.

We are specially grateful to Prof. How Yong NG, Director, NUS Environmental Research, Institute, Singapore and Prof. Raffaele Molinari Vice-Director of the Department of Environmental Engineering, University of Calabria, Italy, who readily obliged us to give the benefit of their expertise.

Thank you.