Dedicated Membrane Research Programme Builds Viable Local Sector

Thanks to research funded by the WRC, South Africa is closer to harnessing the sea as a drinking water resource on a large scale than ever before.

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The Water Research Commission's (WRC's) sustained support of new innovations in membrane technology over the last three decades has resulted in the creation of a viable and innovative local sector. Compiled by Lani van Vuuren.

Worldwide, the demand for the use of membranes continues to increase. Membranes are used in a wide range of applications, including the purification of water for domestic and industrial use, for treatment of effluent water and concentrated waste streams. Membranes are further used in the food and beverage industries as well as non-water related sector, for example, to extract medicinal enzymes from fungi under specific conditions.

In South Africa, while it has taken some time, membranes are now increasingly being accepted as a viable option in the treatment of water and industrial effluent, and over 15 local and international companies are marketing membrane-based technologies here. The local membrane market is dominated by the reverse osmosis (RO) type membrane due to its uses in seawater desalination and wastewater treatment projects.

The WRC has long recognised the potential of membrane systems, and has funded research into membrane technologies as far back as the 1970s. However, it was not until 1993 that a dedicated membrane programme was launched. Since then, the Commission has funded nearly 70 projects to the tune of about R1-million a year.

While the WRC is not the only institution in South Africa providing funds for membrane research, it certainly has been the most important. It is the largest funding institution for this type of research in the country. Membrane research has focused on new product development, improved product and regeneration, guidelines, knowledge expansion and the extraction of valuable components.

Recent research by consulting company Frost & Sullivan shows that this support has been justified. This is evident from the fact that WRC-funded research has led to the establishment of a viable

"WRC-funded research has led to the establishment of a viable South African membrane industry and a growing range of applications of membrane technology."

South African membrane industry and a growing range of applications of membrane technology. From humble beginnings research and development on membranes is today actively pursued not only at a number of tertiary educational institutions, but also by private companies and water and power utilities.

Frost & Sullivan has found that membrane research funded by the WRC has had a number of benefits to South Africans. Research projects have not only resulted in the establishment of a number of membrane-based plants to treat water for rural communities, but has also contributed to job creation and skills development, increased membrane use, export opportunities, increased revenue opportunities, improved use of technology, and best practices implementation.

IMPROVED QUALITY OF LIFE

Most of the projects financed by the WRC have focused on improved water quality and have made a significant contribution to various communities and industrial water users. For example, the development of a mobile testing RO unit by local company Ikusasa. The unit can be taken to a water source where the elements in the water is identified by analysing the waste stream collected through RO.

The unit is designed to assist municipalities and industrial users to determine what pre-treatment, membrane type and post-treatment is needed to ensure that clean water is supplied to the community. The unit has been stationed at Agulhas, where it has delivered clean additional drinking water to holiday visitors during the peak December period.

Research funded by the WRC led to the establishment of the first South African plant for drinking water purposes using membrane technology to be commissioned in 1990. The plant, situated at Bitterfontein, in the South Namaqualand, makes use of tubular reverse omosis membranes.

The first application of membrane technology to treat water for drinking purposes was at Bitterfontein, on the West Coast, in 1990. The system, which

Products developed through WRC-funded research

Type of Technology	Description
Ultrafiltration membranes	Used for producing ultrapure water. Able to remove bacteria from water. Ideal for rural water applications for small communities.
Reverse osmosis developments	Used to desalinate water source. Increase available water resources.
Woven fibre microfiltration	The tubular system consists of two layers of a woven polymer material, stitched together to form rows of parallel filter tubes, called a 'curtain'. Liquid is fed from the inside and clear water permeates from the membrane (clarification process). Can be used for sludge dewatering. A simplified, immersed, flat-sheet system has been developed for potable and industrial water treatment.
Electroconducting membranes	Membrane systems that use positive and negatively charged membranes to remove particles from the stream. Some of the systems are able to produce sodium hypochlorite or ozone as byproducts.
Supported liquid membranes	Shows the potential to extract metals such as nickel from liquid streams.
Membrane bioreactors	Most of the studies are using the outer-skinless UF membrane as reactor (fungi is used in bioremediation of wastewater). Flat-sheet woven microfilter units have lately showed great promise as inexpensive, robust, immersed MBRs.
Membrane fouling studies	Research on membrane fouling centres around three aspects: electromagnetic defouling, enzymatic and chemical defouling, and surface modification.
Affinity separation	A process that involves extracting 'wanted' elements from the stream through chemical reaction (it is being developed as a detector for endocrine disrupting compounds).
Nanostructured membranes	Nanotechnology can aid tailoring of membrane thickness, pore size distribution, permeability, and surface chemistry. Membrane design via templating chemistry allows entirely new and more effective membrane architecture to be engineered and developed. A new, nano-membrane has already been developed which claims to provide RO quality water at much lower pressures.

Source: Frost & Sullivan

TYPES OF MEMBRANE RESEARCH FUNDED BY THE WRC

New product development
The WRC has funded 30 research projects aimed at producing new products or improving existing ones. The new products stemming from this research have resulted in the formation of a number of companies and the creation of numerous jobs.

Improved product operation and regeneration
The WRC has funded 11 projects specifically in the field of defouling techniques and best practices since 1993. As a result of this research, membranes are becoming increasingly attractive and their efficiency has improved.

Membrane research for the extraction of other components
Various projects have been completed for the use of membranes to extract valuable elements from wastewater streams, including metals, enzymes and anti-oxidants.

Knowledge expansion
The WRC has funded 20 studies that have resulted in a better understanding of membrane products and their operation since 1993.

Guidelines
To address the potential for membrane application and advance the use of membranes in the country, the WRC, in conjunction with research institutions, embarked on the creation of various guidelines for the correct selection, installation and operation of membranes to increase performance. These guidelines are based on both laboratory testing and field application observations, and are aimed at membrane operators.

Source: Frost & Sullivan

Yuven Gounden

The mobile membrane testing unit at Struisbaai, in the Western Cape. The unit makes use of polysulphone capillary ultrafiltration membranes with an immersed woven fibre microfiltration pretreatment.

sources its water from three boreholes, serves a population of 5 000. The original RO membranes used in the system were developed by the University of Stellenbosch through funding supplied by the WRC. Since then various communities around the country have benefited from small-scale desalination plants using membranes.

Funding from the WRC has also resulted in the development of products suitable for rural applications, such as the capillary membrane treatment system. This system requires limited operator knowledge and local people can easily be trained to be responsible to operate these systems.

Since membranes are ideally suited for small-scale, rural applications it is expected that this technology will increasingly be applied to provide communities with access to potable water. Therefore a number of guidelines have also been developed to facilitate increased use and improved performance of rural water membrane systems.

NEW AND IMPROVED PRODUCTS

Apart from development of locally-produced membranes, the focus of recent research has also been on improving products through, for example, various techniques for defouling. (Fouling of membranes remains one of the greatest hurdles in the wider application of the technology). Over the years innovative techniques have been developed, such as the ultrasonic device of the Institute for Polymer Science at the University of Stellenbosch, which is able to perform non-intrusive membrane fouling measurement. This method is based on the use of ultrasonic waves and fouling can be detected on the membrane surface, in the membrane module, within ten seconds of initiation thereof.

The WRC has recognised the importance of its efforts, and will continue supporting membrane-related research in future. In addition to the present focus areas, another area expected to receive more attention is the management of intellectual property stemming from this research and development. The WRC has in the past been involved in patenting various ingenious products that were developed through its funding.

Through the Commission's funding of meritorious membrane technologies, local innovations were protected, allowing the free development and commercialisation of these technologies. Although the WRC's brief does not allow it to perform commercialisation *per se*, it assisted in a number of cases to patent worthy inventions which the developers themselves would not have had the means to do.

The WRC has been identified as a key stakeholder in the South African membrane research and development environment and without its dedicated efforts many of the positive benefits of the research conducted would not have materialised.