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تحت رعاية معالي رئيس مجلس الوزراء المصري المهندس شريف إسماعيل
مؤتمر تحلية المياه الحادي عشر في البلدان العربية
UNDER THE PATRONAGE OF THE EGYPTIAN PRIME MINISTER ENGINEER SHERIF ISMAIL
11TH WATER DISALINATION CONFERENCE IN THE ARAB COUNTRIES
18-19 APRIL 2017 • INTERCONTINENTAL CITY STARS - CAIRO - EGYPT

Fabrication of Reverse Osmosis Spiral Wound Membranes using Local Materials

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National Research Centre

بالتعاون مع
Holding Company for Water & Waste Water
وزارة الاسكان والمرافق والمجتمعات العمرانية

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INTRODUCTION

The factors responsible for the rise in water consumption

- *High standards of living*
- -High population growth rate
- -Increasing urbanization and industrialization
- -Failure to adopt basic water conservation principles
- -Insufficient energy for seawater desalination
- -Lack of public awareness
- -Regional conflicts resulting in mass flow of internal migrants

http://www.ecomena.org/tag/water-scarcity-in-arab-world/

INTRODUCTION

Water Problems in Egypt

Contamination of water

Mixing with sewage or agricultural or industrial wastes.

The stability of water resources and high population growth rates

Decline in per capita share of water in Egypt to 600 cubic meters per year.

Nile River (Main source)

- Different forms of Human consumption
- Industry
- Agriculture
- Problems with upstream countries

Problems Solutions

- **Most problem solutions can be carried out by:**

- **Waste Water treatment**
- **Desalination**

In The Research Field

- Application in Lab Scale.

- Application of Research Projects on the ground By applying these projects on pilot units to reach the optimum ways to implement these projects.

NRC and Flat sheet membrane group

Accordingly,

- ***The flat sheet membranes group has been configured in NRC at 2014.***
- ***The header of this group is Prof. Dr. Ahmed Shaban* Vice President of the NRC Centre for Technical Affairs.**
- ***National Research Center was purchased Spiral wound fabrication machines to facilitate production of pilot samples of spiral wound membranes modules and facilitate the Pilot experiments in desalination and water treatment***

Goals of Flat membranes group in National Research Centre

-Benefiting from our previous experience and researches in Membrane Fabrication, Nanomaterials, water treatment and Desalination to Design low power cost desalination and water treatment units.

-Production of different kinds of membranes (MF, UF, NF, FO and RO) in large scale and in the form of spiral wound membrane modules to be applied in different applications.

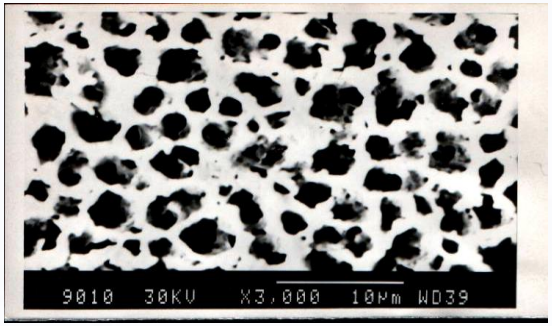
-Production of antifouling Membranes using different kinds of nanomaterials.

-Designing of Low power desalination systems, To serve the coastal and remote areas

Previous work of group in Membrane field

Egyptian Patent 2003 (for water treatment)

(Manufacture of Polyamide-6 using casting technique) for protein removal



Polymeric blend membranes (for Desalination)

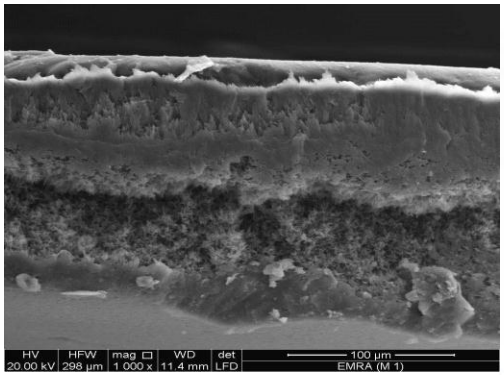
Egyptian Patent 2015

(Fabrication of RO blend PES/CA membranes)

Desalinate brackish Water 6000 ppm

Salt rejection 99%,Permeate flux 21 L/m².h

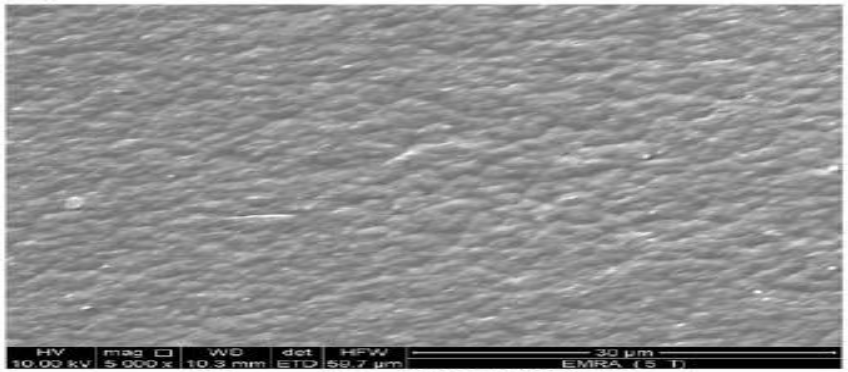
Low RO pressure membrane (15-20 bar)



Previous work of group in Membrane field

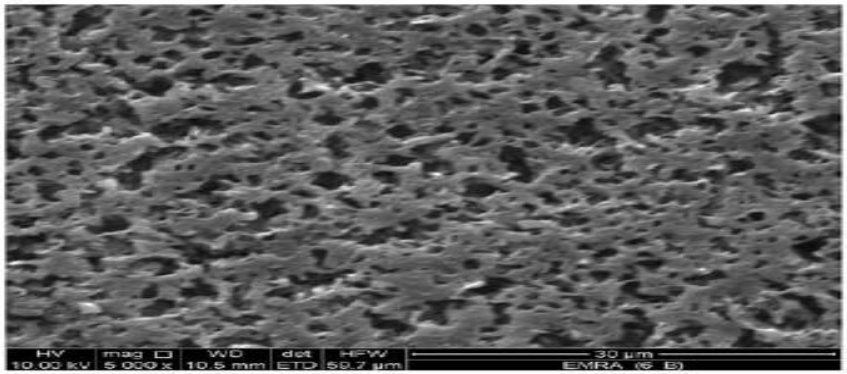
For Water treatment

(a)



Top surface (20PA6/80FA)

(b)



Bottom surface(20PA6/80FA) (big pores)

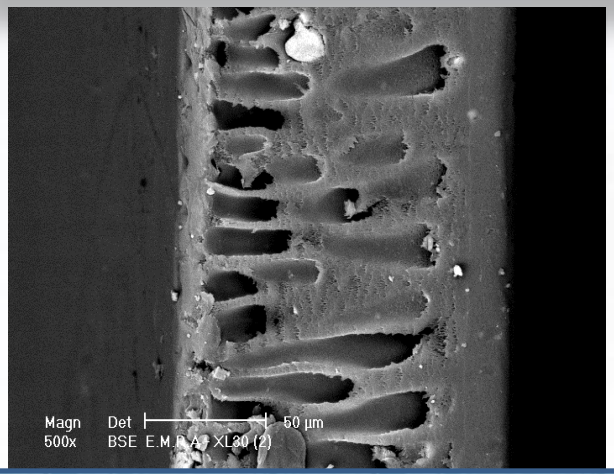
Egyptian Patent 2015

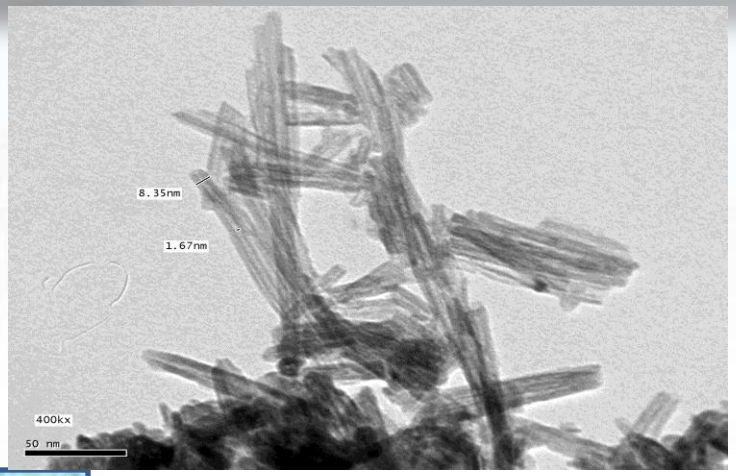
Design and development of Polyamide-6 (PA-6) membranes for pervaporation of water /alcohols mixtures.

Previous work of group in Membrane field

Nano materials blend membranes

Polymer blend with Inorganic Nanotubes to produce high flux RO membranes, with low pressure





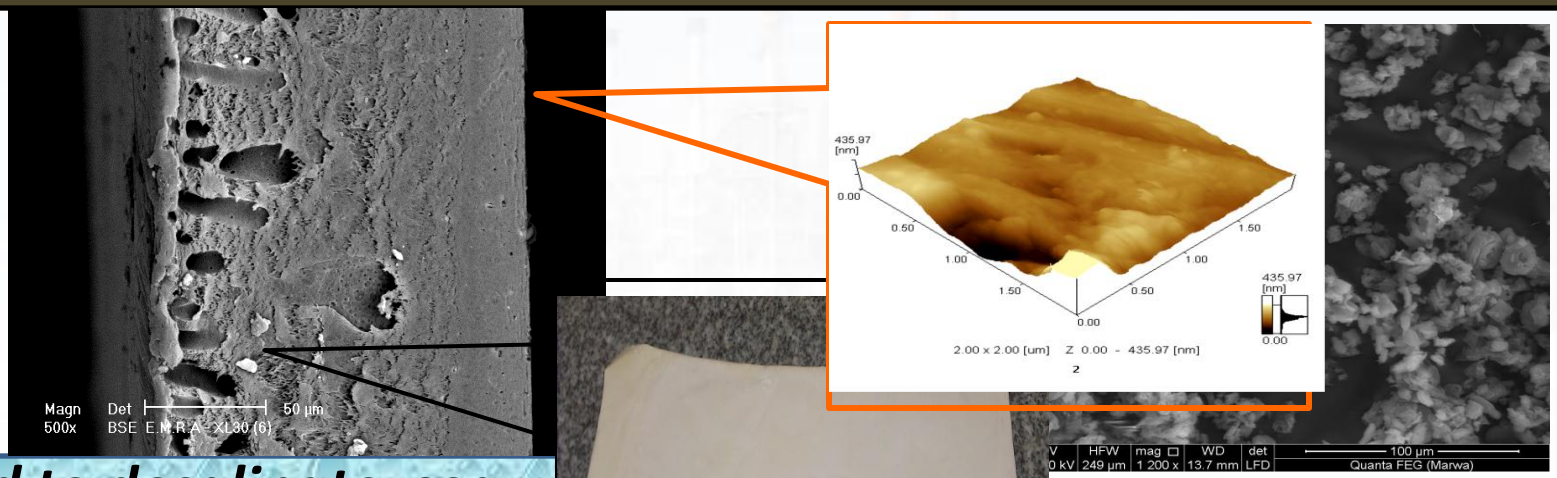
Used to desalinate a wide range of salty concentrated solutions in range of (3000 ppm to 45000 ppm) SR (99-95%) with low pressure (15-30 bar)

TEM analysis for TiO_2 dioxide nanotubes

Previous work of group in Membrane field

Nano materials blend membranes

Polymer blend with Metalorganic Nanomaterials
To produce RO PES membranes



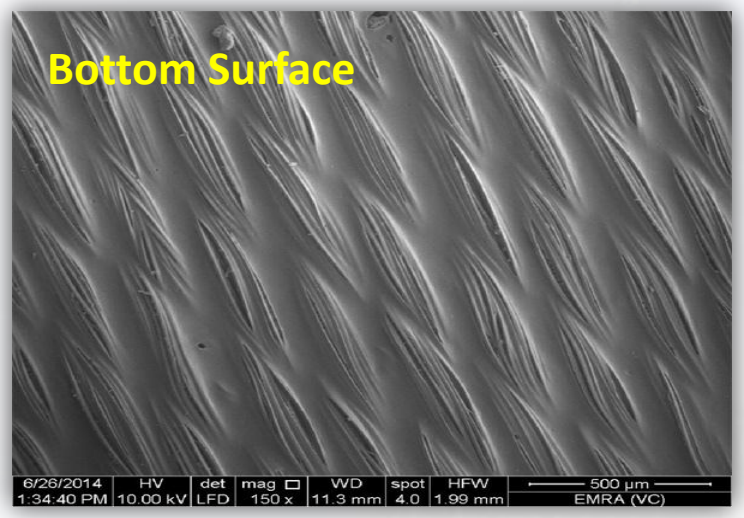
Used to desalinate sea w
ppm to 45000 ppm. **The a**
24.2 L/m²h with salt rejec
with low pressure (20-30 bar)
Decrease in RS (2.4µm PES to 0.24µm)

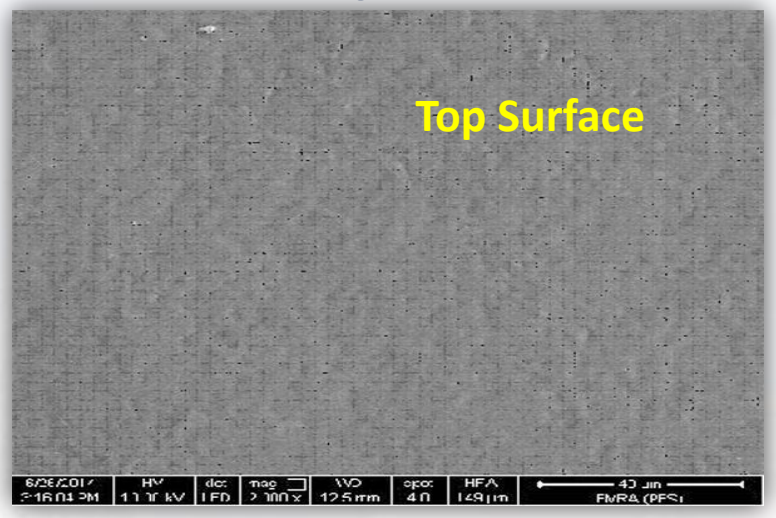
SEM of metalorganic nanomaterials

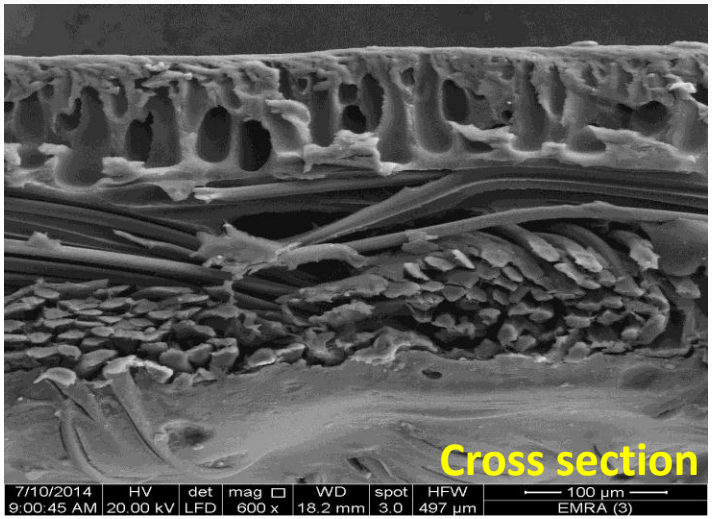
Previous work of group in Membrane field

Forward osmosis membrane

For low energy desalination system







Recently, 2017

Fabrication of Spiral wound membranes

Fabrication of Spiral wound membranes

Materials and Methods

Different polymeric materials were used in membrane preparation, we selected new RO type which was blended PES with amine nano- solution to produce RO flat sheet without outside coating.

We submitted a patent in this polymer membrane preparation for Egyptian Academy of Science & Technology in title:

***Fabrication of Antifouling Spiral Wound Reverse Osmosis Membranes supported by fabric* (Patent No.1301/2016).**

We also, fabricated pilot scale casting machine using raw materials purchased from Egyptian local market and we progress to other patent in title:

Design and manufacture of a device for the preparation of flat membranes (Patent No. 0167/2015).

We also, designed and fabricated testing desalination unit using high pressure up to 200 bar. And we progress to other patent in title:

Design, manufacture and test the unit cells of polymeric membranes (Patent No. 1852/2015)

Fabrication of Asymmetric RO Blend Membranes

Polymeric solution preparation was casted using pilot casting machine

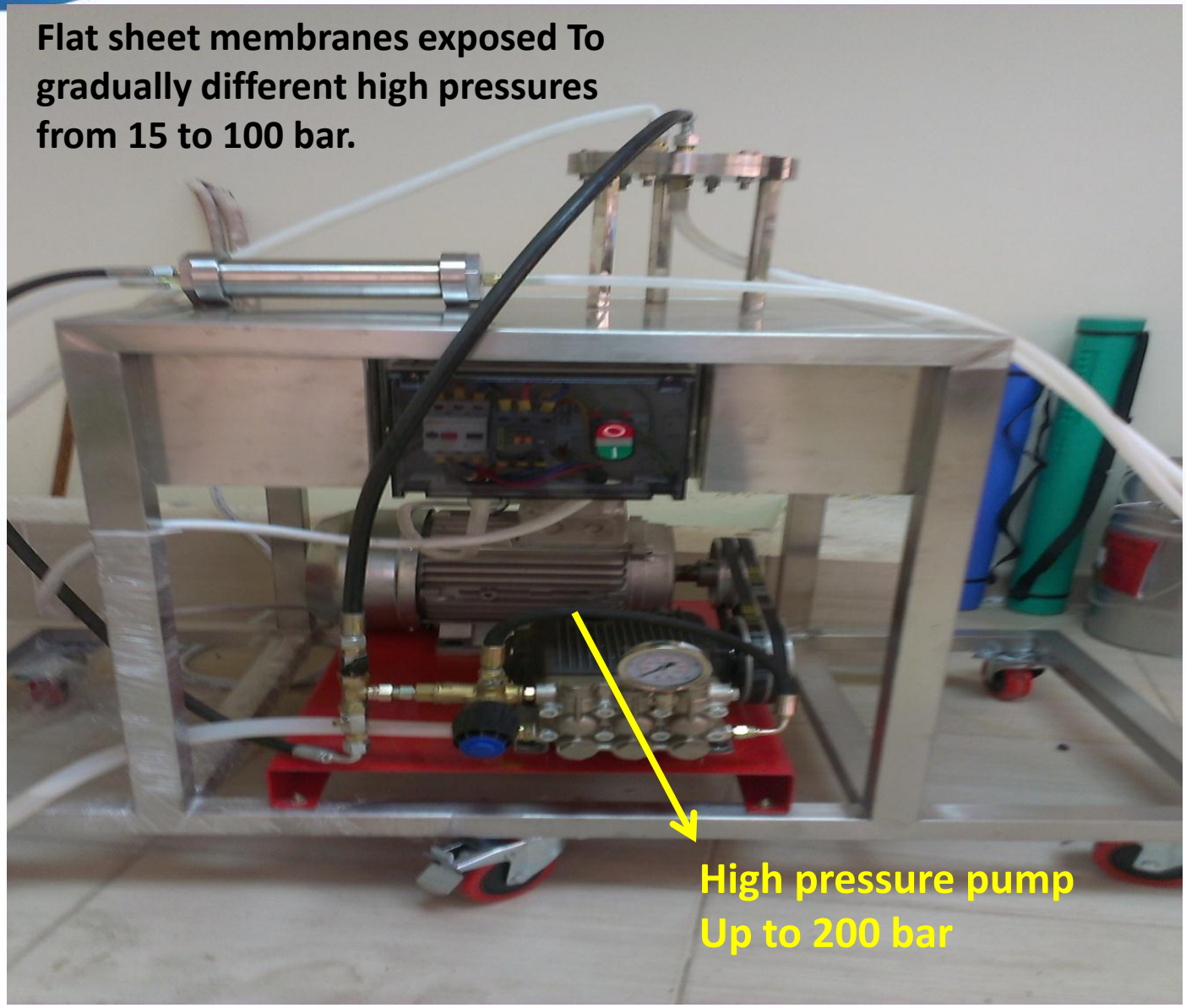
Pilot casting machine

RO produced membrane in size of 65x110 cm

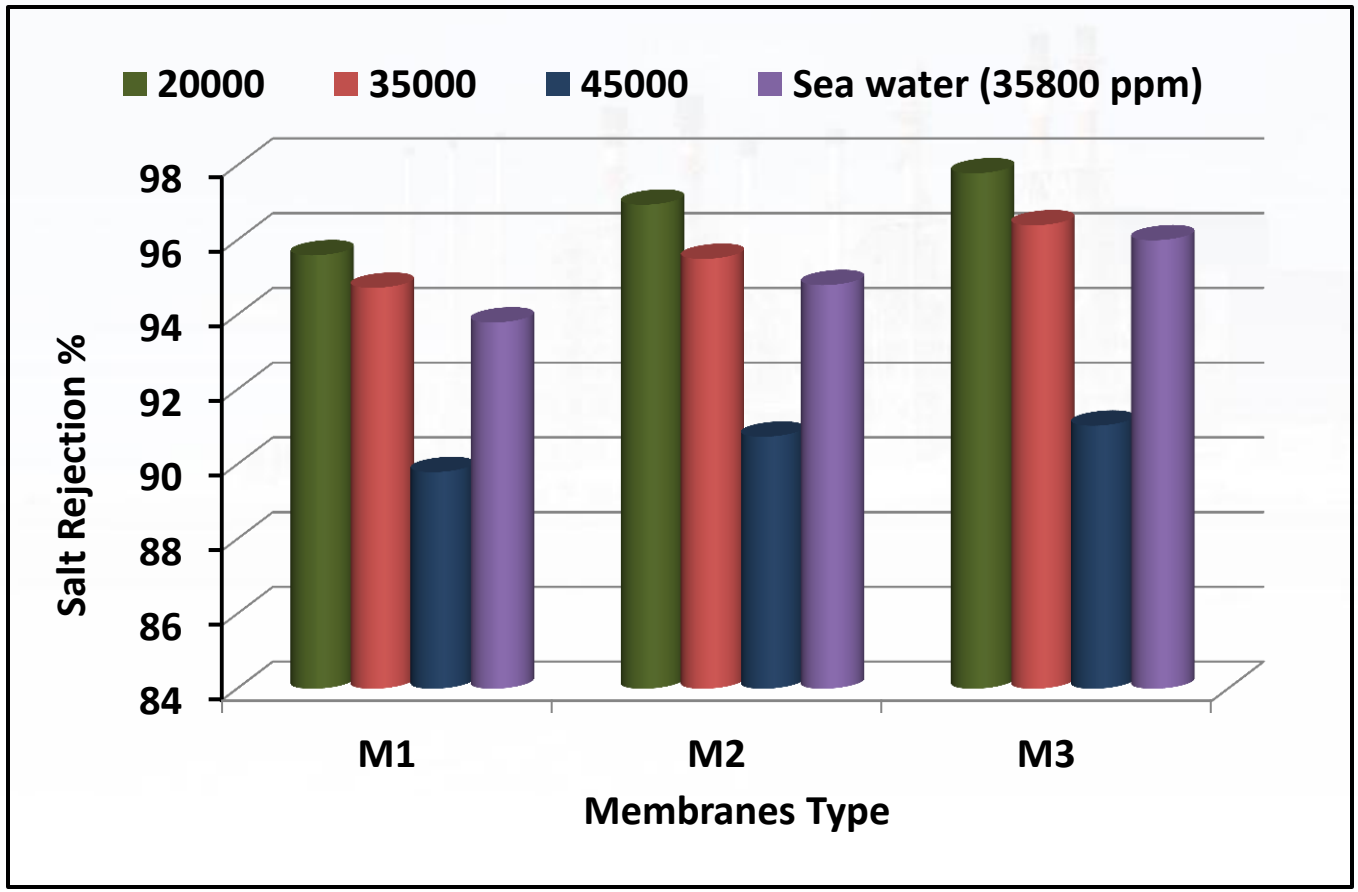
Fabrication of Asymmetric RO Blend Membranes

Flat sheet membrane testing

Flat sheet membranes exposed To gradually different high pressures from 15 to 100 bar.



Desalination Results of RO membranes



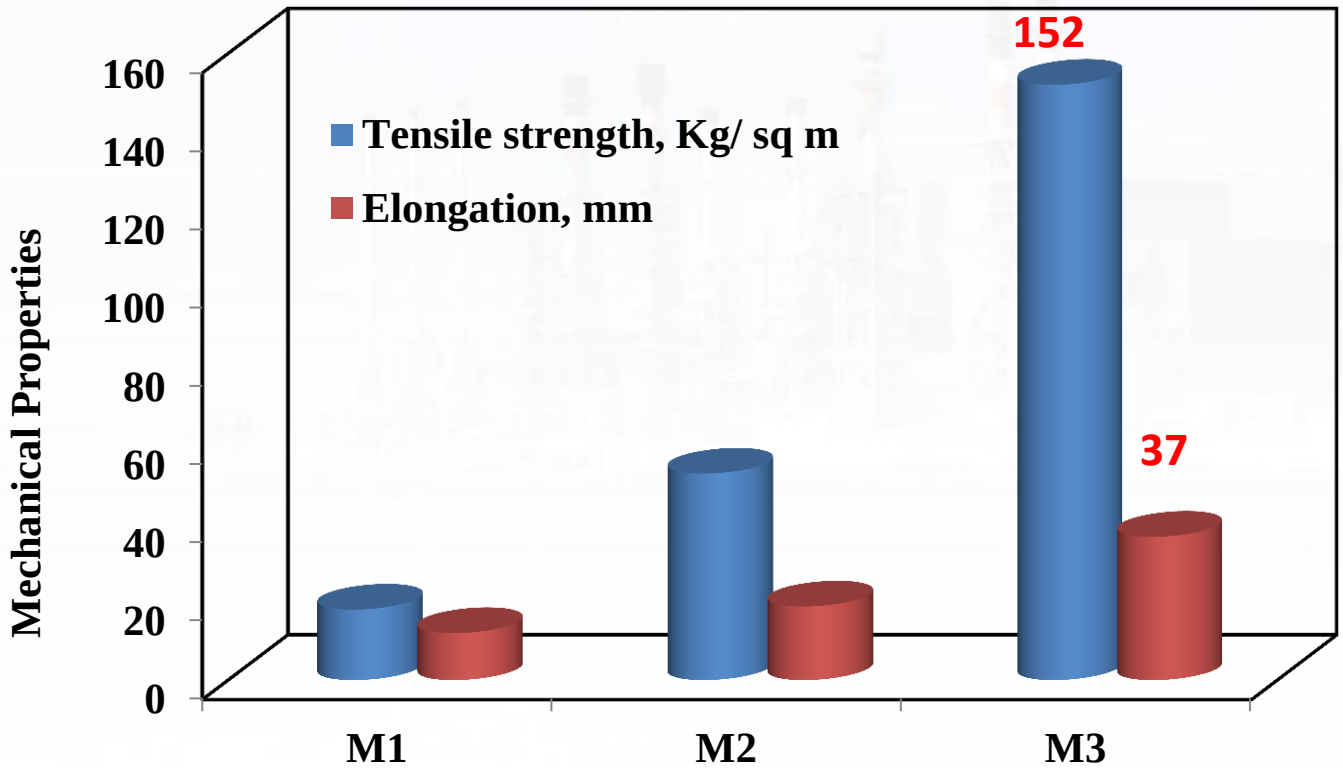
M1: PES /AMS without support

M2: PES /AMS with nonwoven support

M3: PES /AMS with woven support

Under 50 bar pressure

Desalination Results of RO membranes



M1: PES /AMS without support

M2: PES /AMS with nonwoven support

M3: PES /AMS with woven support

Flat Sheet Membrane Housing

*Low surface area and need large space
*low Permeate flux
*low rejection %

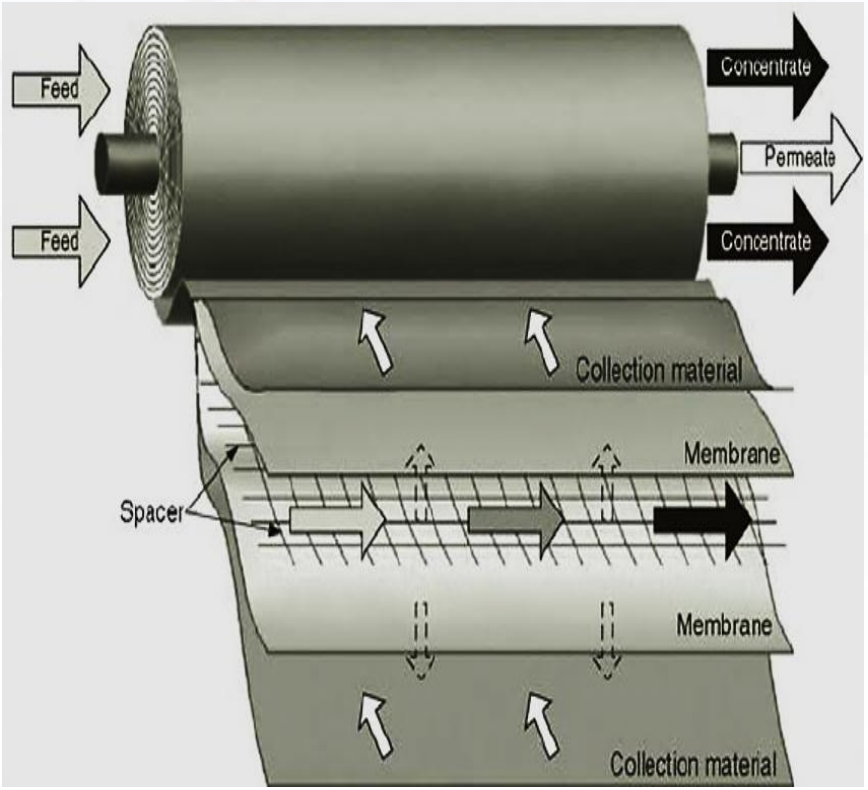
*High surface area according to number of membranes
*Small in Size and don't need large space
*High Permeate flux
*High rejection %

Spiral wound membrane and Housing

Flat Housing of Flat sheet membrane

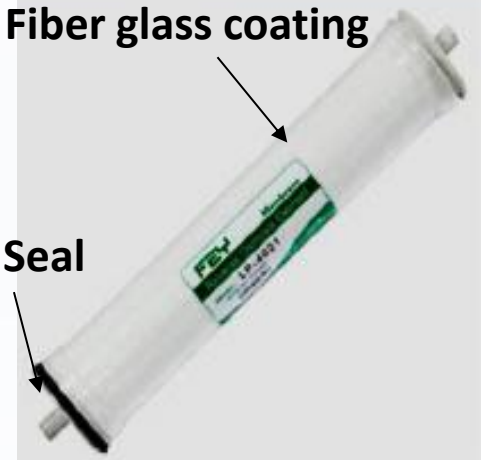
What is spiral wound membrane

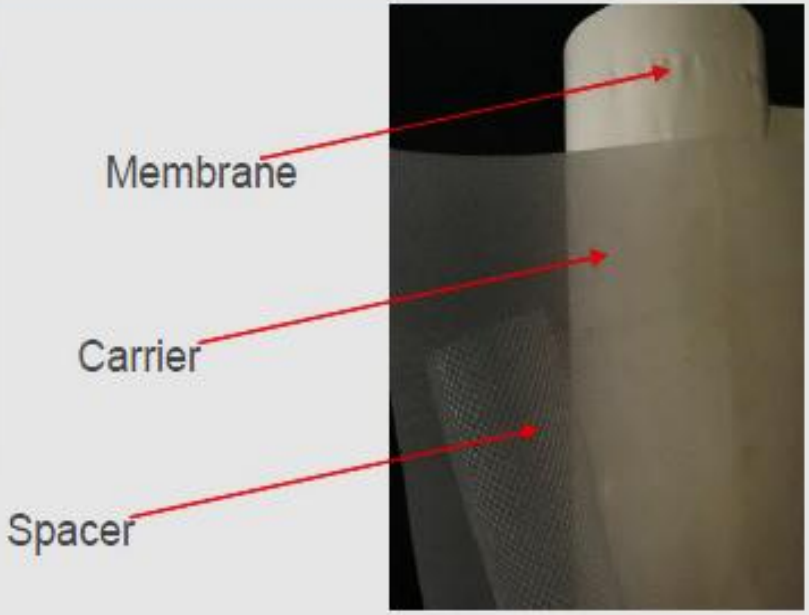
It is layers of flat-sheet membranes and feed separators wrapped around a hollow core. Feed solutions enter one end of the element, flowing under pressure through the membrane into permeate channels, spiral to the central core, and exit as permeate. This configuration offers the highest membrane-packing area with the smallest footprint.

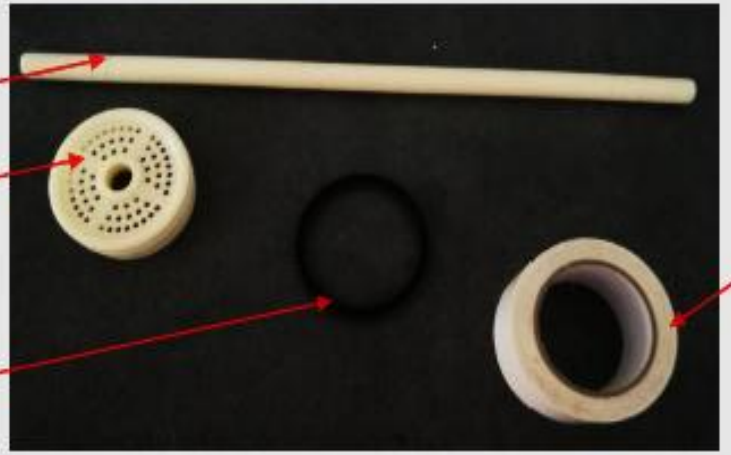


Fabrication of Spiral Wound Membrane

Spiral wound module materials







Antitelscopiing device

Fabrication of Spiral Wound Membrane

Rolling → Trimming (side cutting) → Fiber glass winding

Product types

SPIRAL WOUND MEMBRNAE

- Industrial
  - 8040
  - 4040
  - 4021
  - 3020
- Domestic
  - 3012
  - 1812

Fabrication of Spiral Wound Membrane

Low Power Desalination Pilot Units

UF/RO integrated Pilot system

RO spiral wound modules (4021)
(two modules)

Spiral wound membrane with
local materials SR 99%
Permeate flux 390.3 L/m².h

The Cost of Membranes

The total cost of flat sheet membrane cost using fabricated casting machine is the 1125.4 L.E. /m^2.

The price of commercial flat sheet membrane is around 300 \$/m^2 [*]. Approx . 6000 L.E/m^2 flat sheet .

RO Membrane module	Imported modules [**] ($) without taxes and customs	Imported modules (L.E) without taxes and customs	Approx. price of produced spiral wound modules in NRC labs; Egypt
4"x40" for sea water desalination	1090 $	21,800 L.E	7,500 to 10,500 L.E
8"x 40" for Sea water desalination	1778 $	35,560 L.E	15,750 to 20,750 L.E

[*] http://www.sterlitech.com/reverse-osmosis-ro-membrane.html
[**] http://espwaterproducts.com/commercial-ro-membranes.htm.

Questions