Advantages of CTA Hollow Fiber RO membrane for seawater desalination

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Arabian Japanese Membrane Company
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1. Introduction

a joint venture established by
AJMC Factory in Rabigh, Saudi Arabia

The first manufacturing company of hollow fiber RO membrane element in Saudi Arabia

Inauguration ceremonies were attended by H.E. Abdullah Al Hussayen, Minister of Water and Electricity and H.E. Dr. AbdulRahman Al Ibrahim, Governor of Saline Water Conversion Corporation.
- Vision and Mission

Vision:

AJMC shall be a reliable and credible manufacturer and technical service provider for Toyobo Technology Hollow Fiber RO Desalination Membrane Element, the core Item for desalination plant.

Mission:

(1) To produce high quality membrane to gain full confidence and credibility from Clients
(2) To provide high knowledge, skill and technical services to the clients
(3) To fulfill the need of Corporate Social Responsibility
2. CTA hollow fiber RO element

Brand name: HOLLOSEP®
Type: Hollow fiber RO membrane
(Greater membrane surface area)

Membrane material: Cellulose Tri-Acetate
(Chlorine tolerance, biological fouling prevention)
Application: Seawater desalination
(Stable operation, High availability)
- Major supply records of CTA hollow fiber RO element in GCC

Haql
- 4,400m³/day
- Start 1989

Duba
- 4,400m³/day
- Start 1989

Yanbu
- 128,000m³/day
- Start 1998

Yanbu
- 50,400m³/day
- Start 2006

Rabigh
- 218,000m³/day
- Start 2008

Jeddah 1 & 2
- 113,600m³/day
- Start 1989,1994

Al Birk
- 2,200m³/day
- Start 2001

Ras Al Khair
- 345,000m³/day
- Start 2014

Jeddah RO3
- 260,000m³/day
- Start 2012

Shuqaiq
- 240,000m³/day
- Start 2010

Manifa
- 27,000m³/day
- Start 2011

Tanajib
- 8,700m³/day
- Start 2001

Bahrain
- 22,750m³/day (45,500m³/day)
- Start 2005

Al Jubail
- 85,000m³/day
- Start 2007

Oman
- 300m³/day
- Start 1982

Ras Al Khair
- 345,000m³/day
- Start 2011
Jeddah (Saudi Arabia)

- 113,600m³/day
- Start 1989, 1994

Low Operation cost has been proved at Jeddah RO plant

- High Availability: more than 99%
- Low chemical cost: once/year chemical cleaning
- Long membrane life: more than 7 years
Yanbu (Saudi Arabia)

- 128,000m³/day
- Start 1998
Rabigh (Saudi Arabia)

- 218,000m³/day
- Start 2008
3. Major problem in RO plant operation

- Biological fouling of RO membrane is still a main issue in RO plant operation.

- Biological fouling causes rapid increase of differential pressure and production loss.

- Only solution for Polyamide RO membrane is replacement of fouled membrane and frequent chemical cleaning, which leads to high cost of operation and high down time of the plant.
Potential of biological fouling in the Middle East region is very HIGH.
4. Advantage of CTA hollow fiber RO element (1)

Fouling potential can be shared by large surface area and less membrane fouling takes place in case of hollow fiber type.
- Advantage of CTA hollow fiber RO element (2)

**Cellulose Tri-Acetate (CTA)**

- Superior chlorine tolerance allows chlorine disinfection.
  - Prevent biological fouling
  - Stable Operation
  - Low Production Cost

**Polyamide (PA)**

- No chlorine tolerance.
  - Risk of biological fouling.
    * Low production
    * Frequent Chemical Cleaning
    * Expensive Chemical

Chlorine tolerance is a key to prevent biological fouling and realize stable plant operation at high plant availability.
- Solution

- Cellulose Tri Acetate (CTA) membrane has been providing solution for biological fouling problem.
- CTA membrane has an ability of withstanding chlorine disinfection which cleans up biological matter from RO membrane surface.
- Combination of chlorine disinfection and citric acid cleaning controls differential pressure.
- Control of biological fouling with less frequent citric acid cleaning realizes low cost of operation and low down time of the plant.
- CTA membrane successful solution

Operated successfully as replacement for other type of membranes (polyamide RO membrane) in the worst/difficult seawater condition:

- SWCC Al Juabil plant (Start 2007)
- SWCC Al Birk plant (2001)
- Aramco Tanajeeb plant (2001)
- Bahrain Addur plant (2005)

References;
Abudul Salam Al Mobayed et al., Desalination 178 (2005) 273-286
Abudul Salam Al Mobayed, The 4th gained experience symposium, SWCC 24-26 April, 2005
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Dr. Abdulmajeed Ali Ai Wadhi et al., IDA World Congress: SP05-160
Advantages of TOYOBO RO membrane

- Comparison of operating cost (1)

CTA
Chlorine tolerance

Hollow fiber RO
Large membrane surface area

=  Fouling tolerance

- Less chemical cleaning frequency
- Only citric acid required
- Less membrane replacement ratio

- High plant availability
  low production loss
- Low cleaning chemical cost
- Low membrane replacement cost

Chemical cost in pretreatment and Power consumption ; equivalent

High productivity at low operation cost
- Comparison of operating cost (2)

![Comparison of operating cost chart]

- Labor Cost
- Maintenance Cost
- Membrane Replacement
- Chemicals for Cleaning
- Chemicals for Operation
- Power Consumption

O&M cost [USD/m³]

CTA Hollow Fiber RO vs Others
- Accumulated cost saving estimation

Operating cost saving is beneficial for the plant owner/end user who is in a position to select RO membrane type.
- CTA hollow fiber RO membrane selected repeatedly in recent projects

Client 1: SWCC
1989: Haql (4,400m³/day)
1989: Duba (4,400m³/day)
1989: Jeddah RO1 (56,800m³/day)
1994: Jeddah RO2 (56,800m³/day)
1998: Yanbu (128,000m³/day)
2001: Al Birk (2,200m³/day) (as replacement of polyamide)
2007: Jubai (90,900m³/day) (as replacement of polyamide)
2012: JDRO3 (260,000m³/day)
2014: Ras Al Khair (345,000m³/day)
- CTA hollow fiber RO membrane selected repeatedly in recent projects

Client 2: Saudi Aramco (Tanajib plant)
  2001: Replaced polyamide with CTA Hollow Fiber Membrane (8,700m³/day)
  2011: Selected CTA Hollow Fiber Membrane in the expansion project (27,000m³/day)

Client 3: RAWEC (Rabigh IWSPP project)
  2008: Selected CTA Hollow Fiber Membrane (218,000m³/day)
  2013: Selected CTA Hollow Fiber Membrane in the expansion project (108,000m³/day)
5. New technology using CTA hollow fiber membrane

FO (Forward Osmosis) membrane
Advantage of CTA hollow fiber membrane

Hollow Fiber (Both Open-Ended)
- Uniform flow in a module (less channeling)
- Low concentration-polarization

CTA (Cellulose Triacetate)
- Low biological fouling
- Chlorine resistance

Basically same configuration with AJMC products.
- FO membrane module

Vessel
Element

Feed Solution inlet
Draw Solution inlet
Brine

Draw Solution outlet

Spiral wound FO

Draw Solution (High Osmotic Pressure) → Draw Solution + Water → Water

Feed Solution (Low Osmotic Pressure) → Brine
The driving force for FO is an osmotic pressure gradient. “Draw" solution of high concentration is used to induce a net flow of water through the membrane into the draw solution without applying pressure.
Performance of CTA hollow fiber FO membrane

*Measured in FO mode

![Graph showing normalized flux comparison between TOYOB hollow fiber and competitor spiral wound membrane.](graph)

- TOYOB Hollow Fiber
- Competitor Spiral Wound