

Enhanced Dye Concentration

Using Aquaporin Inside® forward osmosis



DELIVERS
up to 3x
DYE CONCENTRATION

UNIQUE CUTTING-EDGE PROCESS



**ENHANCED
CONCENTRATION**



**REDUCED
WASTEWATER
TREATMENT
COST**



**WATER
RECYCLING &
REUSE**



**LOW FOULING
PROPENSITY**



**EASY
RETROFITTING
TO EXISTING
PROCESS**

- ✓ Dyes and salts can be concentrated 3x and retained with minimal loss (close to 100% dyes retention)
- ✓ Savings on dye-contaminated wastewater (NF/RO permeate) treatment cost
- ✓ 67.5% or more water can be recycled and reused
- ✓ Lower fouling propensity compared to NF & RO
- ✓ The Aquaporin Inside® FO process can be easily retrofitted to existing processes and customized according to manufacturing needs
- ✓ Simple flush cleaning with water to regain process performance

THE NEED FOR BETTER DYE CONCENTRATION

The dye manufacturing industry will benefit from adopting new technologies to address strong global demands for higher quality dyes and deal with the ever-increasing stringent wastewater discharge regulations. Forward osmosis is a novel technology that can potentially be the solution to meet this challenge.

A decade ago, nanofiltration (NF) and reverse osmosis (RO) replaced conventional dye precipitation and filtration processes to become the most widely used high throughput dye concentration technology.

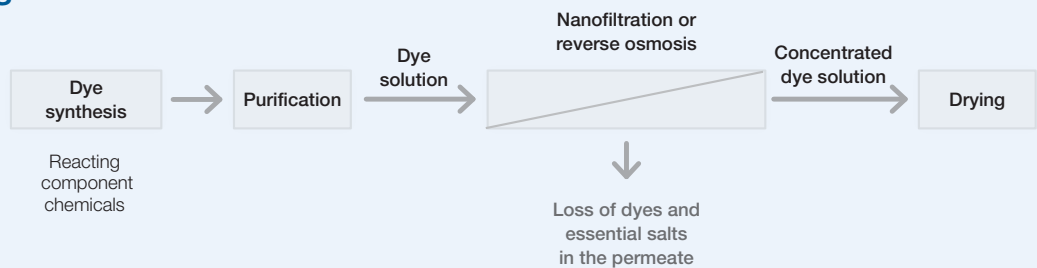
However, the hydraulic pressure driven nature of NF & RO meant that a significant amount of salt and dye molecules pass through into the permeate stream. This poses as a challenge to water reuse and treatment. Concurrently, membrane fouling reduces overall operational stability.

Forward osmosis (FO) is the next generation dye concentration process allowing dye molecules to be concentrated and retained at mild conditions, while reducing membrane fouling propensity.

IMPROVED DYE PROCESS USING FORWARD OSMOSIS

Current process

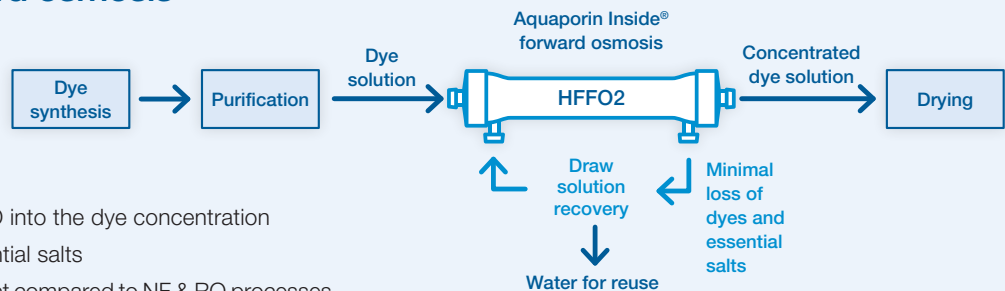
Conventional dye manufacturing process



- Application of pressure-driven processes result in the loss of dyes and essential salts in the permeate
- Dye contaminated permeate must be further treated before it is fit for discharge.

Benefits of forward osmosis

Incorporating Aquaporin Inside® into the dye manufacturing process



- ✓ Easy incorporation of FO into the dye concentration
- ✓ No loss of dyes or essential salts
- ✓ Higher quality dye product compared to NF & RO processes
- ✓ Reduction of wastewater volume
- ✓ Attain higher dye concentration

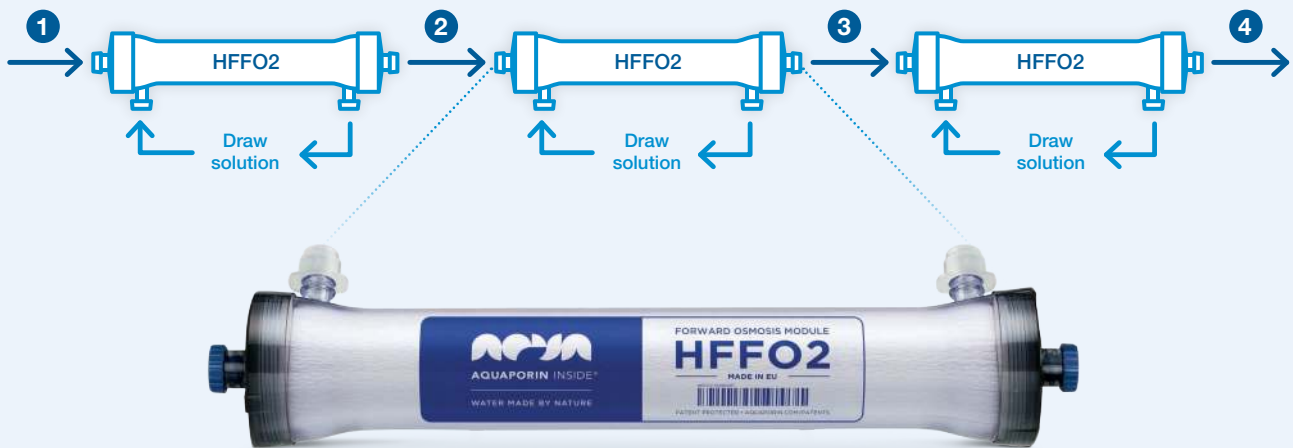
CASE STUDY

Method

A lab-scale study using Aquaporin Inside® HFFO2 was carried out to validate the technical feasibility. Experiments were performed in FO mode where active layer of the membrane was facing the feed side.

Experiment plan for dye concentration using HFFO2:

Mode of operation	3 x HFFO2 passes in series
Feed solution	Dye solution
Draw solution	NaCl
Operating conditions	0.7-1.0 LPM feed inlet 0.4 LPM draw inlet 0.1-0.2 bar TMP FO mode (feed in lumen side), co-current, room temperature
Membrane type	Aquaporin Inside® Hollow Fiber Forward Osmosis Module (2.3 m ²)
Membrane QC	Before and after dye test



Results

- ✓ 3 x concentration of dye solution (67.5% water recovery)
- ✓ Complete retention of dye molecules at close to 100% for all 3 HFFO2 passes.

Stream	Description	Volume (L)	Osmolarity (Osm/kg)	TOC (ppm)	Cumulative recovery (%)
1	1 st pass feed inlet	20.0	0.80	41,360	
2	2 nd pass feed inlet / 1 st pass feed outlet	14.0	1.20	58,400	30.0
3	3 rd pass feed inlet / 2 nd pass feed outlet	8.5	1.90	93,400	57.5
4	3 rd pass feed outlet	6.5	2.45	113,680	67.5

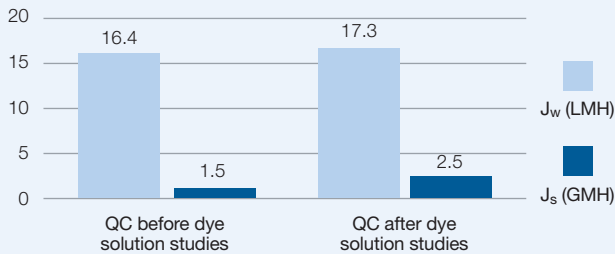
Outstanding dye quality

The concentrated dye quality was evaluated by our test partner, Huntsman Textile Effects. The Aquaporin Inside® FO process was able to concentrate dyes to a higher concentration without the loss of dyes and essential salts. This improves dye adhesion on the textiles during the dyeing process.



Quality control test

FO membrane performance is fully recovered after cleaning.



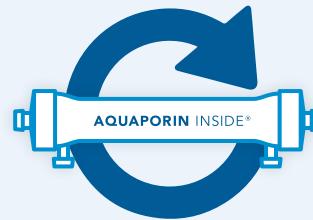
- 1 Before lumen wash
- 2 During lumen wash
- 3 After lumen wash



CONCLUSIONS



Aquaporin Inside® FO can be easily retrofitted to existing processes to attain higher quality dye products at higher concentrations. In conclusion, FO is capable of delivering novel and high quality products at low fouling propensity.



Want to learn more about how Aquaporin Inside® FO can benefit your business? Please contact Aquaporin's FO experts at FO@aquaporin.com for more information.

About Aquaporin

Aquaporin A/S is a global water technology company located in Denmark.

Aquaporin is dedicated to revolutionizing water purification with its' novel membrane technology.

The main goal of Aquaporin is to develop the Aquaporin Inside® technology which is capable of separating and purifying water from all other compounds.

The Aquaporin Inside® platform uses biotechnological principles in a technological context, which is a novel upcoming field with large commercial perspectives. This is a field where Denmark has taken an early global lead.

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