Nanofiltration
The Newest Class of Membrane Filtration

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Nanofiltration (NF) is the newest of the four classes of pressure-driven membranes. Initially utilized in the 1970's for water softening, it was originally developed to bridge the gap between reverse osmosis (RO) and ultrafiltration (UF). Today, a variety of NF membranes are commercially available, and continue to be developed, for a number of unique applications.

HISTORY OF NANOFILTRATION

Microfiltration (MF) was developed in the early 1900s – the first of the membranes – and has become increasingly essential in medicine, pharmaceutical production and microbiology. RO was the next class of membranes to be invented in 1959 by Loeb and Sourirajan at the University of California, Los Angeles with an initial purpose producing drinking water from brackish water and seawater. Not much later, UF was born and fit nicely between the salt-rejecting RO and salt-passing, particle-retaining MF. RO and UF membranes worked well for many applications, but there was an increasing need for a membrane with performance characteristics between those of RO and UF membranes.

NF membranes were initially developed as "loose RO" and "RO/UF hybrid" membranes in order to bridge the gap between RO which essentially rejects all salt ions and most uncharged organic solutes, and UF which allows complete passage of ionic species, but retains uncharged solutes above as small as several thousand Daltons. Applications including, but not limited to, water softening, disinfection byproduct removal, desalting proteins and other food streams, removing sugar from protein or plant matter and separating monosaccharaides from polysaccharides, required the development of a new membrane since neither RO nor UF membranes could perform the necessary separations.

The earliest documented application of NF membranes was a water softening application in Florida in the late 1970s and the first documented process NF membrane was commercialized for the purpose of desalting a small food-grade dye in 1983. In 1984, FilmTec Corporation coined the term "nanofiltration" based on the estimated size of the pores in a NF membrane, queuing the birth of the fourth class of pressure-driven membranes.

NF is often referred to as modified RO because it is based on very similar operating principles. Similar to RO, NF is a pressure-driven membrane filtration process that utilizes a semipermeable membrane and cross-flow filtration to

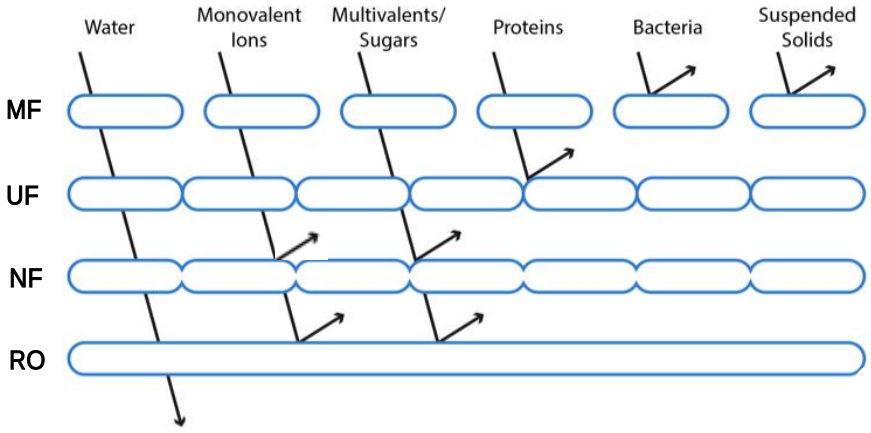

Figure 1. The filtration spectrum.

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separate a feed stream into a purified "permeate" stream and a "concentrate" stream containing a high percentage of the impurities found in the raw water. Unlike RO, NF requires lower operating pressures and has a slightly more open structure allowing predominantly monovalent ions to pass through the membrane, while largely rejecting divalent ions. This has been especially relevant in the application of water softening, where NF membrane technology is used to reduce hardness and remove organics, color, bacteria, THM precursors and other impurities from the raw water supply. Although RO is necessary for seawater desalination and brackish water treatment containing very high levels of dissolved solids (TDS), many water supplies do not require the almost total salt removal provided by RO. NF membranes partially demineralize water, removing between 10 to 90% of dissolved salts compared to 99.5% for RO.

Today, NF membranes are used for a variety of applications including industrial water softening, food & dairy, beverage, pharmaceutical and many other processes. It's evident that the fourth class of pressure-driven membranes has distinguished its own niche within the water and process industries and continues to grow its presence worldwide.

MICRODYN-NADIR'S NF MEMBRANES

MICRODYN-NADIR's proprietary membrane and element technologies and ability to customize makes them the Specialty Membrane Company. As a company, MICRODYN-NADIR focuses on customers, markets and applications where often times it is necessary to utilize customization capabilities to make products that other companies do not offer. It has the ability to use custom materials, sizes and geometries of feed spacers, permeate carriers, permeate tubes, outer wraps and anti-telescoping devices (ATDs) to meet the needs of a particular application or match the specifications of other manufacturers' products for direct replacement to a product that has been discontinued.

Figure 2. MICRODYN-NADIR has the ability to build customized products using various materials, geometries, and sizes.

MCIRODYN-NADIR offers a line of seven unique polyamide-, piperazine-, and cellulose acetate-based NF membrane chemistries that are available in flatsheet and a multitude of spiral-wound element designs. These seven NF membranes are used in a wide variety of applications.

TRISEP® TS80

TS80 is a semi-aromatic polyamide NF membrane with nominal monovalent ion rejection of 80-90% and >99% divalent ion rejection. It is a versatile nanofiltration membrane that offers high solute rejection of both salts and uncharged organic solutes while operating at lower pressure than reverse osmosis membranes. In many water purification applications, TS80 is considered a "softening" membrane, and these elements operate at a pressure of about 100 psi. TS80 membrane is available in other element designs for use in industrial process applications.

TRISEP® TS40

TS40 is a piperazine-based NF membrane with a molecular weight cut-off in the 200-300 Dalton range. Its nominal solute rejection is 40-60% NaCl, depending on feed concentration, and greater than 99% for $MgSO_4$ and sucrose. TS40 is primarily used in food & dairy and other process applications.

TRISEP® TS50

TS50 is a piperazine-based NF membrane that is designed to reject organics with a molecular weight cut off above 300 Daltons while passing monovalent ions. This NF membrane is often used in food & dairy processes, desalting, purification and other separations.

TRISEP® XN45

XN45 is a piperazine NF membrane that has a high rejection of divalent ions while allowing the great majority of monovalent ions to pass through the membrane. Its nominal solute rejection is 10-30% NaCl and greater than 90% for $MgSO_4$ and sucrose. With a molecular weight cut-off in the range of 300-500 Daltons, XN45 is ideal for demineralization of organic solutes and have the versatility to be used in process streams as well as lower pressure water purification.

TRISEP® UA60

UA60 is a piperazine-based thin-film composite membrane with a similar chemistry to XN45. It has been considered both a "tight" UF membrane as well as an "open" or "loose" NF membrane. UA60 has a molecular weight cut-off in the 1,000 and 3,000 Dalton range and has limited monovalent salt rejection. Its $MgSO_4$ rejection is nominally 80%. This product is frequently used in process applications requiring a tight UF membrane or open NF membrane.

TRISEP® SB90

SB90 is a cellulose acetate / triacetate blend NF membrane that delivers an excellent combination of solute rejection, fouling resistance and chlorine tolerance. SB90 has a nominal solute rejection of 85% NaCl and greater than 97% $MgSO_4$ and can tolerate continuous free chlorine at up to 1.0 ppm and operates at about half the pressure (200 psi) of cellulose acetate RO membranes. This high flow cellulose acetate NF membrane is used primarily in beverage applications where cleaning regimens require frequent use of chlorine to maintain a sanitary environment.

TRISEP® SBNF

SBNF is a cellulose acetate membrane with a nominal MWCO of 2,000 Daltons and can tolerate continuous free chlorine at up to 1.0 ppm. SBNF was developed specifically for customers treating surface waters in Northern Europe and is well-suited for removal of organics and color.

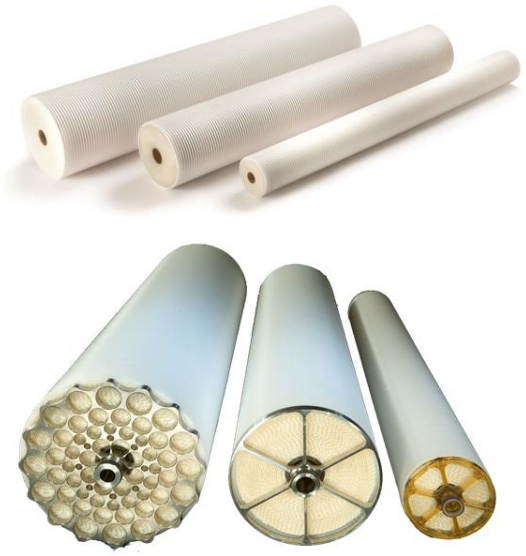

Figure 3. Microdyn-Nadir's TurboClean® elements for sanitary applications (i.e. food & dairy).

CONCLUSION

The world of membrane filtration continues to grow as additional applications and the need for new membranes continue to rise. Nanofiltration itself, as the newest class of membrane filtration, continues to grow and MICRODYN-NADIR is constantly working to develop the next membrane or product in order to meet the needs of customers and their unique applications. The company welcomes customers with new or advanced projects or ideas that may seem difficult or even impossible as it has the extensive knowledge base of membrane, element and system design, application know-how and troubleshooting solutions to determine or develop the best product for the particular application.

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