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NANO FILTRATION – A REVIEW ON NEW DIMENSION IN NANOTECHNOLOGY APPLICATIONS FOR PURIFICATION OF WATER

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ABSTRACT

Nanofiltration is a pressure driven separation process. The filtration process takes place on a selective separation layer formed by an organic semipermeable membrane. The driving force of the separation process is the pressure difference between the feed (retentate) and the filtrate (permeate) side at the separation layer of the membrane. However, because of its selectivity, one or several components of a dissolved mixture are retained by the membrane despite the driving force, while water and substances with a molecular weight < 200 D are able to permeate the semipermeable separation layer. Because nanofiltration membranes also have a selectivity for the charge of the dissolved components, monovalent ions will pass the membrane and divalent and multivalent ions will be rejected.

Pleated filter cartridges combining high efficiency particulate filtration with a high efficiency (powdered) activated carbon (PAC) into a single depth media - NanoCeram-PAC is a further advancement in Argonide's series of filters and is a major breakthrough in using activated carbon for purifying water. Typically granular activated carbon (GAC) is used in a packed bed or is combined into a media using adhesives or via a foamed polymer. What is new with NanoCeram-PAC is that fine activated carbon powder (-325 mesh) is held within the structure by electro-adhesive forces, without using adhesives that would blind or deactivate the carbon. As compared to media containing GAC, PAC offers a much greater external surface area that the results in much more rapid adsorption of soluble contaminants. Contaminants removed include chlorine, iodine or soluble organics that may be highly toxic or may cause unpalatable taste and odor. The result is much greater *adsorption efficiency at moderate to high flow rates and/or with thin beds of media, such as a single layer pleated cartridge. At the same time, the media is capable of retaining bacteria, virus and colloidal particles with efficiency that is unsurpassed as compared to a depth media, a microporous membrane or even an ultraporous membrane.*

Key Words: Nano technology, Nano filteration, purification of water, Organic semipermeable membranes.

I.INTRODUCTION

Nanofiltration is a membrane filtration-based method that uses nanometer sized through-pores that pass through the membrane. Nanofiltration membranes have pore sizes from 1-10 nanometers, smaller than that used in microfiltration and ultrafiltration, but just larger than that in reverse osmosis.

Reverse osmosis (RO) and Nanofiltration (NF) are physical separation technologies used to remove contaminates from liquid streams. In recent years, RO/NF technologies have become more efficient and affordable for use across a variety of industrial applications, including potable water generation and the treatment of brackish water, seawater, and wastewater.

Similarities between Nano filteration and Reverse Osmosis:

RO and NF are membrane filtration technologies in which pressure is applied to a liquid stream, driving it though a semipermeable membrane in order to remove dissolved solids. In this way, RO/NF closely resemble other forms of membrane filtration, including Microfiltration (MF) and Ultrafiltration (UF), yet are capable of removing even smaller molecules, such as dissolved organics, pesticides, and agricultural chemicals.

Differences between Nano filteration and Reverse Osmosis:

While RO and NF are very similar, they can be distinguished based on the size of particulates that each is able to remove. Comparatively, RO and NF are capable of removing finer contaminates than MF and UF, with applications including the removal of hardness, nitrates, sulfates, total dissolved solids (TDS), heavy metals, radionuclides, and organic macromolecules from process and waste streams.

II.REVERSE OSMOSIS

RO is the finest of all membrane filtration systems, with extremely small pores capable of removing particles as small as 0.1 nm. RO has existed since the 1950s, and is used chiefly for desalination, as in potable water generation from seawater or brackish water sources. Other applications of RO include filtering process water for industrial applications, such as in the printing industry, in order to sustain optimal equipment performance. RO membranes are very efficient at removing all ions, large and small.

III.NANOFILTRATION

NF delivers slightly coarser filtration than RO, with the ability to remove particles as small as 0.002 to 0.005 µm in diameter. NF is a relatively recent technology that was developed mainly for potable water generation. NF

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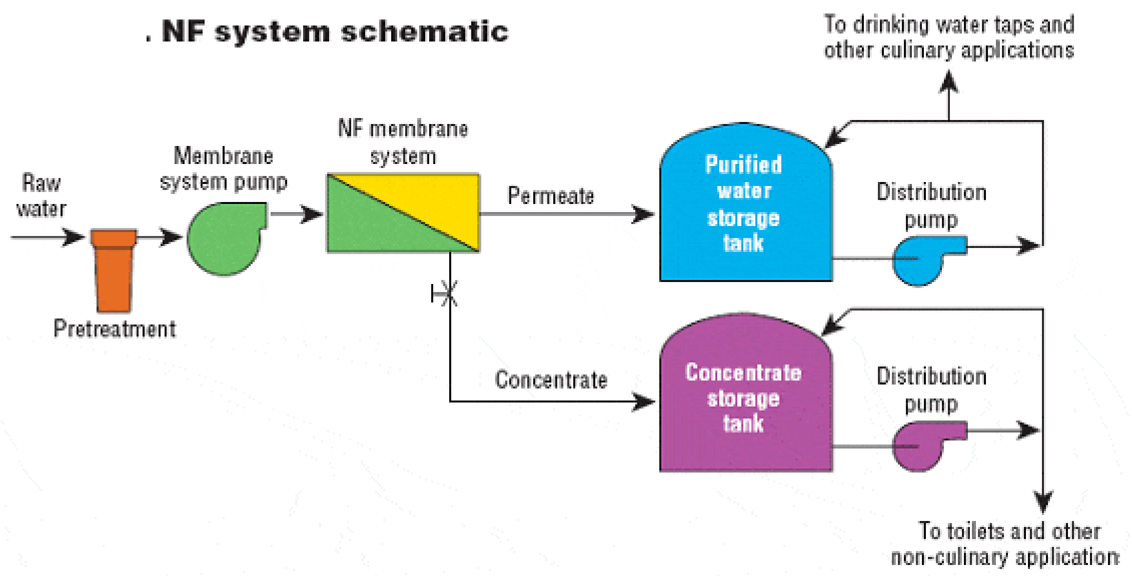
removes harmful contaminates, such as pesticide compounds and organic macromolecules, while retaining minerals that RO would otherwise remove. Nanofiltration membranes are capable of removing larger divalent ions such as calcium sulfate, while allowing smaller monovalent ions such as sodium chloride to pass through.
The following diagram represents the Nano Filteration for purification of water:



Nanofiltration is a relatively recent membrane process used most often with low total dissolved solids water such as surface water and fresh groundwater, with the purpose of softening (polyvalent cation removal) and removal of disinfection by-product precursors such as natural organic matter and synthetic organic matter.
Nanofiltration (NF) is one of the four membrane technologies, which utilize pressure to effect separation of contaminants from water streams. The other three are microfiltration, ultrafiltration and reverse osmosis (RO). All of these technologies utilize semi-permeable membranes that have the ability to hold back (reject) dissolved and/or suspended solids from a water stream containing these contaminants.
Nanofiltration is also becoming more widely used in food processing applications such as dairy for simultaneous concentration and partial (monovalent ion) demineralization.
This mechanism depends upon the valence of the salt ion in question. Recognize that a salt is a compound of two or more ions with an electronic charge. Valence is the number of charges on the ions that form the specific salt, which is not always sodium chloride (NaCl); sodium and chloride are monovalent ions because they have only one charge, whereas ions such as calcium and sulfate are multivalent because they have more than one charge. A defining characteristic of NF membranes is that they reject multivalent ions to a significantly greater degree than monovalent ions. The specific rejection of ions varies from one membrane manufacturer to another, but a multivalent ion rejection of 95 percent with a monovalent ion rejection of only 20 percent isn't unusual for NF membranes.

Most of these membranes available today are in spiral wound construction only, although it's expected that capillary fiber nanofilters will soon be on the market. Figure 1 illustrates NF in terms of its removal efficacy.

In much of the developing world, clean drinking water is hard to come by, and nanotechnology provides one solution. While nanofiltration is used for the removal of other substances from a water source, it is also commonly used for the desalination of water. As seen in a recent study in South Africa, tests were run using polymeric nanofiltration in conjunction with reverse osmosis to treat brackish groundwater. These tests produced potable water, but as the researchers expected, the reverse osmosis removed a large majority of solutes. This left the water void of any essential nutrients (calcium, magnesium ions, etc.), placing the nutrient levels below that of the required World Health Organization standards. This process was probably a little too much for the production of potable water as researchers had to go back and add nutrients to bring solute levels to the standards levels for drinking water. On another note, providing nanofiltration methods to developing countries, to increase their supply of clean water, is a very inexpensive method compared to conventional ones. However, there remain issues as to how these developing countries will be able to incorporate this new technology into their economy without creating a dependency on foreign assistance.

To dissolve air for flotation, three types of pressurized systems are used. Full-flow or total pressurization is used when the wastewater contains large amounts of oily material. The intense mixing occurring in the pressurization system does not affect the treatment results. Partial-flow pressurization is used where moderate to low concentrations of oily material is present. Again, intense mixing by passage through the pressurization systems does not affect treatment efficiency significantly. The recycle-flow pressurization system is for treatment of solids or oily materials that would degrade by the intense mixing in the other pressurization systems. This approach is used following chemical treatment of oil emulsions, or for clarification and thickening of flocculent suspensions.

In the schematic drawing of dissolved-air flotation system shown in the figure, The solids-laden or oily-water influent mixture enters the flotation vessel, and the air-solids mixture rises to the liquid surface. The air-solids mixture has a specific gravity less than water. Solids having a specific gravity greater than water tend to settle to the bottom and are removed by a rotating scraper arm. Attached to the same shaft is a rotating skimmer blade that removes the floating matter from the surface of the vessel into a skimming hopper. Clean water passes underneath a skirt and then must leave the vessel through a launder, which is located in the peripheral region.

Some typical applications for Nanofiltration are:

- Desalination of food, dairy and beverage products or byproducts
- Partial Desalination of whey, UF permeate or retentate as required
- Desalination of dyes and optical brighteners
- Purification of spent clean-in-place (CIP) chemicals
- Color reduction or manipulation of food products

- Concentration of food, dairy and beverage products or byproducts
- Fermentation byproduct concentration.

Nanofiltration and softening : Water softening generally involves the removal of hardness ions, specifically calcium and Magnesium. Because these ions are multivalent, they're preferentially removed by NF membranes.

As a matter of fact, NF has been used for a number of years for municipal softening, particularly in Florida. The advantage of NF over RO, the other membrane technology that rejects ions, is that NF has a higher flux rate. This means that fewer membrane elements are required and it operates at a lower pump pressure—pounds per square inch (psi) or bars—thereby offering savings in operating costs.

The particular advantage of membrane technology in this application is that no chemicals are required to facilitate the removal of hardness ions, whether soda lime for municipal softening or common salt (sodium chloride) in the case of regeneration of typical residential water softeners. Sodium ion exchange, the standard technology for residential water softening for more than 50 years, utilizes ion exchange resin (in the sodium form) that adsorbs hardness ions from water passing through a bed of such resin, and releases sodium ions in exchange. Because this technology requires sodium or potassium chloride for regeneration of the resin, these are released into the sewer (or septic tank) with every regeneration cycle.

Recent legislation has been enacted to limit these discharges, based upon concerns ranging from excessive chlorides to total dissolved solids (TDS) contamination, and it appears that an increasing number of communities will prohibit the installation of traditional residential water softeners in the future.

IV.APPLICATIONS

1. RO and NF benefit from pretreatment

With the smallest pores of all filtration membranes, RO and NF membranes can foul quickly if larger particles aren't removed by upstream filtration technologies, such as media filtration or MF/UF. Pretreating process streams to remove these problematic particulates can also reduce the amount of energy needed to maintain adequate pressure in a RO/NF system.

When process streams are sufficiently pretreated, RO/NF membranes can have a long service life and require relatively little maintenance. This is because feed water constantly flows across the surface of the filtration membrane in what is called crossflow filtration, which results in rejected substances being swept away with the waste stream, as opposed to caking onto the membrane.

2. RO and NF require pressure to function

While RO and NF are fairly efficient purification technologies, both demand energy to move water across their membranes. This is because their fine pores result in a high concentration of salts and other compounds on the retentate side of the membrane, and as a result, enough pressure must be applied that the water is able to overcome the osmotic pressure that causes water to resist flowing through the membrane.

3. Both are used in place of conventional treatment technologies

Conventional water treatment trains typically consist of several unit processes, including: coagulation, flocculation, sedimentation, clarification, ion exchange, and filtration. While conventional treatment systems are effective in removing dissolved solids, they do so through a complex series of steps that often demand a large footprint and investment in an assortment of specialized equipment and chemical agents. As RO/NF membrane technologies have become more efficient and affordable in recent years, they are increasingly being adopted as more compact, efficient, and environmentally-friendly alternatives to conventional treatment trains. When NF is used in place of traditional lime softening, for example, multiple treatment steps are consolidated into one, and no concentrated brine byproducts are produced.