Applications | Pharmaceutical | E.D.I.

Electrodeionization in pharmaceuticals

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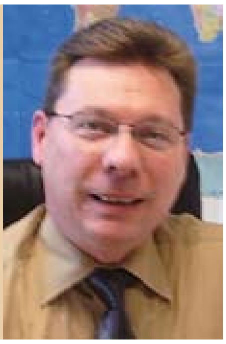

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The high ionic and bacteriological quality water that is required to meet different European, American and Japanese pharmaceutical specifications is normally produced by using membrane techniques.

Reverse osmosis has clearly imposed itself against conventional ion exchange techniques. The use of chemicals (HCl and NaOH) needed for regenerating resins and, more especially, the instability of the bacteriological and organic quality of the water produced have definitively pushed this technology to the side-lines in the world of pharmaceuticals.

Even if bacteriological requirements have got the better of this system, it cannot be denied that the ionic quality of the water produced by ion exchange techniques was incomparable.

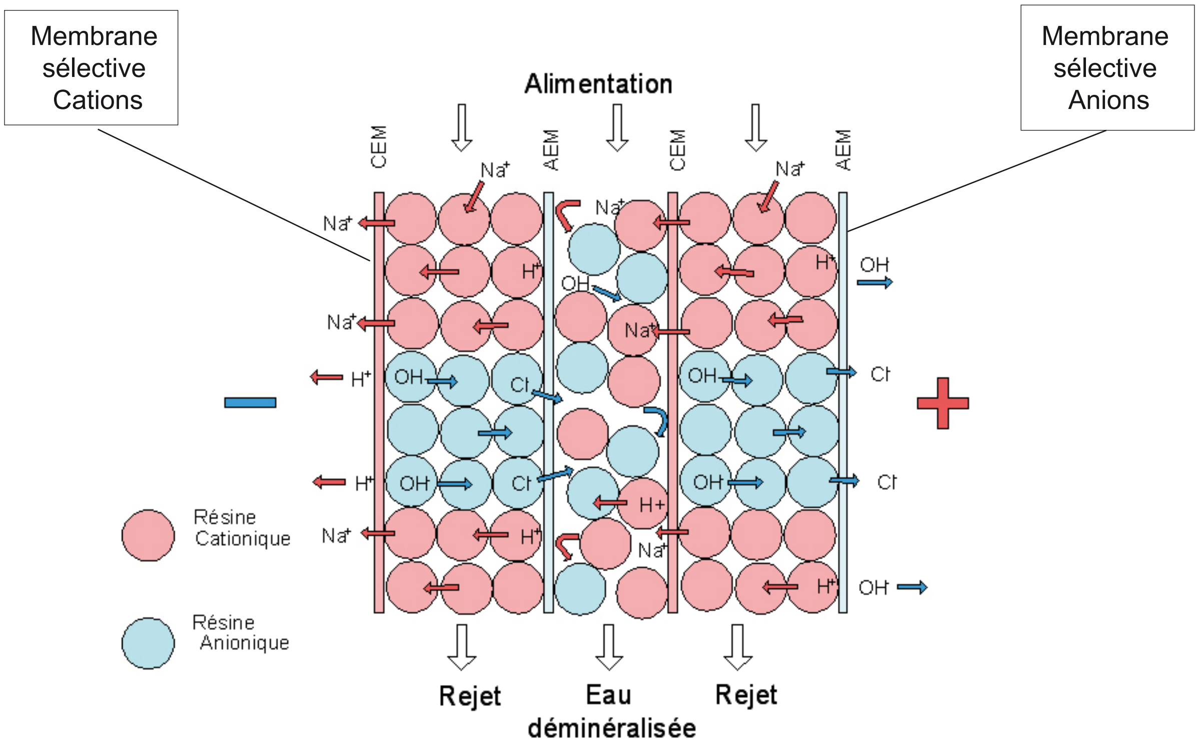
For improving the ionic performance of reverse osmosis systems, water treatment specialists have developed a standard that has rapidly imposed itself and which can be found in numerous specification sheets today :
double reverse osmosis. It is most certainly true to say that this combination is a guarantee of high bacteriological quality.

It also enables ionic specifications to be met for producing highly purified water where a level of conductivity is required that is equal to or under 1,3µs at 25°C.

On the other hand, it has been shown that this quality can only be maintained at the cost of higher water consumption and permanent control for correction of the pH content, which in turn requires increased maintenance on the soda adding system.

Over twenty years ago, a new technology appeared, considered to be revolutionary at the time, which enabled highly demineralised water to be produced without adding any extra chemicals.
The electrodeionization process (EDI) is a combination of ion exchange resins, ion selective membranes and an electric current.

HOW ELECTRODEIONIZATION WORKS



The water goes through one or more chambers charged with cationic and anionic resins.
These resins not only enable the ions to be captured but they also optimise the kinetics of the water's movement through the chambers concerned. An electric current is generated on the electrolysis principle using a cathode and an anode located at either side of the exchange chambers.
The magnetic field created in this way attracts the positive ions to the anode and the negative ions to the cathode.
Each exchange chamber is surrounded by selective membranes impervious to water.
The direct current applied causes the ions to be transferred through the selective membranes towards the electricity gradient and, therefore, towards the "rejection" chambers.
Selective membranes are made using ion exchange resins made up in the form of leaves.
The anionic and cationic resins exchange their load (OH- and H+) with the ions in the feed water (Cl-, Na+, CO2, SiO2...). They are continuously regenerated by the direct current supply.
The ion exchange phenomenon creates an electrochemical unbalance that is balanced by water hydrolysis.
As a result, the electrodeionization process creates heavy fluctuations in pH which entail a bactericidal effect.

THE ADVANTAGES OF ELECTRODEIONIZATION

There are a wide number of advantages in this type of system, which have convinced most of the pharmaceutical laboratories interested in producing high quality water.
Electrodeionization may be used continuously, it does not give birth to any chemical effluent and its operating costs remain low at 0.05 Kw/m3.
The ionic quality of the water produced is between 16 and 18,1Mohms which, when used in combination with a reverse osmosis system, leads to a reduction of 99.9% of ions in the water that is fed in. The TOC is lower than 20ppb and silica lower than 5ppb.

Setting up an EDI system is simple and requires no complex automation systems.
The compact form of EDI modules reduces assembly costs to a minimum.
Module service life is long as there are absolutely no rotating parts.

WARNING

Electrodeionization is used in combination with a reverse osmosis unit placed up-line to the EDI.
This reverse osmosis unit provides a stable production of water with a low mineral content and exempt from germs.
Electrodeionization modules are particularly sensitive to the presence of calcium.
Therefore it is essential that an ion-exchange water softener be installed up-line to the reverse osmosis unit.

An anti-scalant injection may also be envisaged on condition that the EDI is preceded by a double osmosis unit.

Carbon dioxide is present dissolved in the water and is not trapped by osmosis membranes.

However, it is perfectly well trapped by the EDI. If a reduction in the CO_2 load is required up-line to the EDI, this is to obtain a conductivity level in the incoming water supply that is as low as possible (CO_2 included), remembering that, depending on the module chosen, the initial level must not be higher than 40µs.cm².

Carbon dioxide will be trapped by an injection of NaOH up-line of the dialyser or by membrane type degasification unit placed between the osmosis unit and the electrodeionization system.

Taking account of the fact that electrodeionization enables chemicals to be done away with, it is preferable to use a membrane type degasification system rather than to inject caustic soda.
It is also essential that any chlorine be eliminated before the RO + EDI production unit, either with active carbon cartridges, or by injecting bisulphite or by photo-oxidation using UV rays.

In short, the pre-treatment to be installed up-line to an RO + EDI production unit is identical to the pre-treatment used with a double osmosis unit, taking more particular care to ensure that the dechlorinating unit operates efficiently.

IMPLEMENTATION

As it is the case for every well-designed water-treatment system,it is important to make sure that there are no stagnation zones and that the unit operates in permanent recirculation mode.

“Batch” modes can of course be considered and give good results. In this case, preliminary rinses are essential and permeate should be released as per a predetermined programme.

Of course, any chain subjected to a high bacterial challenge should be handled in continuous recirculation mode, for guaranteeing a high and stable quality of permeate.

Moreover, the recirculation mode gives rise to significantly less mechanical constraints, which results in longer service life for most of the operating elements.

PRECONCEIVED IDEAS

- **Electrodeionization consumes large amounts of water.**

False! The conversion rate is normally between 90 and 95%.
Certain systems even run at a rate of 99%.
Moreover, the EDI concentrate can be completely returned to the system separation tank placed in front of the water treatment chain.
(Water savings are a constant concern at Epuro).

- **High electricity consumption.**

False! When compared with a double osmosis unit, where the second stage normally runs at high pressure, and which is distinctly more energy-consuming than the use of one or more electrodeionization modules.

- **Decontamination is complicated.**

False! Electrodeionization modules can be sanitized with peracetic acid preferably injected up-line to the dialyser. By opting for modules capable of resisting high temperatures, pasteurisation procedures at 85°C can be envisaged in prophylactic mode.

- **Heavy, complicated maintenance.**

False! Only the fixing systems on small modules for water-tightness need to be regularly checked.
Larger modules are of spiral design and do not require this type of check.
Instrument systems for EDI modules are relatively limited.

CONCLUSION

In comparison with traditional systems and more especially with double osmosis units, it is undeniable that electrodeionization gives the user a definitely wider safety margin and a higher quality of water.

Epuro was one of the first water treatment companies to install electrodeionization systems in France.

With over 20 years' experience in designing and installing highly purified water production lines, Epuro has made electrodeionization a technological standard recognised and specified by the major pharmaceutical laboratories.

For optimising existing production lines running in double osmosis mode and unable to produce permeate at under 1µs.cm² at 20°C, Epuro proposes EDI systems mounted on stainless steel skids that can be added to existing production units. These operations are relatively simple and enable users to attain conductivity levels of less than 0,1µs.cm² at 20°C.

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