

Ion Exchange Resins for Ultra-pure Water in the Electronics and Semiconductor Industry

UltraClean™

Just ask Purolite.

PUROLITE[®]
ION EXCHANGE RESINS

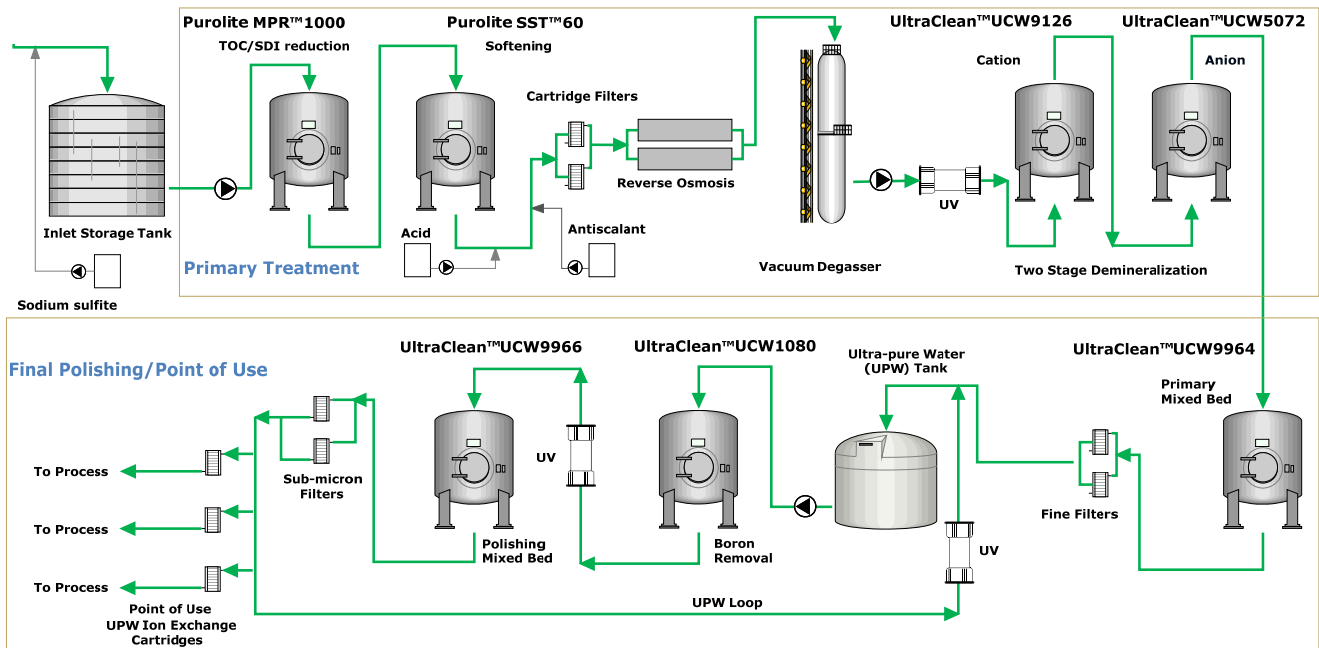
Introduction

Since the early days of synthetic ion exchange resins (IER) there has been a demand for cleaner, purer resins for use in the food and beverage as well as the power, defense, nuclear and pharmaceutical industries. However, the most exacting demands have been those from the electronics industry. Their requirements have been not only to achieve the highest possible water quality, but to ensure IER do not contaminate the high purity circuits when first installed. The electronics industry requires ultimate purity and very quick rinse down times. Purolite ion exchange resins for ultra-pure water (UPW) are specially manufactured to meet the exacting needs of the electronics industry for wafer and microchip production.

Purolite has supplied IER to this industry for many years, but is aware of the continued demand for improvements in this area. With this in mind Purolite embarked on a Research and Development program to attain a higher level of purity and performance which resulted in our new range of Purolite resins marketed as UltraClean™.

These new Purolite **UltraClean™** resins demonstrate excellent rinse down times to a resistivity >18.2 MΩ-cm (megohm-cm) and very low levels of total organic carbon (TOC). Figure 3 shows an example of rinse profiles for Purolite **UltraClean™ UCW9966** and **UltraClean™ UCW9964**. This is of particular advantage to the wafer and microchip plant, by reducing the volume and cost of rinse water when installing new resin beds and reducing outage times of operating plants. The availability of “in specification” water for the plant after resin changes translates into higher productivity and reliable consistent production.

Figure 1 – Ultra-pure Water (UPW) System Schematic



Electronics and Semiconductor Industry

To achieve the ultimate in water purity for the electronics industry, extensive treatment is needed. This normally requires a pretreatment stage followed by what is sometimes referred to as primary treatment that comprises Reverse Osmosis (RO) or Ion Exchange (IE) Make-Up water plants, or more often, a combination of both to achieve a resistivity of 12 to 17 MΩ-cm. To achieve the ultimate quality, i.e. resistivity > 18.2 MΩ-cm, a final polishing stage, comprising a recirculation loop and a point of use treatment using special UPW resin grades, is required.

Purolite's all round technical capability and extensive range of products enables us to assist end users in all three phases of UPW production; Pretreatment, Primary Treatment and Final Polishing.

Ultra-pure Water Resin Requirements

The demands on resin quality and performance are driven by the particular plant specifications and requirements. To meet the requirements of the electronics and semiconductor industry ion exchange resins must exhibit the following basic requirements:

- Ultimate Quality from a high quality feed
- Low TOC leachables
- Quick "rinse up" to quality on installation
- No particulate release
- Excellent kinetic performance
- 6 months shelf life after manufacture
- Consistent life expectancy and performance
- Acceptable pressure drop through the bed
- High conversion to the regenerated forms
- High conversion into the regenerated form

Additional requirements may include:

- Efficient regenerability
- Remain mixed at the initial vessel loading and rinse stage (non-separable mixed beds)
- Good separability of components (regenerable mixed beds)

The above demands require resins that have been subject to special production techniques using raw materials of high purity, including the water used in their production. The resins are also subjected to special post treatment at different stages of the production process. The final conversion to the regenerated form is with chemicals and water of the highest purity, particularly during the final rinse stage. Only then can the above requirements be achieved.

Pretreatment

Pretreatment plant designs vary considerably and all the different designs cannot be covered in this document. The extent of pretreatment is determined by the source and nature of the incoming raw water supply which can be variable and contain a wide range of contaminants.

Pretreatment can include some or all of the following stages: chemical dosing (to aid pretreatment or to condition the water), clarification/sedimentation, multi-media filtration, organic scavenger resins, activated carbon filtration, cartridge filtration, membrane protection resin, and softening (pre RO). Purolite has considerable experience in this area with our range of Organic Scavenger resins and SST™ and standard Softening resins (Strong Acid Cation or Weak Acid Cation) and our Membrane Protection Resin MPR™1000 for Silt Density Index (SDI) and TOC reduction. Often the pretreatment stage has to obtain water of a suitable purity for feeding a Reverse Osmosis plant. The purity of this water is often measured by the water's SDI. The lower the SDI, the higher the flux rate that can be employed on the downstream membrane plant and the lower the membrane fouling potential.

Primary Treatment

Combinations of RO membranes and IER resins have been used primarily to remove the bulk of the ionic contaminants. From this treatment end users typically achieve water qualities of 12-17 MΩ-cm. The ion exchange section can vary considerably depending on whether there is a preceding RO plant. There are also many different ion exchange combinations that can be employed depending on the quality of the water fed to the plant. Weak acid cation (WAC), strong acid cation (SAC), weak base anion (WBA), strong base anion (SBA) resins and mixed beds

(a combination of SAC/SBA in a single column) have all successfully been used. Some clients only employ mixed beds in their primary make-up section after RO and these units can employ ultrapure resins, while many still use high quality or specially purified industrial grade resins in this duty.

Once again the choice is determined by the nature of the water and the pretreatment design. Where single beds of resin are incorporated into the design, some employ co-flow (co-current) regeneration while more recent designs employ a variety of counter-flow (counter-current) techniques for regeneration, including packed beds, air or water hold down, split flow, etc. Purolite supplies grades of resins to cover all these different techniques.

Our PureDesign software program can be used to help engineers and end-users to select the best ion exchange option and Purolite's Technical Sales Team can advise on the best choice of resins and grades for your plant.

Final Polishing / Point of Use

As mentioned earlier, the ultimate quality is always obtained by using IER of the highest quality and purity and this is where our UltraClean™ resins are of such importance. Table 1 below lists the current range of products offered by Purolite for use in Pretreatment, Primary Treatment and Final Polishing.

Usually, in the system there are also other stages of treatment such as UV sterilization, Vacuum Degassing, Fine-Filtration with sub-micron filters or Ultra-Filtration, etc. as well as primary and polishing mixed beds. In some cases, these mixed beds are both regenerable, on other sites they are non regenerable. Purolite offers UPW resins for both applications. See Table 1.

Table 1 – Purolite Range of Ultra-pure Water (UPW) Resins

Product	Description
UltraClean™ UCW9966	Low TOC, High Purity, UPW non-separable mixed bed resin for final polishing and point of use treatment
UltraClean™ UCW9964	Low TOC, High Purity, UPW separable mixed bed resin for final polishing and point of use treatment
UltraClean™ UCW9126	UPW High Purity , Uniform Particle Size, gel, strong acid cation exchange resin for single cation vessels or as cation component of regenerable mixed beds
UltraClean™ UCW5072	UPW High Purity , Uniform Particle Size, gel, strong base type I anion exchange resin for single anion vessels or as anion component of regenerable mixed beds
UltraClean™ UCW3900	High cation capacity mixed bed resin for high purity water production
UltraClean™ UCW3700	Balanced mixed bed resin for high purity water production
UltraClean™ UCW3600	High anion capacity mixed bed resin for high purity water production
UltraClean™ UCW1080	Selective boron removal resin

Boron removal is also increasingly required and to achieve this UltraClean™ UCW1080 is used in the UPW loop to maintain boron to < 50 ppt as boron .

Product data sheets featuring typical physical and chemical characteristics for each **UltraClean™** product are available on our web site www.purolite.com .

Purolite continues to develop new and improve products for the electronic and semiconductor industry. With over 25 years successfully developing our production and post treatment techniques, we continue to meet the ever increasing needs of our customers. In all areas Purolite strives to provide the best economical solution to the complex challenges of today and the future.

The Purolite **UltraClean™** resins meet the exacting demands of the current generation of electronic industry installations.

Post Production Testing

Purolite recognizes the importance of testing every batch of **UltraClean™** resin to ensure the highest performance is achieved, and to provide the end user with the confidence that the resin will perform consistently, as expected in the application.

Performance - Low Total Organic Carbon (TOC) Release

The two premier products from our range are the **UltraClean™ UCW9966** and **UltraClean™ UCW9964** mixed bed resins. These are especially designed for the highest purity UPW production where the specification requires <1 ppb Total Organic Carbon (TOC) and >18.2 MΩ·cm, with minimum rinse times.

Table 2 – Typical UPW Product Characteristics

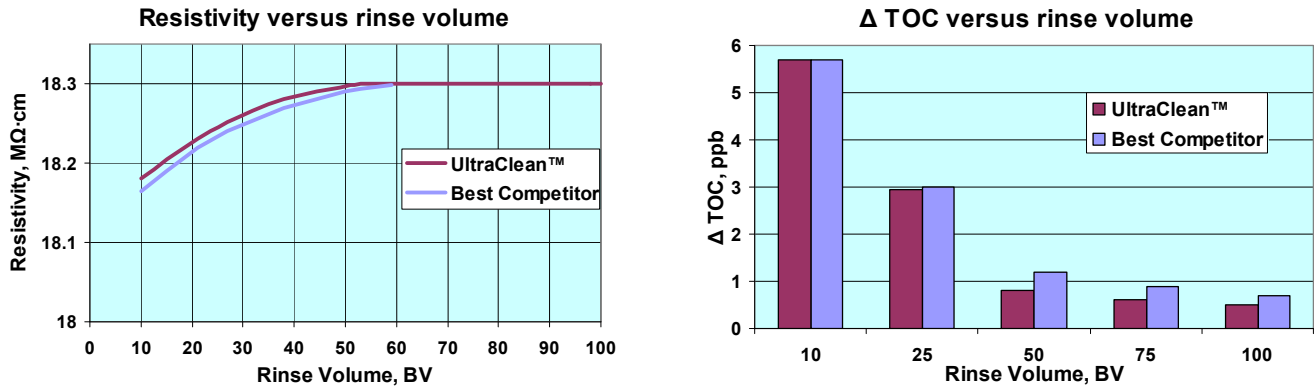
Product	Strong Acid Cation	Strong Base Anion	Mixed Bed	Non-separable	Regenerable	>18.0 MΩ·cm in < 2 BV	Δ TOC, ppb
UltraClean™ UCW9966			√	√		√	<1 in 100 BV
UltraClean™ UCW9964			√		√	√	<1 in 100 BV
UltraClean™ UCW9126	√				√		<6 in 100 BV
UltraClean™ UCW5072		√			√		<2 in 100 BV
UltraClean™ UCW3900			√		√	√	<10 in 40 BV
UltraClean™ UCW3700			√		√	√	<10 in 40 BV
UltraClean™ UCW3600			√		√	√	<10 in 40 BV

To achieve ultimate quality from our UCW range in final polishing mode, it is necessary to use rinse water with the following minimum characteristics: resistivity > 17.5 MΩ·cm, TOC < 2 ppb, SiO₂ < 2 ppb at a flow rate > 30 BV/h

For other mixed bed duties where the TOC specification is slightly more relaxed with specified TOC levels < 10 ppb after rinsing with 30-40 Bed Volumes (BV), then our **UltraClean™ UCW3900**, **UltraClean™ UCW3700**, **UltraClean™ UCW3600** resins should be employed.

In all cases where low TOC levels are required, it is assumed that high purity water with only trace TOC is present in the water being used to rinse the beds prior to placement in service and during service operation.

Figure 3 - Typical UltraClean™UCW9964 and UltraClean™ UCW9966 mixed bed resistivity and Δ TOC versus rinse volumes (BV)



Mixed Bed UPW Options

The new **UltraClean™ UCW** separable and non-separable Mixed Beds comprise a 1:1 chemical equivalent (40:60) cation to anion ratio. The individual gel cation and anion components of the premier separable mixed bed are also available as **UltraClean™ UCW9126** and **UltraClean™ UCW5072** respectively.

Purolite Corporation was founded in 1981 and is a leading manufacturer and developer of ion exchange, catalyst, absorbent and specialty resins and is the only company to focus exclusively on this market. Headquartered in Bala Cynwyd, PA, the company has ISO 9000:2001 certified manufacturing and R&D facilities sites in North America, Europe and Asia, and sales offices in more than 40 countries. Purolite’s dedicated central “Centre of Excellence” research and development facility is located in the United Kingdom and coordinates research in China, Romania, Russia, UK, and USA.

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