

Ion Exchange Resins for Ultrapure Water



This Application Guide reviews ion exchange resins for ultrapure water (UPW) that are manufactured to meet the exacting needs of the electronics industry for wafer and microchip production.



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About Purolite

Purolite is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. With global headquarters in the United States of America, Purolite is the only company that focuses 100% of its resources on the development and production of resin technology.

Responding to our customers' needs, Purolite has the widest variety of products and the industry's largest technical sales force. Globally, we have strategically located research and development centers and application laboratories. Our ISO 9001 certified manufacturing facilities in the USA, United Kingdom, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.

Purolite has been part of Ecolab since 2021. A trusted partner at nearly three million commercial customer locations, Ecolab (ECL) is the global leader in water, hygiene and infection prevention solutions and services. Ecolab delivers comprehensive solutions, data-driven insights and personalized service to advance food safety, maintain clean and safe environments, optimize water and energy use, and improve operational efficiencies and sustainability for customers in the food, healthcare, hospitality and industrial markets in more than 170 countries around the world.



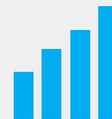
PREMIER PRODUCTS

The quality and consistency of our products are fundamental to our performance. Throughout all Purolite plants, production is carefully controlled to ensure that our products meet the most stringent criteria, regardless of where they are produced.



RELIABLE SERVICE

We are technical experts and problem solvers. Reliable and well-trained, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales team in the industry.



INNOVATIVE SOLUTIONS

Our continued investment in research and development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.

Ion Exchange Resins for Ultrapure Water

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Introduction to Ion Exchange Resins for Ultrapure Water

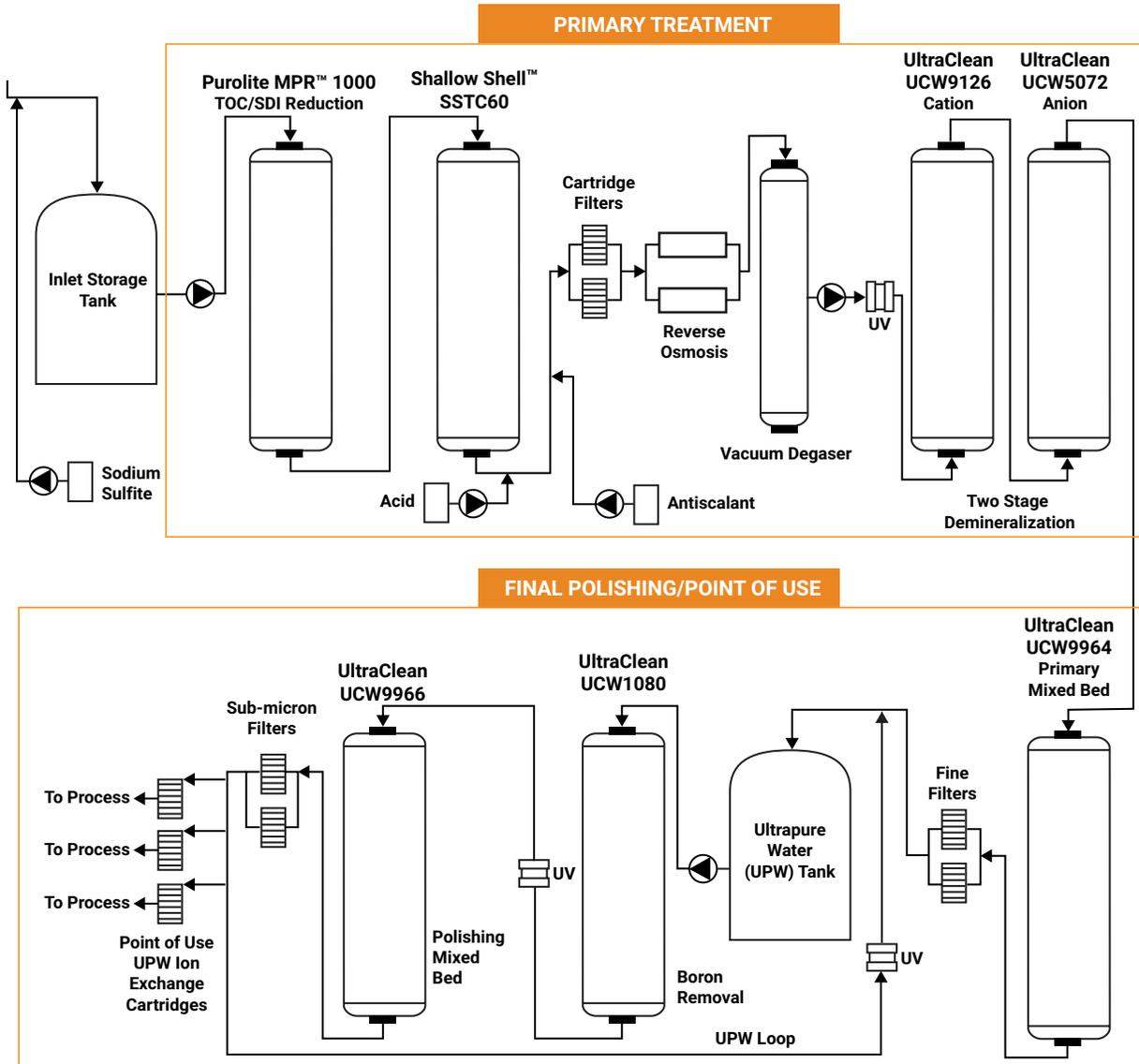
Since the early days of synthetic ion exchange resins, there has been a demand for cleaner, purer resins in food and beverage and power, defense, nuclear and pharmaceutical industries. However, the most exacting demands have been those from the electronics industry. They have required the highest possible water quality and ensure ion exchange resins 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 ultrapure water (UPW) are specially manufactured to meet the exacting needs of the electronics industry for wafer and microchip production.

Purolite has supplied ion exchange resins 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, resulting in our well-established line of Purolite UltraClean™ resins.

These 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 [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. After resin changes, the plant's availability of "in specification" water translates into higher productivity and reliable, consistent production.

FIGURE 1

Ultrapure Water (UPW) System Schematic



Electronics and Semiconductor Industry

Extensive treatment is needed to achieve the ultimate in water purity for the electronics industry. This typically 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 12–17 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 technical capabilities and extensive range of products enable us to assist end-users in all three phases of UPW production: pretreatment, primary treatment and final polishing.

Ultrapure Water Resin Requirements

The particular plant specifications and requirements drive resin quality and performance demands. To meet the needs 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
- Six 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:

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

Resins subject to special production techniques using only materials of high purity, including a UPW water system. A special post-treatment is used at different stages of the production steps. Conversion to regenerated form is accomplished with chemicals and water of the highest purity, particularly during the final rinse stage.

Pretreatment

Pretreatment plant designs vary considerably, and this document cannot cover all the different options. 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 suitable purity for feeding a reverse osmosis plant. The water's SDI often measures the purity of this water. 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 ion exchange 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 if there is a preceding RO plant. Many different ion exchange combinations 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 makeup section after RO, and these units can employ ultrapure resins. At the same time, 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.

In contrast, 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 PRSM™ software ([Purolite Resin System Modeling](#)) can help engineers and end-users 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 ion exchange resins 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 there are other stages of treatment in the system, such as UV sterilization, vacuum degassing, fine filtration with sub-micron filters or ultra-filtration, etc, and 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.

TABLE 1 Purolite Range of Ultrapure Water (UPW) Resins

Product	Description
UltraClean UCW1080	Selective boron removal resin
UltraClean UCW3600	High anion capacity mixed bed resin for high purity water production
UltraClean UCW3700	Balanced mixed bed resin for high purity water production
UltraClean UCW3900	High cation capacity mixed bed resin for high purity water production
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 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 UCW9964	Low TOC, high purity, UPW separable mixed bed resin for final polishing and point of use treatment
UltraClean UCW9966	Low TOC, high purity, UPW non-separable mixed bed resin for final polishing and point of use treatment

Boron, used in the silicon etching of microprocessors as a doping agent, is often found in influent steams to UPW mixed beds. Recently published studies, carried out at a UPW facility in the US, showed the interference of silica removal by boron uptake in working UPW mixed beds.

UPW facilities have decided that any boron remaining in ultrapure water is detrimental to product yield. The challenge to water treatment companies is to remove both boron and silica to very low levels effectively. For high GP chips, the limits on boron are < 50 ppt and < 0.1 ppb SiO₂ and also maintaining < 0.5 ppb TOC. The current problem is that mixed bed resins are not very selective for boron under neutral pH. Mixed beds must be regenerated four times more often than breakthrough based on silica to maintain undetectable levels of boron.

The equilibrium constant (K₁) for boric acid is 10⁻¹⁰ compared to K₁ for silica acid of 10⁻⁷ and K₁ for carbonic acid of 10⁻⁵. The closeness of the equilibrium constants shows the difficulty in boron exchange, plus silica removal in the low pH environment of a mixed bed unit.

[UltraClean UCW1080](#) boron selective resin, when used in a stand-alone vessel, is the proven media to lower boron for over two years, which also extended the life of the polishing mixed beds.

Product datasheets featuring typical physical and chemical characteristics for each UltraClean product at www.purolite.com. Purolite continues developing new and improved products for the electronic and semiconductor industry. With over 25 years of successfully enhancing 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 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 to End Water Quality (>18.0 MΩ·cm) Including Low Total Organic Carbon (TOC) Release

TABLE 2 Typical UPW Product Characteristics

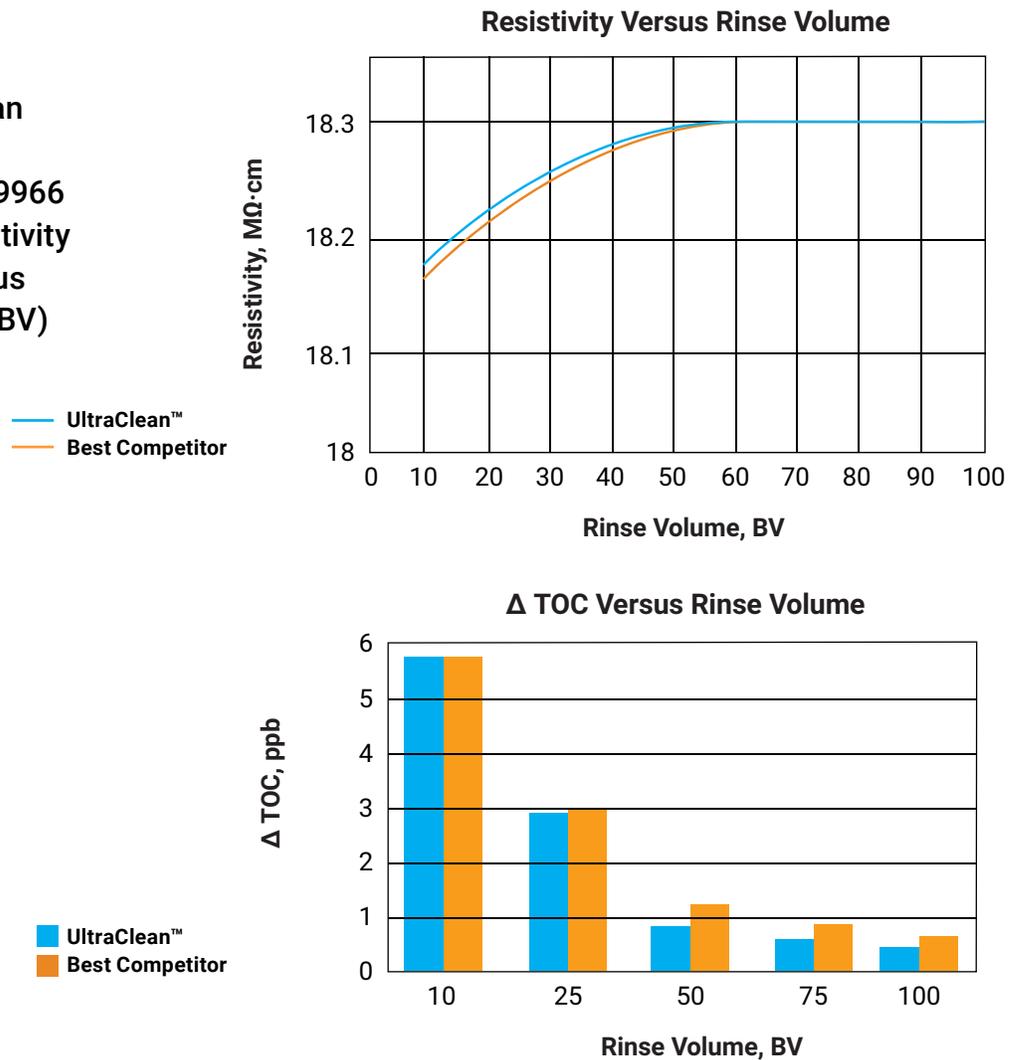
Product	Strong Acid Cation	Strong Base Anion	Mixed Bed	Non-Separable	Regenerable	>18.0 MΩ·cm in < 2 BV	Δ TOC (ppb)
UltraClean UCW3600			✓		✓	✓	< 10 in 40 BV
UltraClean UCW3700			✓		✓	✓	< 10 in 40 BV
UltraClean UCW3900			✓		✓	✓	< 10 in 40 BV
UltraClean UCW5072		✓			✓		< 2 in 100 BV
UltraClean UCW9126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

To achieve ultimate quality from our UCW range in final polishing mode, it is necessary to use rinse water with the following 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](#) and [UltraClean UCW3600](#) resins should be used. 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 before placement in service and the during service operation.

FIGURE 3

Typical UltraClean UCW9964 and UltraClean UCW9966 Mixed Bed Resistivity and Δ TOC Versus Rinse Volumes (BV)





Algeria
Australia
Bahrain
Brazil
Canada
China
Czech Republic
France
Germany

India
Indonesia
Israel
Italy
Japan
Jordan
Kazakhstan
Korea
Malaysia

Mexico
Morocco
New Zealand
Poland
Romania
Russia
Singapore
Slovak Republic
South Africa

Spain
Taiwan
Tunisia
Turkey
UK
Ukraine
USA
Uzbekistan



Americas

Purolite
2201 Renaissance Blvd.
King of Prussia, PA 19406
T +1 800 343 1500
T +1 610 668 9090
F +1 800 260 1065
americas@purolite.com

EMEA

Purolite Ltd.
Unit D
Llantrisant Business Park
Llantrisant, Wales, UK
CF72 8LF
T +44 1443 229334
F +44 1443 227073
emea@purolite.com

FSU

Purolite Ltd.
Office 6-1
36 Lyusinovskaya Str.
Moscow, Russia
115093
T +7 495 363 5056
F +7 495 564 8121
fsu@purolite.com

Asia Pacific

Purolite China Co. Ltd.
Room 707, C Section
Huanglong Century Plaza
No.3 Hangda Road
Hangzhou, Zhejiang, China 310007
T +86 571 876 31382
F +86 571 876 31385
asiapacific@purolite.com

Purolite, the leading manufacturer of quality ion exchange, catalyst, adsorbent and specialty high-performance resins, is the only company that focuses 100% of its resources on the development and production of resin technology.

We're ready to solve your process challenges. For further information on Purolite products and services, visit www.purolite.com or contact your nearest Technical Sales Office.



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