Addressing Pressing Needs for Wastewater Treatment and Contaminant Removal
With Dow’s Ion Exchange and Adsorbent Resins

Heavy Metals? TOC? Oil?
Are any of these challenging your operations?
Are you targeting a smaller waste footprint via recycling?
Circular Economy

Since the industrial revolution, wastewater generation has constantly grown. Faced with strong regulations and a highly competitive environment, industries have taken actions that are ultimately more environmentally sustainable and economically feasible, particularly in the development of sustainable waste solutions and residuals management. Moving towards a circular economy is at the heart of the sustainability agendas for governments and corporations. What used to be regarded as ‘waste’ can be turned into a resource.

Industries are already addressing water scarcity issues by wastewater reuse and recycle; examples are depicted in the infographic on the following page.

Product Range

Dow Water & Process Solutions offers a broad spectrum of proven technologies for a wide variety of treatment schemes – allowing customers to mix and match technologies to achieve their waste and process stream treatment objectives. Dow technologies include:

- **TEQUATIC™ PLUS Filters** for a simple, self-cleaning solution for tackling high-solids water
- **Ultrafiltration (UF) Modules** for suspended solids removal
- **Fouling-resistant Reverse Osmosis and Nanofiltration Membrane Elements** for dissolved salts removal
- **Polymeric Adsorbents and Ion Exchange Resins** for selective and non-selective removal

Learn more on the following pages how Dow’s ion exchange resins and other products can solve your wastewater needs.
Global Wastewater Recovery Across Markets

OIL FIELD
A U.S. OILFIELD OPERATOR IS INCREASING THE VOLUME OF RECYCLED PRODUCED WATER TO NEARLY 100% WHILE REDECTING OPERATING COSTS BY 60%

COAL MINE
WASTEWATER FROM A COAL MINE IN SOUTH AFRICA IS FEEDING THE LOCAL POWER STATION TO PROVIDE ELECTRICITY TO RESIDENTS AND BUSINESSES

INDUSTRIAL
A STEEL PLANT IN SHANXI, CHINA, IS RECOVERING 2074 m³/h OF ITS WASTEWATER FOR REUSE

TEXTILE
A TEXTILE PLANT IN LÜLEBURGAZ–KIRKLARELI, TURKEY, IS RECOVERING 73% OF ITS WASTEWATER FOR REUSE

AUTOMOTIVE
AN AUTOMOTIVE MANUFACTURER IN INDIA IS REUSING 100% OF ITS WASTEWATER

POWER PLANT
A POWER PLANT IN BEIJING, CHINA, IS REUSING 70% OF ITS COOLING TOWER BLOWDOWN

MUNICIPAL
FOUNTAIN HILLS, ARIZONA, IS RECOVERING 94% OF ITS WASTEWATER TO MAINTAIN AQUIFERS AND PRESERVE DRINKING WATER

SEMICONDUCTOR
A SEMICONDUCTOR MANUFACTURER IN TAIWAN IS RECLAIMING WASTEWATER FROM CHEMICAL MECHANICAL POLISHING TO ALLEVIATE STRESS ON LOCAL FRESHWATER RESOURCES AND DECREASE WASTEWATER DISCHARGE

REFINING
A REFINERY IN BEIJING, CHINA, IS RECLAIMING PETROCHEMICAL WASTEWATER TO PRODUCE DEIONIZED WATER FOR BOILER MAKE-UP
Contents

Importance of Effective Removal of Contaminants ................................................................. 6

Suspended Solids .................................................................................................................. 6

Organics ................................................................................................................................... 7

Oil Removal from Produced Water and Wastewater
  Oil Wet Solids
  Free Oil
  Emulsified Oil
  Dissolved/Water-Soluble Oil
    BTEX
    Gasoline Range Organics & Diesel Range Organics
    Total Petroleum Hydrocarbons
    Phenols and Naphthenic Acids

Aromatic & Phenolic Compound Removal from Industrial Effluents
  Benzene and Cumene
  Phenol
  Bisphenol A
  Alkylphenols/Naphthenic Acid

Natural Organic Matter (NOM) ............................................................................................ 10

Chromate ............................................................................................................................... 12

Heavy Metals ....................................................................................................................... 13

Nitrate ...................................................................................................................................... 14

Cyanide ................................................................................................................................. 14

Perchlorate ............................................................................................................................ 15

Boron ...................................................................................................................................... 15

Selenium ................................................................................................................................. 16

Radium ................................................................................................................................... 16

Uranium ................................................................................................................................. 17

Mercury .................................................................................................................................... 18
Importance of Effective Removal of Contaminants

Water scarcity is a global pressing issue. Preserving and restoring the world’s water supply remains as one of the world’s top challenges for future generations. Minimizing waste is one of the principles behind any of the circular economy initiatives. Failing to purify water before discharging it back to the environment has dire consequences. More stringent legislation across the globe as well as an increased awareness of corporate social responsibility towards sustainability are leading towards enforcing and implementing more measures to actually tackle some of the issues that an uncontrolled disposal of these pollutants may pose to our planet.

Effective removal of critical contaminants can help avoid:
1) Hindering downstream unit operations
2) Fines/penalties for exceeding discharge permits
3) Polluting the environment

In the end, it can be costly to ignore the importance of effectively removing certain contaminants. Finding cost-effective solutions is as important as ever. Read on in this brochure to get more information about your particular wastewater challenge.

Suspended Solids Removal

The very first consideration for any wastewater treatment process should be the removal of suspended solids because if they are not properly filtered out, it has the potential to significantly impact the operating cost of the necessary downstream processes meant to remove dissolved solids.

For many waters, ultrafiltration (UF) systems can effectively remove suspended solids in a continuous, relatively low-pressure operation. DOW IntegraFlux™ Ultrafiltration Modules are made with high-strength, hollow fiber membranes that offer the following features:

- 0.03-μm nominal pore diameter for removal of bacteria, viruses, and particulates including colloids to protect downstream processes.
- PVDF polymeric hollow fibers for high mechanical strength with excellent chemical resistance, providing long membrane life and reliable operation.
- Outside-In flow configuration allowing a wide range of solids in the feedwater, minimizing the need for pretreatment processes and reducing the backwash volume compared to Inside-Out configurations.
- Up to 35% higher permeability than previous generation modules, helping to improve operating efficiencies and productivity.

For difficult feedwaters with total suspended solids (TSS) from 100 – 10,000 mg/L, TEQUATIC™ PLUS Filters can help remove solids down to 15 μm in a convenient, self-cleaning filter that resists constant plugging, even in the presence of fats, oils, greases, and fibers.

More information on Dow’s ultrafiltration and TEQUATIC™ PLUS Filters is available at www.dowwaterandprocess.com.

<table>
<thead>
<tr>
<th>Product</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOW IntegraFlux™ Ultrafiltration Module</td>
<td>Removal of colloids, bacteria, and other fine solids down to about 0.03 μm</td>
</tr>
<tr>
<td>TEQUATIC™ PLUS Filters</td>
<td>Removal of high concentration of solids, including those in the presence of oil or oily feed streams</td>
</tr>
</tbody>
</table>
Organics Removal

Discussion of wastewater treatment capabilities requires a focus on organic compound removal. The organic composition of a wastewater stream is often the key parameter for meeting National Pollutant Discharge Elimination System (NPDES) discharge permits or for recycling that water.

- For discharge, the organic load expressed as BOD, COD, TOC or O&G is usually a limit for wastewater discharge permits. For water that is sent to a municipal wastewater treatment plant (WWTP), surcharges are often added to the cost of treating the water based on the organic load.
- Downstream water recycle and recovery processes (such as reverse osmosis) are often sensitive to the organic load so pretreatment is required.

In the case of environmental remediation of contaminated soils, the removal of the organic/solvent/fuel is the focus of the work.

Measurements for Organic Load

**BOD (biological oxygen demand)** is based on the principle that if sufficient oxygen is available, aerobic biological decomposition by microorganisms will consume all of the organic material present. It is a test that measures the consumption of oxygen over a 5-day period under prescribed conditions.

**COD (chemical oxygen demand)** is the most popular alternative to BOD because it can be performed in a few hours. The test uses a chemical (potassium dichromate in 50% sulfuric acid) to chemically oxidize the organics and inorganics in the water sample. Because inorganics are measured, a COD result is often higher than a BOD measurement.

**TOC (total organic carbon)** is gaining popularity because the test can be performed in 5 – 10 minutes. A TOC measurement is like a COD measurement in that it uses oxidation methods to break down the organics to CO₂, followed by quantification.

**O&G (oil & grease)** measures the hydrophobic components of wastewater (fat, oil, grease, and petroleum hydrocarbons) and can exist as emulsions which are tiny particles of the O&G suspended in water.

**BTEX (benzene, toluene, ethylbenzene and xylene)** is a specific group of petroleum hydrocarbons that can be called out for specific quantification and restrictions on discharge. Levels are typically measured by GC or GC-MS. Limits on benzene can be in the parts-per-billion range.

Traditional Methods of Removing Organics

The following table compares traditional methods of removing organics from wastewater.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Background</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Conventional Biological Treatment | Conventional sanitary wastewater contains a wide variety of organic compounds that are treated with conventional aerobic and anaerobic biological processes. | • Generally works well for destruction of organic compounds  
• Works very well for “easy” to breakdown organic compounds | • Microorganisms are living creatures, sensitive to physical variables such as temperature and pH  
• Does not work very well for difficult organic compounds such as NOM (tannic, humic, and fulvic acids)  
• Requires fairly long residence times and, thus, large ponds (large footprint) |
| Oxidation Processes | Various advanced oxidation processes *(in situ* generation or pumping in the oxidant) use ozone, hydrogen peroxide and/or UV light. | • Works well with low levels of organic contaminants | • Requires the injection or generation of oxidants so it can be expensive, particularly when the organic concentration is high |
| Activated Carbon (AC) | Activated carbon has been used for decades to remove organics from air and water in chemical process and wastewater streams. It is typically used as a disposable media or sent off-site for reactivation. | • Readily available  
• Cheap to buy | • Needs to be reactivated in an off-site furnace at 400–500°C where part of the AC is burned  
• There is no option to recover the hydrocarbons  
• Transportation and change-out often requires substantial inventories of AC on site  
• Expensive to use |
Synthetic, Engineered Adsorbents

The paradigm shift proposed by Dow is the use of an engineered adsorbent with designed pore size distribution that enables effective removal of organic contaminants in wastewater streams. Synthetic adsorbents can either replace or be complementary to traditional methods.

The principle at the core of polymeric adsorbents is quite simple. Wastewater is passed through a column containing the spherical polymeric adsorbent. The organic materials are retained on the resin while water and simple salts pass through. When the resin is fully loaded, the organics are stripped from the resin with steam, solvents, or a dilute caustic solution. In some cases, the organic material may be concentrated by orders of magnitude. The choice of solvent, or regenerant, usually depends on the availability at the particular location.

DOWEX OPTIPORE™, AMBERLITE™, and AMBERSORB™ Polymeric Adsorbents are engineered resins supplied in the form of hard spherical beads. They possess both a high level of surface area within micropores and a high pore volume in the mesopore and macropore structure. This results in a high loading capacity and rapid mass transport (kinetics). Due to the engineered pore structure of the product, DOWEX OPTIPORE, AMBERLITE, and AMBERSORB polymeric adsorbents can be thermally regenerated on site in a few hours and quickly put back into service. This allows minimization of system size and reduces overall treatment costs.

DOWEX OPTIPORE, AMBERLITE, and AMBERSORB polymeric adsorbents offer an alternative to activated carbon for the removal of a wide variety of organic compounds from industrial wastewater and produced water.

Synthetic, engineered adsorbents have been available for decades and fall into three major categories, summarized in the following table:

<table>
<thead>
<tr>
<th>Adsorbent Resin</th>
<th>Polymer Composition</th>
<th>Pore Size</th>
<th>Surface Area</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>XAD™</td>
<td>Macroporous polymer of divinyl benzene</td>
<td>Typically larger than the other types</td>
<td>300 – 700 m²/g</td>
<td>Larger, macro molecules</td>
</tr>
<tr>
<td>AMBERSORB™</td>
<td>Pyrolyzed macroporous polymer</td>
<td>Very small micropores</td>
<td>500 – 600 m²/g</td>
<td>Lowest boiling point solvents, difficult-to-capture components of 1,4-dioxane, and Freon™ Refrigerants</td>
</tr>
</tbody>
</table>
| DOWEX OPTIPORE™ | Macroporous methylene-bridged polymer of styrene and divinyl benzene | Balance of micropores, mesopores, and macropores (facilitates transportation in and out of the media) | > 1100 m²/g | Very versatile for capturing a wide variety of organic molecules:  
  - chlorinated solvents  
  - alcohols and ketones  
  - volatile monomers  
  - BTEX and hydrocarbons |

Advantages of synthetic, engineered adsorbents:
1) Versatility — high adsorption capacity for a wide variety of organics
2) Engineered distribution of pores — leads to quicker contaminant desorption
3) Ease of regeneration — just need low-pressure steam

Macroporosity comprises a sizable portion of the DOWEX OPTIPORE™ Polymeric Adsorbent compared to activated carbon, and these larger pores help to facilitate more effective adsorption and desorption kinetics.
Oil appears in industrial wastewater in a number of different forms including free oil, emulsified oil, oil wet solids, and dissolved oil. One source of oily water is from the overhead distillates from refineries and chemical processors. Also, the treatment of water associated with hydraulic fracturing as a byproduct of oil and gas drilling, in particular that known as produced water, presents an opportunity to recover valuable hydrocarbons as well as to make water suitable for recycling or disposal.

**Oil Wet Solids**
This category includes oil that adheres to sediments and other particulate matter that is common in industrial wastewater or produced water. Such oily solids can be removed with TEQUATIC™ PLUS Filters.

**Free Oil**
Free oil rises rapidly to the surface of the water tank under calm conditions when the oil drops are large enough. In this case, the oil can be removed by an overflow weir in the tank and a skimmer. However, small oil droplets, a few microns in size, can be difficult to remove in this manner.

**Emulsified Oil**
Oil can be mixed with water as an emulsion due to shear that can result from travelling through a pump, splashing into a tank, or anything that will break up and disperse larger oil drops. Mechanically emulsified oil is stabilized by electrical charges and other forces that result in droplets with varying size from single-digit microns up to hundreds of microns. The smallest droplets, especially, can be very difficult to remove with conventional mechanical techniques, but this emulsified oil can be removed by coalescing and decanting, using an ion exchange resin bed containing AMBERLITE™ ROC110 Resin.

Key features of this packed bed oil removal system include:
- No chemical addition of coagulants
- Continuous operation
- Systems can be designed for up-flow or down-flow operations
- No regeneration of the resin
- Tolerant of elevated temperatures that are beneficial for processing heavy oils
- Very long resin lifetime

Emulsified oil can also coat suspended solids. TEQUATIC™ PLUS Filters can help remove oily solids down to 15 µm in a convenient, self-cleaning filter.

**Dissolved/Water-Soluble Oil**
Dissolved oils are the water-soluble members of the oil spectrum, such as:
- Benzene, ethylbenzene, toluene, and xylene — collectively known as “BTEX”
- Gasoline range organics (GROs) — typically, C6 – C12 compounds
- Diesel range organics (DROs) — typically, C10 – C28 compounds
- Total petroleum hydrocarbons (TPH)
- Phenols and naphthenic acids

These compounds are uncharged carbon-containing compounds that lack an “ionic handle” so they must be removed by adsorption. DOWEX OPTIPORE™ and AMBERLITE™ XAD™ Polymeric Adsorbents can effectively remove a wide variety of these organic compounds.

**Applications:**
- Hydrocarbon production: produced water
- Hydrocarbon transportation: ballast water, BTEX associated with methane-hydrate inhibition
- Hydrocarbon refinery: crude oil desalter, process water condensate
- Chemical process industry
- Oily waste treatment in the food industry
- Other processes where oil and water are mixed

### Solids, Suspended Oil, and Dissolved Oil Removal

<table>
<thead>
<tr>
<th>Product</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEQUATIC™ PLUS Filters</td>
<td>Removal of high concentration of solids, including those in the presence of oil or oily feed streams</td>
</tr>
<tr>
<td>AMBERLITE™ ROC110 Ion Exchange Resin</td>
<td>Removal of emulsified oil with a modified ion exchange resin</td>
</tr>
<tr>
<td>DOWEX OPTIPORE™ L493 Polymeric Adsorbent</td>
<td>Adsorption of BTEX and dissolved hydrocarbons using a high surface area adsorbent with significant microporosity</td>
</tr>
<tr>
<td>DOWEX OPTIPORE™ LS503 Polymeric Adsorbent</td>
<td>Removal of BTEX and dissolved hydrocarbons using a larger-bead adsorbent with high surface area and significant porosity</td>
</tr>
<tr>
<td>AMBERLITE™ XAD™4 Polymeric Adsorbent</td>
<td>Good loading and excellent kinetics using a large mesopore volume adsorbent</td>
</tr>
<tr>
<td>AMBERLITE™ XAD™16 Polymeric Adsorbent</td>
<td>Effective adsorption of organics from liquid or vapor streams using a large mesopore volume</td>
</tr>
</tbody>
</table>
Aromatic & Phenolic Compound Removal from Industrial Effluents

Many of the materials produced by the phenol industry are toxic and cannot be discharged without treatment. Current treatment processes usually involve biological degradation, chemical oxidation or adsorption on activated carbon. Sensitive to operating conditions, these processes can perform inconsistently and destroy the product. Because organic concentrations in wastewater tend to be high (1 – 5%), especially for phenol, recovery of that organic waste can result in substantial cost savings.

Benzene and Cumene
Both benzene and cumene are very easily removed from wastewater using DOWEX OPTIPORE™ L493 and AMBERLITE™ XAD™4 Polymeric Adsorbents. In a properly designed system, leakage of benzene is less than 1 ppm. Regeneration of the resin can be accomplished with a solvent such as ethanol, acetone, or steam.

Phenol
AMBERLITE™ XAD™4 and DOWEX OPTIPORE™ L493 Polymeric Adsorbents are in use in several locations around the world to remove phenol from wastewater. Concentrations of phenol as high as 20,000 ppm have been effectively treated. The resin’s capacity to treat phenol escalates with increasing phenol concentration. Regeneration of the resin is accomplished with a wash of 0.5% sodium hydroxide or solvents such as acetone, methanol, formaldehyde, or steam. Acetone is frequently used since most phenol plants also produce acetone.

Natural Organic Matter (NOM) Removal
Natural Organic Matter (NOM) is found in many surface water sources and is the by-product of decay of organic materials such as plant matter. In its natural state, NOM poses no specific health risk, although it can give water a yellow to brown tint that can be an aesthetic issue. However, when hypochlorite and chloramines are used as disinfecting agents, these oxidants can react with NOM to generate regulated compounds called Disinfection By-Products (DBPs). Removing NOM reduces DBPs (i.e., trihalomethane formation potential – THMFP) and reduces the required amounts of disinfectant.

Bisphenol A
AMBERLITE™ XAD™4 and DOWEX OPTIPORE™ L493 Polymeric Adsorbents have been shown to be effective in removing BPA from wastewater. Regeneration can be achieved using a solvent such as acetone or methanol. Acetone is most commonly used since it is readily available and the BPA/acetone washings can be recycled back into the reactor. Steam is also an effective regenerant for DOWEX OPTIPORE L493.

Alkylphenols/Naphthenic Acid
Alkylphenols can be removed from wastewater with AMBERLITE™ XAD™4 and DOWEX OPTIPORE Polymeric Adsorbents. However, since these phenols usually contain large organic side chains, the larger pores of a polymeric adsorbent such as AMBERLITE XAD16 might be more effective. A protic solvent such as methanol, ethanol, acetone, or isopropyl alcohol is usually employed for regeneration.

Emulsified Oil
In some cases, there might be a need to remove emulsified oil in a chemical process. Refer to Page 9 for more information.

Applications:
- Petrochemical industry wastewater treatment: recovery of hydrocarbons and compliance with disposal limits
- Metallurgy: workshop waste for certain metals
- Plastics and other chemical manufacturing
- Wash water

<table>
<thead>
<tr>
<th>Aromatic and Phenolic Compounds Removal</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEQUATIC™ PLUS Filters</td>
<td>Removal of high concentration of solids, including those in the presence of oil or oily feed streams</td>
</tr>
<tr>
<td>AMBERLITE™ ROC110 Ion Exchange Resin</td>
<td>Removal of emulsified oil with a modified ion exchange resin</td>
</tr>
<tr>
<td>DOWEX OPTIPORE™ L493 Polymeric Adsorbent</td>
<td>Adsorption of BTEX and dissolved hydrocarbons using a high surface area adsorbent with significant microporosity</td>
</tr>
<tr>
<td>DOWEX OPTIPORE™ L503 Polymeric Adsorbent</td>
<td>Removal of BTEX and dissolved hydrocarbons using a larger-bead adsorbent with high surface area and significant porosity</td>
</tr>
<tr>
<td>AMBERLITE™ XAD™4 Polymeric Adsorbent</td>
<td>Good loading and excellent kinetics using a large mesopore volume adsorbent</td>
</tr>
<tr>
<td>AMBERLITE™ XAD™16 Polymeric Adsorbent</td>
<td>Effective adsorption of organics from liquid or vapor streams using a large mesopore volume</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types of Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOM is addressed in water compositions most commonly as COD, KMnO₄ and TOC. There is no fixed conversion factor between these components. In calculating the size of resin scavenger systems, the Permanganate Value (PV) is most commonly used. Guidelines are available to convert to the PV in case this value is not directly available (refer to Dow’s Answer Center at <a href="http://www.dowwaterandprocess.com">www.dowwaterandprocess.com</a>).</td>
</tr>
</tbody>
</table>
**Effect of NOM on Downstream IX and RO Systems**

In resin applications, (natural) organic components in the water pose a risk to the installed anion resin of the demineralization unit as the organic components can foul the resin. Fouling means that the organic components removed from the water are not effectively eluted from the resin during regeneration and, therefore, accumulate. Fouling is one of the most common causes for resin performance loss and, as a consequence, an increase of water production cost.

The organics in the feedwater can also compromise the reverse osmosis (RO) performance due to organic fouling and/or biofouling. A reduction of organic species in the feedwater will facilitate the operational reliability of RO systems, reducing the cleaning frequency and subsequent chemical cost.

**Available Solutions**

A scavenger is a resin technology designed to remove the organic species from the water and, therefore, decrease the organic fouling potential of the water. The removal mechanism is based on a combination of adsorptive and exchange mechanics that are determined by the composition of the organics and the operational circumstances.

NOM can also be effectively removed by nanofiltration or reverse osmosis. However, the circumstances to which the membrane is subjected needs careful assessment. Under challenging circumstances the membrane can suffer from bio and/or organic fouling and create operational difficulties such as high cleaning frequency and reduced membrane lifetime. In such cases a resin scavenger can be used as a membrane protector.

Scavengers can be used as fixed bed technology preceding a resin or membrane treatment system to remove the bulk of organics, but they can also be used as a post-system polisher.

**Applications:**

- Sacrificial protector for selective resins
- (Industrial) wastewater reuse
- Cooling tower blowdown
- Demineralization

Resin selection, system requirements and operating conditions will differ as NOM is water source specific with respect to the molecular weight and characteristics like hydrophobicity of the organic matter. Please consult with your Dow Technical Service Representative when considering NOM removal with anion resins.

---

**From Conventional Scavengers…**

For those interested in maintaining an existing system with conventional scavenger resins…

Dow offers a range of state-of-the-art resin products for NOM removal. They are designed to effectively remove organics from the water under different operational circumstances, bringing your water quality and operational stability back in your control.

Conventional scavengers can be applied for the bulk removal of organics. In these systems highly fouling-resistant strong base anion (SBA) resins are used. Strong base anion exchange resins have a significant affinity for NOM and can result in its reduction by 50 – 80%. Once SBA scavenger resins reach their maximum load of organics, they require regeneration to remove the adsorbed organics. SBA resins are typically regenerated with an (alkaline) brine solution. This type of technology is applied for waters with neutral to alkaline pH.

**…to Innovative Scavengers**

For those interested in reducing cost either by retrofitting an existing system or installing a new system with an innovative scavenger…

Dow has developed two resins to remove NOM under acidic feedwater conditions. These resins maximize adsorption and remove organic species effectively, while also eluting them under mild regeneration circumstances. This makes the technology highly cost-effective and also reduces waste volume and waste composition to a large extent. Unlike the conventional resin technology, this technology offers flexibility in operational, quality, and cost management.

Advantageous features of this innovative scavenger technology include:

- Implementation of this resin technology can be applied as a standalone unit or fully integrated in an ion exchange demineralization system. When it is fully integrated, the system will reduce the operational downtime for regeneration, thereby maximizing the net production capacity of the water treatment system.
- It can be operated in two different modes enabling the opportunity to maximize the NOM removal when desired or as circumstances dictate.
- The standard regeneration no longer requires (alkaline) brine solution and enables the opportunity to reuse excess chemicals for regeneration; this feature can reduce OPEX up to 80% compared to conventional (alkaline) brine regeneration.
- This technology can be fitted in existing scavenger systems.

---

**Natural Organic Matter Removal**

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Features</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOWEX™ TAN-1</td>
<td>Styrenic, ultra-macroporosity, extra high water content for effective loading and desorption of organics</td>
<td>Removal of large, complex, hydrophobic NOM and color species (such as humic and fulvic components) and general polishing of organics remaining after bulk removal at neutral to alkaline pH</td>
</tr>
<tr>
<td>AMBERLITE® IRA958</td>
<td>Acrylic, macroporous, easy regeneration</td>
<td>Removal of high load hydrophilic and hydrophobic NOM at neutral to alkaline pH, with excellent resin lifetime and long, stable performance</td>
</tr>
<tr>
<td>AMBERLITE® IRA900</td>
<td>Styrenic, high removal capacity, high chemical and thermal stability</td>
<td>Removal of high load hydrophobic (aromatic-based) NOM requiring acidic, neutral, or alkaline pH</td>
</tr>
<tr>
<td>DOW™ XUS-TOCSCV-1</td>
<td>Easy regeneration, flexible operation</td>
<td>Removal of hydrophobic and hydrophilic NOM species for high free mineral acidity (FMA) waters at acidic pH</td>
</tr>
<tr>
<td>DOW™ XUS-TOCSCV-2</td>
<td>Easy regeneration, flexible operation</td>
<td>Removal of high load hydrophilic and hydrophobic NOM for low free mineral acidity waters at acidic pH</td>
</tr>
</tbody>
</table>
Chromium is commonly found in process and waste solutions in either the Cr\(^{3+}\) or the Cr\(^{6+}\) oxidation states. Sources of chromium include wastes from chromium-plating operations, and it has been used in other industrial applications. While trivalent chromium (Cr\(^{3+}\)) is not considered to be as harmful as the toxic hexavalent chromium (Cr\(^{6+}\)), both are receiving attention from regulators.

### Chromate Removal

If the chromium ion to be removed from the wastewater stream is in the +3 oxidation state, then it typically behaves as a cation, so a cation exchange resin, either gel (DOWEX\(^{\circledR}\) G-26 H Resin) or macroporous (AMBERLYST\(^{TM}\) 16WET Polymeric Catalyst) is recommended.

However, if the chromium is in the +6 oxidation state, there can be two different forms of Cr(VI), depending on pH. Above pH 6, Cr(VI) is present as the yellow (CrO\(_4\))\(^{2-}\) chromate ion, and between pH 2 and pH 6 it is present as orange (Cr\(_2\)O\(_7\))\(^{2-}\) dichromate. If the ion in solution is dichromate, the resin can load more chromium; therefore, it is advisable to keep the pH below 6.

Two approaches can be considered for removing Cr(VI):

1) SBA alone: Cr\(^{6+}\) is likely in the form of an oxyanion, which can be removed by a strong base anion exchange resin such as DOWEX\(^{TM}\) 21K XLT Resin.

2) SAC – WBA (→ SAC): Convert Cr\(^{6+}\) to Cr\(^{3+}\) (in the form of chromic acid) with a macroporous strong acid cation resin and then subsequently remove the chromic acid with a weak base anion resin. This arrangement is normally used for the recovery of chromate from plating waste. A variation includes a third column with another SAC resin which is used in the H-form to treat the effluent from the WBA, converting sodium chromate into a relatively concentrated chromic acid, which can be reused.

### Applications:
- Metal plating
- Industrial waste (explosives, pigments, etc.)

### Ion Exchange Resin

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOWEX(^{TM}) G-26 H</td>
<td>Removal of Cr(^{3+}) with gel resin</td>
</tr>
<tr>
<td>AMBERLYST(^{TM}) 16WET</td>
<td>Removal of Cr(^{3+}) with macroporous resin</td>
</tr>
<tr>
<td>AMBERLYST(^{TM}) 4400 or DOWEX(^{TM}) 21K XLT</td>
<td>Removal of Cr(^{6+}) using the one-step process</td>
</tr>
<tr>
<td>AMBERLYST(^{TM}) 16WET + AMBERLYST(^{TM}) A21</td>
<td>Removal of Cr(^{6+}) using the two-step process</td>
</tr>
</tbody>
</table>
Heavy Metals Removal

Because individual manufacturing facilities can produce their own unique combination of metal wastes, the ion exchange removal process will be site specific. To learn more about the best solution for your facility, contact your local Dow representative.

Many of these metals can be selectively removed from solution with chelating resins like AMBERSEP™ IRC748i Resin, AMBERSEP™ GT74 Resin, or DOW™ XUS 43600.00 Developmental Thiouronium Resin.

In metal-working operations, acid baths can be used to brighten metal finishes resulting in accumulation of some metals in the acid. Disposal of the acid would require neutralization, which can be very expensive. Another approach is the use of an anion exchange resin, such as AMBERSEP™ 4400 Cl Resin or DOWEX™ 21K XLT Resin, to remove the halo-metal complexes which can form under certain acidic conditions, as illustrated on the figure below.

Halo-metal anion complexes are effectively removed from solution with a strong base resin or a weak base resin. Optimal resin selection may be dependent on additional factors, such as overall water composition or loading with organic content.

Applications:
- Metal plating
- Process water recycling
- Industrial wastewater treatment
- Other discharge limitations

### Heavy Metals Considered in this Section

- Gallium (Ga)
- Antimony (Sb)
- Germanium (Ge)
- Thallium (Tl)
- Cadmium (Cd)
- Lead (Pb)
- Indium (In)
- Bismuth (Bi)
- Tin (Sn)

Other heavy metals could be the subject of other sections within this document.

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBERSEP™ IRC748i</td>
<td>Selective removal with an iminodiacetic acid chelating resin</td>
</tr>
<tr>
<td>AMBERSEP™ GT74</td>
<td>Selective removal with a thiol resin</td>
</tr>
<tr>
<td>DOW™ XUS 43600.00</td>
<td>Selective removal with a thiouronium resin</td>
</tr>
<tr>
<td>AMBERSEP™ 4400 Cl or DOWEX™ 21K XLT</td>
<td>Removal of metals forming an anionic complex</td>
</tr>
<tr>
<td>AMBERLITE™ IRA958 or DOWEX MARATHON™ MSA</td>
<td>Removal of metals forming an anionic complex in streams with high organic content</td>
</tr>
<tr>
<td>AMBERLYST™ A21 or AMBERLYST™ A24</td>
<td>Removal of metals forming an anionic complex with easier regeneration</td>
</tr>
<tr>
<td>AMBERLYST™ 16</td>
<td>High oxidative stability with a macroreticular strong acid cation exchanger</td>
</tr>
</tbody>
</table>
Nitrate salts are common agricultural fertilizers and are produced naturally during the decomposition of organic matter. As a pollutant, increased nitrate levels in aquatic ecosystems lead to algal blooms and accelerated eutrophication. Extensive use of nitrate fertilizers in the agricultural sector and wastewater produced from livestock farms are among the main sources for aquatic contamination with nitrates.

In order to treat wastewater to prevent aquatic contamination, nitrogen-containing compounds such as nitrate, nitrite, amines, and ammonia can be removed in different manners, depending on its form, according to the table below.

Dow has developed a special nitrate-selective resin for dealing with waters containing nitrate in the presence of other anions such as sulfate.

**Applications:**
- Agriculture
- Water remediation

### Nitrate Removal

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBERLYST™ A21</td>
<td>Nitrate anion present under acidic conditions</td>
</tr>
<tr>
<td>DOWEX™ 2.1K XLT</td>
<td>Nitrate anion present as a salt</td>
</tr>
<tr>
<td>DOWEX MARATHON™ A2</td>
<td>Anion present as a salt, with easier regeneration</td>
</tr>
<tr>
<td>DOWEX™ MAC-3</td>
<td>Ammonia in the free-base form</td>
</tr>
<tr>
<td>DOWEX™ G-26 H</td>
<td>Ammonia as a salt or cationic amines</td>
</tr>
<tr>
<td>AMBERLITE™ PWA5</td>
<td>Groundwater remediation when SO$_4^{2-}$/NO$_3^-$ ratio &gt; 1 using a regenerable nitrate-selective resin</td>
</tr>
</tbody>
</table>

### Cyanide Removal

Cyanide is well-known as an extremely toxic anion. The WHO guideline for drinking water is 0.07 mg/L (70 µg/L).

Cyanide can be found in wastewater in two forms.

1) Cyanide makes stable anionic complexes with heavy metals such as iron, nickel, and copper. These complexes, typically hexacyanoferrate (also called ferrocyanide), are removed from wastewater with an ion exchange process that uses an acrylic strong base anion exchanger – AMBERLITE™ IRA958 Cl Resin.

2) In “free” or ionizable cyanide, such as hydrogen cyanide (HCN) or potassium cyanide (KCN), anion exchange resins have little affinity for the cyanide ion. As a result, free cyanide cannot be removed selectively, but only together with all other anions in a complete demineralization system. However, ferrous sulfate (FeSO$_4$) can be added to the wastewater to convert any free cyanide into cyanoferrate, which can be removed as stated above.

**Applications:**
- Gold mining
- Metal plating

### Cyanide Removal

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBERLITE™ IRA958 Cl</td>
<td>Cyanide anionic complexes</td>
</tr>
</tbody>
</table>
Perchlorate Removal

Perchlorates (ClO$_4^-$) are man-made inorganic chemicals used in munitions and rocket propellants. They are highly soluble in water so they can be widely found in groundwater due to their high mobility. Once dispersed, ClO$_4^-$ can remain in the environment for decades as it does not readily degrade. While the acute toxicity of perchlorate is low, when ingested, it mimics iodide in the body and lodges in the thyroid gland, impacting health over the long term. DOWEX™ PSR-2 Resin can be used as a non-regenerated media to bind and remove ClO$_4^-$ at the ppb levels.

Because of its high selectivity for perchlorate over typical ions in ground water including chloride and sulfate, DOWEX PSR-2 can operate successfully for long periods of time. Disposal of the single-use exhausted resin media usually is done via incineration of the perchlorate-loaded resin at an approved disposal facility.

**Applications:**
- Ground water remediation
- Pyrotechnics production

### Perchlorate Removal

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOWEX PSR-2</td>
<td>Selective removal of perchlorate</td>
</tr>
</tbody>
</table>

Boron Removal

Sometimes mildly toxic to humans and often very toxic to plants, especially citrus varietals, boron is regulated in most regions of the world. Boron is a natural element prevalent in ground water from areas with volcanic geology, and is commonly found in deposits of coal and other fossil fuels. Industrially, boron is used in the manufacture of commercial products such as detergents, ceramics, and semiconductors.

Dow Water & Process Solutions manufactures AMBERLITE® IRA743 Resin, a boron-selective weak base anion resin that is regenerable with a two-step procedure that uses acid and base, to help meet discharge or product requirements. In coal-fired power plants, AMBERLITE IRA743 has been demonstrated for the treatment of boron found in flue gas desulfurization wastewater; additional trials have demonstrated its utility for treatment of elevated boron levels in produced water from hydraulic fracturing.

**Applications:**
- Ceramics
- Flue gas desulfurization
- Produced water
- Other discharge limitations

### Boron Removal

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBERLITE IRA743</td>
<td>Selective removal of boron</td>
</tr>
</tbody>
</table>
Selenium can exist in solution in a number of different forms, which can complicate its removal from solution. Selenium species most frequently associated with aqueous systems are Se⁴⁺ and Se⁶⁺ valence states, which typically present themselves as selenite (SeO₃²⁻) and selenate (SeO₄²⁻), respectively. The partially-reduced selenite form is readily removed from solution using a variety of different technologies, including ion exchange, adsorption, biological reduction, and coagulation/precipitation techniques. The oxidized selenate form is more difficult to remove as it does not respond as well to chemical reduction or adsorption. While ion exchange is a technical solution for removal of both selenate and selenite, this is often complicated by the presence of other anions such as sulfate at concentrations which are higher by orders of magnitude.

To this end, general removal of anions using a strong base anion resin like AMBERSEP™ 4400 Cl Resin or DOWEX™ 21K XLT Resin can be employed. Here the resin will remove all of the anions along with the Se.

### Selenium Removal

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBERSEP™ 4400 Cl or DOWEX™ 21K XLT</td>
<td>Non-selective removal of selenium</td>
</tr>
<tr>
<td>AMBERSEP™ 34</td>
<td>Selective removal of selenium</td>
</tr>
</tbody>
</table>

When a selective product is preferred, AMBERSEP™ 34 Resin has been specially engineered to have a high selectivity for selenate and selenite anions so that they can be removed in the presence of much higher concentrations of competing anions such as sulfate. These resins will remove selenium species over a broad range of water pH, and can be regenerated using either acid or caustic. These resins have been demonstrated to remove selenium from a variety of different wastewaters from various applications in the (coal) power, refinery, and mining industries.

### Applications:
- Mining: tailings pond water
- Refinery: wastewater
- Power: coal pile runoff
- Other discharge limitations

Radium is found in uranium and (to a lesser extent) thorium ores in trace amounts. Radium is of concern in mining applications. In uranium mining, radium is dealt with by direct barium precipitation techniques. These processes require equipment which takes up a lot of space and generates large quantities of sludge that must be further treated. Dow produces a distinct ion exchange product named DOWEX® RSC Resin that is extremely effective at removing radium. DOWEX RSC does not remove other hardness ions. The resin is not regenerable and it concentrates the radium into a small volume for economical disposal.

DOWEX RSC can also be used to remove radium from waste brine from non-selective softening operations.

Before use, please check local regulations for use and disposal.

### Applications:
- Remediation of mine tailings (trace contaminant removal)

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOWEX® RSC</td>
<td>Removal of radium</td>
</tr>
</tbody>
</table>
Uranium is found widespread in nature, occurring in granites and various other mineral deposits. It is used mainly as a fuel in nuclear reactors. Uranium is present in the environment as a result of leaching from natural deposits, release in mill tailings, the combustion of coal and other fuels, and the use of phosphate fertilizers that might contain uranium. Circumstances in which uranium is present in a drinking water source have been known and uranium even occurs naturally in seawater.

Much of the world’s mined uranium is produced via in situ leach (ISL) processes, in which uranium is leached from ore bodies via carbonate or sulfate lixiviants and pumped to the surface in liquid form. Uranium is recovered from this pregnant leach solution (PLS) directly using anion exchange. For this purpose DOWEX™ 21K XLT and AMBERSEP™ 4400 Cl Anion Resins are very effective products with broad adoption in the mining industry.

Uranium recovery from highly concentrated liquors (> 100 mg/L) is a well-developed process, but treating concentrations in the low ppm and µg/L range was very difficult based on existing resin technology. In order to enable treating low concentrations, a novel resin type – polyphenol impregnated anion resin (patent WO2014126699) – was developed and tested for removal of U in the presence of other metals. This resin has demonstrated very good performance (no leakage from 1 ppm uranium feed after 1000 bed volumes of throughput), and is a robust performer across a wide range of solution pH and ionic strength. This innovative product could be applicable in treating contaminated water from active and depleted mine sites prior to disposal.

Other resins (strong base anions or chelating resins) are also available for treating uranium-containing streams, depending on the concentration of uranium and/or ionic background of the solution. Contact your Dow expert for more information.

Applications:
- Uranium mining
- Power industry
- Agriculture

### Uranium Removal

<table>
<thead>
<tr>
<th>Ion Exchange Resin</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOWEX™ 21K XLT or AMBERSEP™ 4400 Cl</td>
<td>Removal of uranium</td>
</tr>
<tr>
<td>Polyphenol impregnated experimental anion resin</td>
<td>Removal of uranium at the low ppm and µg/L range</td>
</tr>
</tbody>
</table>
Mercury Removal

An extremely toxic metal, mercury pollution is under increased scrutiny and is being regulated to extremely low levels in waste and discharge water. For example in the Great Lakes of North America, the discharge limit is 0.7 parts per trillion and other regions have similarly low levels. In spite of its toxicity and persistence as a pollutant, mercury still plays important roles in industry. Mercury is used in some chlor-alkali brine applications, and was once a common ingredient in such household products as fluorescent lights and paints, and in medical devices such as thermometers and dental amalgams.

Mercury is a very reactive molecule that can exist in multiple forms – the most common forms include the volatile zero-valent Hg(0), the charged ion Hg^2+, and organo-mercury compounds such as methyl mercury. Because it is so reactive, mercury can also form colloidal complexes with other ions that require removal by ultrafiltration. Many Dow technologies can be used for the removal of mercury from wastewater, depending on the state of the mercury that is present; for instance,

- DOW™ Ultrafiltration SFP Modules can effectively remove colloidal particles that contain mercury.
- DOWEX OPTIPOR™ L493 Polymeric Adsorbent can adsorb Hg(0) and organo-mercury complexes.
- AMBERSEP™ GT74 and DOW™ XUS 43600.00 Chelating Resins can effectively remove ionic mercury to reach sub-ppb discharge requirements.

Since multiple forms of mercury can be present in the same stream, multiple removal techniques may need to be employed in series. Contact your Dow expert for more information.

Applications:
- FGD blowdown and ash ponds
- Chlor-alkali brine (protection of membrane cell processes)
- Environmental remediation of mercury

<table>
<thead>
<tr>
<th>Product</th>
<th>Best For</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOWEX OPTIPOR™ L493 Polymeric Adsorbent</td>
<td>Hg(0) and organo-mercury</td>
</tr>
<tr>
<td>AMBERSEP™ GT74 Ion Exchange Resin</td>
<td>Ionic mercury</td>
</tr>
<tr>
<td>DOW™ XUS 43600.00 Ion Exchange Resin</td>
<td>Ionic mercury</td>
</tr>
<tr>
<td>DOW™ Ultrafiltration SFP Modules</td>
<td>Colloidal complexes containing mercury</td>
</tr>
</tbody>
</table>

Global Presence

With a large global manufacturing footprint, strong R&D expertise and technical support services and systems, we supply market-leading volumes with high quality. Dow partners with you, our customer, to understand unmet needs and develop tailored solutions.

Research & Development
Chauny, France*
Collegeville, PA*
Edina, MN*
Huzhou, China
Kaust Jeddah, KSA*
Midland, MI*
Shanghai, China*
Tarragona, Spain**

Commercial Operations
Astana, Kazakhstan
Bangkok, Thailand
Budapest, Hungary
Dubai, UAE
Horgen, Switzerland
Johannesburg, South Africa
Kuala Lumpur, Malaysia
Moscow, Russia
Mumbai, India
Nairobi, Kenya
Rheinmünster, Germany
São Paulo, Brazil
Seoul, Korea
Sydney, Australia
Tokyo, Japan
Warsaw, Poland

Manufacturing
Chauny, France
Edina, MN
Fombo, Italy
Huzhou, China
Jubail Industry City, Saudi Arabia
Menlo Park, CA
Midland, MI
Qingpu, China
Soma, Japan
Stade, Germany

*DW&PS Technology Center
**Global Water Technology Center
Dow is the largest manufacturer of reverse osmosis membranes and ion exchange resins worldwide. Our comprehensive product line, technical expertise, and global reach allow for optimized performance of even complex wastewater problems, helping you move towards the goals of a circular economy. With continuous investment in product innovation and manufacturing excellence, we have global expertise in serving multiple markets across the industry.

Dow products consistently offer:
• **Reliability** – capital investment in worldwide production facilities to supply increasing global demand and offer leading quality, global service, and support.
• **Value** – products designed for applications that lower operating costs, increase throughput and yield, and help you meet discharge requirements.
• **Innovation** – R&D focused on delivering innovative performance products.

**Dow Expertise**

**DOW DIRECTOR℠ Services**
Dow has unparalleled expertise to solve tough separation problems. On the phone and in the laboratory, we can help. We are here to listen to your separation need and help you select the right product. Wastewater can present different challenges depending on the source; if you need a feasibility study, Dow offers DIRECTOR℠ Services to test your water with our products.
WARNING: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

NOTICE: No freedom from infringement of any patent owned by Dow or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other government enactments. The product shown in this literature may not be available for sale and/or available in all geographies where Dow is represented. The claims made may not have been approved for use in all countries. Dow assumes no obligation or liability for the information in this document. References to “Dow” or the “Company” mean the Dow legal entity selling the products to Customer unless otherwise expressly noted. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED. All information set forth herein is for informational purposes only. This information is general information and may differ from that based on actual conditions. Please note that physical properties may vary depending on certain conditions and while operating conditions stated in this document are intended to lengthen product lifespan and/or improve product performance, it will ultimately depend on actual circumstances and is in no event a guarantee of achieving any specific results. Nothing in this document should be treated as a warranty by Dow. These resins may be subject to drinking water application restrictions in some countries. Please check the application status before use and sale.

NOTICE: If products, such as DOW™ XUS products, are described as “experimental” or “developmental”: (1) product specifications may not be fully determined; (2) analysis of hazards and caution in handling and use are required; (3) there is greater potential for Dow to change specifications and/or discontinue production; and (4) although Dow may from time to time provide samples of such products, Dow is not obligated to supply or otherwise commercialize such products for any use or application whatsoever.

Innovation to Meet Future Customer Needs

The Dow research and development process starts with you. We proactively communicate with our customers and listen for unmet needs. Our goal is to develop products that help lower your cost of production and offer the most economical approach to new and/or difficult separations.

Dow’s commitment is demonstrated through our multiple research and product development centers around the world. These technology centers have delivered innovative new technologies. See below for a timeline of some of our most significant breakthroughs over the past 60+ years.

1950
First commercial synthesis of styrene-based weakly basic anion exchanger (AMBERLITE™ IRA45 Resin).

1953
Rohm and Haas develops acrylic-based weakly basic anion exchange resin (AMBERLITE™ IRA67 Resin).

1951
First use of ion exchange resins for treatment of sugar.

1959
Rohm and Haas discovery of macroporous ion exchange resins.

1961
Rohm and Haas introduces macroporous (macroporous) ion exchange resins for use as catalysts.

1965
New macroporous polymeric adsorbents (AMBERLITE™ XAD™2, XAD4, etc.) introduced.

1974
First commercial use of boron-specific resin (AMBERLITE™ IRA743 Resin, methyl-glucamine).

1990
The Dow Chemical Company introduces DOWEX OPTIPURE™ SD-2 Adsorbent Resin.

1952
First commercial use of anion exchange resins for recovery of uranium from leach liquor.

1988
The Dow Chemical Company introduces uniform particle size DOWEX MONOSPHERE™ Resins. An industry leap forward.

2009
The Dow Chemical Company merges with Rohm and Haas, creating an industry-leading separations and purifications company.

1988
The Dow Chemical Company introduces DOWEX MONOSPHERE™ 77 Weak Base Anion Resin to enable a lower deashing OPEX.

1950
Development of ion exchange resins in powdered form for sodium reduction therapy.

1951
First use of ion exchange resins for treatment of sugar.

1953
Rohm and Haas develops acrylic-based weakly basic anion exchange resin (AMBERLITE™ IRA67 Resin).

1959
Rohm and Haas discovery of macroporous ion exchange resins.

1961
Rohm and Haas introduces macroporous (macroporous) ion exchange resins for use as catalysts.

1965
New macroporous polymeric adsorbents (AMBERLITE™ XAD™2, XAD4, etc.) introduced.

1974
First commercial use of boron-specific resin (AMBERLITE™ IRA743 Resin, methyl-glucamine).

1990
The Dow Chemical Company introduces DOWEX OPTIPURE™ SD-2 Adsorbent Resin.

2003
The Dow Chemical Company introduces DOWEX MONOSPHERE™ 99/310 Chromatography Resin for improved separations.

1996
The Dow Chemical Company introduces DOWEX MONOSPHERE™ 77 Weak Base Anion Resin to enable a lower deashing OPEX.

1951
First use of ion exchange resins for treatment of sugar.

1953
Rohm and Haas develops acrylic-based weakly basic anion exchange resin (AMBERLITE™ IRA67 Resin).

1959
Rohm and Haas discovery of macroporous ion exchange resins.

1961
Rohm and Haas introduces macroporous (macroporous) ion exchange resins for use as catalysts.

1965
New macroporous polymeric adsorbents (AMBERLITE™ XAD™2, XAD4, etc.) introduced.

1974
First commercial use of boron-specific resin (AMBERLITE™ IRA743 Resin, methyl-glucamine).

2003
The Dow Chemical Company introduces DOWEX MONOSPHERE™ 99/310 Chromatography Resin for improved separations.

1996
The Dow Chemical Company introduces DOWEX MONOSPHERE™ 77 Weak Base Anion Resin to enable a lower deashing OPEX.

Water & Process Solutions
7600 Metro Blvd.
Edina, MN 55439

For more information, contact our Customer Information Group: dowwaterandprocess.com
Asia Pacific +86 21 3851 4988
Europe, Middle East, Africa +31 115 672626
Latin America +55 11 5184 8722
North America 1-800-447-4369

WARNING: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

NOTICE: No freedom from infringement of any patent owned by Dow or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other government enactments. The product shown in this literature may not be available for sale and/or available in all geographies where Dow is represented. The claims made may not have been approved for use in all countries. Dow assumes no obligation or liability for the information in this document. References to "Dow" or the "Company" mean the Dow legal entity selling the products to Customer unless otherwise expressly noted. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.

All information set forth herein is for informational purposes only. This information is general information and may differ from that based on actual conditions. Please note that physical properties may vary depending on certain conditions and while operating conditions stated in this document are intended to lengthen product lifespan and/or improve product performance, it will ultimately depend on actual circumstances and is in no event a guarantee of achieving any specific results. Nothing in this document should be treated as a warranty by Dow. These resins may be subject to drinking water application restrictions in some countries. Please check the application status before use and sale.

NOTICE: If products, such as DOW™ XUS products, are described as "experimental" or “developmental”: (1) product specifications may not be fully determined; (2) analysis of hazards and caution in handling and use are required; (3) there is greater potential for Dow to change specifications and/or discontinue production; and (4) although Dow may from time to time provide samples of such products, Dow is not obligated to supply or otherwise commercialize such products for any use or application whatsoever.

Printed in the U.S.A
™ Trademark of The Dow Chemical Company (“Dow”) or an affiliated company of Dow
Form No. 177-03571, Rev.0 CDP
May 2016