SolmeteX™ The Power of Applied Science™

ArsenX^{np} Capabilities & Technical Specifications

50 Bearfoot Road • Northborough, MA 01532 • Phone: 508-393-5115 • Fax: 508-393-1795 • Web: www.solmetex.com

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1.0 Capabilities

1.1 ArsenX^{np} Description

ArsenX^{np} is a nanoparticle-based selective resin designed to remove arsenic (arsenate and arsenite) from water. **ArsenX^{np}** combines a unique chemistry based on hydrous iron oxide nanoparticles with a very high affinity for arsenic and a very durable polymer substrate. This ideal combination of selectivity and substrate durability mean that **ArsenX^{np}** can effortlessly reduce arsenic to safe consumption levels.

The high iron surface area generated by nanoparticles provides great capacity, a strong affinity and rapid absorption kinetics for arsenic. The impregnation of the iron oxide nanoparticles into a polymer substrate provides excellent durability creating a product that is not only easy to use but is also regenerable. That means **ArsenX^{np}** can be reused many times, significantly reducing your cost of treatment.

1.2 The Arsenic Problem

When the EPA lowered the MCL for arsenic from 50 µg/l to 10 µg/l, it placed over 4,000 municipal drinking water treatment systems across the nation in jeopardy. These systems would be out of compliance with this new standard and the technology required to meet the new standard would be unaffordable for many communities. Even more dramatic would be the cost of safety for the individual homeowner whose well water is above the new arsenic standard. There are estimates indicating that close to 14 million private homeowner wells exceed the new standard.

The available technologies that are able to remove arsenic to below 10 µg/l in drinking water come with limitations that impair their ability to be successfully deployed in the field. Ion exchange, alumina adsorbents, reverse osmosis, coagulation/filtration, lime softening, granulated iron media (GIM) and electrodialysis have demonstrated an ability to achieve the new MCL Arsenic Standard, but each has inherent problems. Ion exchange and activated alumina have very low operating capacities for arsenic, poor kinetics and poor ion selectivity. These weaknesses add to the cost and complexity of running the systems in the field. The inherent structural weakness of GIM granules increases operating costs since the product's instability makes re-use impractical. As a result the GIM must be replaced when its capacity is reached which increases operating costs. In addition, fracturing of the material during operations means that post filtration and regular backwashing must be done further complicating the operational requirements. Reverse osmosis, which can also meet the standard, requires passing the water across a membrane to "filter" out arsenic. This process is

non-selective and creates a concentrated hazardous rejectate that must be handled according to local hazardous waste regulations and also requires extensive capital investment making it uneconomic for smaller systems. The remaining technologies, precipitation/coagulation and lime softening all require filtration as a part of the process. The filtration option is expensive and creates large volumes of a hazardous sludge that must be disposed of as hazardous waste. There are no technologies available that have demonstrated an ability to reduce arsenic to the new MCL Standard of 10 µg/l that are easy to use, reliable and create no hazardous waste by-products. SolmeteX has developed a nanotechnology based absorbent, **ArsenX^{np}** that is already being used industrially to reduce arsenic to below 10 µg/l.

The current technologies in widespread use include:

Activated Alumina (AA) - The primary method for removal of arsenic from water. AA is able to reduce arsenic concentrations to less than 10 ppb but requires significant contact time due to relatively slow kinetics. Additionally, the limited amount of capacity demonstrated by AA, even with pH adjustment, is small. AA is regenerable but as is the case with regenerable systems, the user must be responsible for the regenerant waste by-products. The cost effectiveness of AA in point of use systems is questionable.

Ion Exchange - This technique is most widely used on water with low ion concentrations. Ion exchange resins have relatively low ion selectivities and bind all ions, including the toxic metals, which can be stripped from the loaded resin with strong acid/base forming a hazardous liquid waste. This method can sometimes achieve low discharge levels at the cost of expensive columns that generate large quantities of waste by-products.

Reverse Osmosis (RO) – This technique (developed for desalination of water) can achieve low arsenic levels in some cases, but with very high capital, operating and maintenance costs. Like ion exchange, it is non-selective, so non-toxic salts can interfere with the process. RO systems generate a concentrated liquid hazardous rejectate that must be handled according to local hazardous waste regulations. This makes it a very unlikely technology for point of use systems.

Coagulation/Filtration - In this technique, chemicals are placed in the influent stream to precipitate and/or absorb the contaminant which can be filtered out. The major problem with this technique is the economics of arsenic removal. Chemical consumption is high and effective filtration of the arsenic-laden precipitate requires complex filtration systems. The resultant sludge must then be disposed of according to local environmental regulations.

Granulated Iron Media (GIM) – Granular Ferric Hydroxide and Granular Ferric Oxide are absorbents that are able to remove arsenic from drinking water. They have a relatively low cost per pound but a high cost per gallon of treated water They are non-regenerable materials that must be replaced when near saturation due to their lack of structural integrity. The low durability causes attrition of absorbent granules during use and as a result, the effluent must be mechanically filtered to remove any small arsenic-

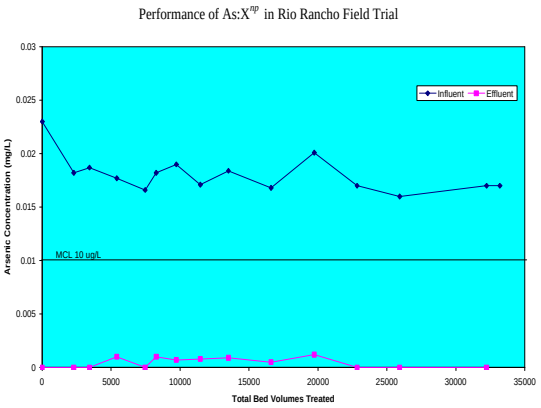
saturated particles released into the treated water. The poor structural characteristics also mean that water pressure must be reduced to prevent collapse of the granules. This adds to the capital expenditure and operating costs since water exiting the media beds must be re-pressurized.

2.0 Features

2.1 Achieve the Drinking Water Standard

ArsenX^{np} can meet the most stringent demands for water quality in terms of arsenic removal. **ArsenX^{np}** binds arsenic extremely tightly, enabling extremely low arsenic concentrations to be achieved. The material is NSF-61 compliant and has been successfully implemented in the field.

2.2 High Effective Capacity



The key parameter for resin performance is "effective capacity". Effective capacity is the loading achieved by the absorbent while maintaining the drinking water arsenic concentration below the desired level of 10 µg/l. **ArsenX^{np}** can maintain low arsenic levels longer due to very rapid absorption kinetics, tight binding and high equilibrium capacity. This graph illustrates the ability of **ArsenX^{np}** to consistently remove arsenic to below the new standard.

2.3 Substrate Morphology

The particle size distribution of **ArsenX^{np}** is 300-1200 microns, providing predictable flow and homogeneous utilization of the resin capacity The particles are spherical which, by design, provide much less turbulent flow characteristic than irregularly shaped materials and superior utilization of available arsenic binding sites. The matrix composition is a cross-linked organic polymer that provides superior crush strength under "wet" or operating conditions as opposed to inorganic compositions which tend to be fragile and difficult to scale up.

2.4 Regeneration

ArsenX^{np} can be regenerated multiple times with negligible loss of capacity using low volumes of a dilute caustic solution. SolmeteX provides a proprietary absorbent for the removal of the arsenic from the caustic that reduces the volume of liquid wastes generated and provides a solid waste that will pass TCLP. Each reuse/regeneration of

the resin lowers the overall cost of the water treatment and mitigates any long term liability common with hazardous wastes.

2.5 Ease of Use

ArsenX^{np} can be engineered and operated like standard ion exchange resins. Pre or post treatment of the influent water is normally not necessary due to the integrity of the polymer beads. Using **ArsenX^{np}** allows you to easily scale systems from small point of entry/point of use to large scale industrial/community systems. The uniformity of the product provides predictable flow characteristics ensuring operational reliability and performance.

2.6 Customer Support

SolmeteX is committed to solving customer problems in the removal of metals from water. SolmeteX has the laboratory and analytical skills and equipment to find innovative solutions. To that end, SolmeteX can perform treatability studies and optimization studies. Whether the need is information, bulk resin or complete systems, please contact SolmeteX.

3.0 Application Notes

There are over 4,000 municipal water treatment facilities in the United States that are now in need of arsenic remediation. Typically, these are high flow rate applications in areas where low maintenance and low costs per gallon are required. **ArsenX^{np}**, due to its very high arsenic capacity can clean water at low cost. Since the resin also has high structural strength and no pre or post treatment requirements, the need for system maintenance is minimized.

There are nearly 14 million homes with wells that have unsafe levels of arsenic in them. The resin's high capacity and superior kinetics will allow small compact systems to treat large water volumes. Again, the lack of pre or post treatment requirements will allow this technology to be economically applied.

Many consumers are drinking bottled water throughout the world that has arsenic levels exceeding the MCL. **ArsenX^{np}** can be easily applied to this application for the reasons mentioned above. It is also important to note that not all anions are removed, making the drinking water as tasteful after treatment as before treatment.

4.0 Specifications

The following specifications represent typical values for **ArsenX^{np}.**

Typical Values for ArsenX^{np}

Characteristic	Value
Structure	Macroporous Polystyrene
Appearance	Brown spherical beads
Whole Beads	95% minimum
Functional Group	Hydrous Iron Oxide
Bulk Density	790-840 g/l (as sold) (49-52 lb/cu.ft)
Material Density	1,180 g/l
Static Arsenic Capacity	38 mg As /g of resin
Recommended Contact Time	3 minutes
Operating Temperature Range	1-80° C (33-172° F)
Void Fraction	33%
Particle Size	300 -1200 microns
Operating pH Range	4 - 9