Advancing arsenic adsorption

Specialty media can be used for POU / POE systems.

By Gregory C. Gilles

Specialty chemical adsorbents (media) designed for arsenic reduction are rapidly emerging as one of the most promising categories of technology for point-of-use / point-of-entry (POE / POU) applications.

For community water systems, the US Environmental Protection Agency (EPA) currently recognizes a handful of technologies, including ion exchange, activated alumina, lime softening and filtration / membrane processes (Reverse osmosis, nanofiltration and electrodialysis) as qualifying for best available technology for arsenic removal.

Common adsorbent and filtration media, including common adsorbents such as activated alumina, zeolites, manganese greensand, and even granular activated carbon to a lesser extent, have been used commercially to remove arsenic in larger centralized drinking water and remediation systems.

The US Environmental Protection Agency has also considered activated alumina as one of the best available adsorbents for removing arsenic and other contaminants such as fluoride.

Reasons include relative simplicity of use, full-scale experience and relative cost-effectiveness in comparison with other technologies.

As pointed out in a previous article (see July issue "Specialty media developed for arsenic removal"), a number of new adsorbents are on the horizon for arsenic removal. Included in the category of adsorbents also are some emerging specialty media, including metal oxide, iron-based media and others being demonstrated both in the United States and in Europe.

One type of specialty media for arsenic removal uses a combination of inorganic, high-porosity metal oxides.

Metal oxides of alumina, iron, manganese, silica and others can be combined using a patented processes to create hybrid co-particles with enhanced arsenic-removal capabilities. Figure 1 depicts the basic structure of one type of composite media.

All in the media

Compared with conventional adsorbents, metal-oxide based adsorbents exhibit physical and chemical properties very favorable for use in POU and POE systems. These include high-capacity, rapid kinetic efficiencies and operating flexibility. Additionally, depending on the specific application, regeneration or chemical handling using chemicals such as sodium chloride, sodium hydroxide or acids would be unnecessary.

Higher capacities, coupled with the strong affinity of arsenic to the media, enable units to be discarded as nonhazardous solid waste (e.g., typical POE application) when spent. Some claim to remove both common aqueous forms of arsenic, As III and As V, although experience has shown that efficiencies for arsenic V (oxidized form) are typically much greater.

Metal-oxide based adsorption media can be employed in a variety of POE and POU systems and devices to meet the needs of end users for arsenic removal. The technology can be incorporated into existing treatment trains as an add-on component, such as a post-softening step for arsenic removal, or as a stand-alone technology.

These composite adsorbents can be manufactured to specific particle sizes that are adaptable to conventional filter housings, precoat cartridges, pleat-

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Table 1

Performance of a specialty adsorbent media for arsenic removal

Arsenic concentration range[1]	5-500 ppb
Arsenic species removed [2]	As III and V forms; greater efficiency with As V species
Removal efficiency[2]	>90 percent typical
Media life expectancy [3, 4]	Three months-one year
Prechlorination or oxidation	Conversion of As III to V form improves performance, but not essential for some required for arsenic reduction in point-of-entry (POE) applications
Kinetics	Very rapid removal of arsenic in seconds to minutes
Disposal	Media is nonhazardous when discarded
Adaptability	Media can be used in conventional cartridges, filters and POE tanks
Media certifications	NSF 61; NSF 53 [5] (Pending reinstatement)

Notes:

1. Typical arsenic concentration in US waters is less than 100 parts per billion.

2. Specialty adsorptive media for arsenic removal often can remove both species; As V removal efficiency is greater than As III with short empty bed contact time.

3. Efficiency depends on contact time and water quality profile.

4. This is application-dependent based on arsenic concentrations, water usage and water profile.

5. NSF 53 arsenic claim is currently under development.

Parameters and operating conditions for specialty media in POU/POE applications *Table 2*

Parameter	POU cartridge[4]	POE cartridge	POE tank	POE tank	POE tank	POE tank	Commercial system
Cartridge/tank dimensions	2.5”x10”	4.5”x20”	10”x42”	10”x54”	12”x48”	16”x54”	24”x60”
Bed surface area (square ft.)	—	0.11	0.54	0.54	0.78	1.40	3.14
Amount of media (cubic feet)[1]	.02	.18	1.2	1.6	2.0	2.3	10.0
Weight (pounds) adsorptive media[2]	0.7	7	48	61	76	88	380
Typical particle size (Tyler or US mesh)	20-325 mesh (varies with application)	80x325, 40x120 28x48	28x48 12x32	28x48 12x32	28x48 12x32	28x48 12x32	28x48 12x32
Bed depth (inches)[1]	—	—	28	36	32	36	40
Continuous flow rate (gpm)	0.5	2	5	5	7	8-9	25
Peak flow rate (gpm)	0.75	3	7	7	10	10	30
Loading rate (gpm / square feet)	—	—	9.2	9.2	8.9	8.9	8.0
Contact time (EBCT minutes) at continuous flow	10 seconds	45 seconds	2.0	2.5	2.1	2.5	3.0
Backwash flow rate (gpm/sq ft)	N/A	N/A	5-6	5-6	5-6	5-6	5-6
Pressure drop	varies	varies	< 3 psi	< 3 psi	< 3 psi	< 3 psi	< 3 psi

Notes:

1. Media quantity for POE applications assumes 30-percent bed expansion for backwashing.
2. Apparent bulk density is +/- 10 percent.
3. Gravel, garnet or sand is typically used; quantity will vary based on vessel design.
4. Example shown is for standard 10-inch granular media cartridge; Point-of-use devices also include carbon blocks and others incorporating arsenic media.

ed nonwoven fabrics and conventional fiberglass point-of-entry tanks for whole-household water treatment.

Form and function

For POU applications, the media can be formulated as a sole component or active ingredient to carbon blocks, carafes and other devices for achieving multiple functionality where arsenic reduction can be achieved along with other health or aesthetic-related benefits.

Some specific POE and POU configurations for arsenic adsorption media include:

• Household POE treatment vessels incorporating granular media for arsenic removal

• POU granular cartridges and carbon blocks (countertop and under-the-counter for general purpose, ice makers, etc.)

• Pre- and post- reverse osmosis cartridges

• Faucetmount cartridges and blocks

• Water bottles, coolers, recreational filters and other specialty applications

Table 1 displays typical performance ranges and advantages for the specialty arsenic adsorbent. Table 2 indicates some ways arsenic adsorption media can be incorporated into conventional POU and POE devices and cartridges. Also included in the table are some basic material and operating specifications for the media in these examples.

Some unique differences exist between centralized systems and POU/POE devices for arsenic removal, especially for small water systems. Advances in adsorption media can now offer cost-effective options for compliance that have not previously existed.

For the first time, the Safe Drinking Water Act recognizes that POU/POE devices may also be appropriate for small systems (serving less that 10,000 people) compliance.

Although significant implementation issues must be addressed, it is believed that POU and POE technologies could be used to economically meet the proposed MCL for arsenic. More discussion with the EPA, state regulators, utilities, and economic analysis is needed to advance this opportunity. □

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