Total System Approach To Reagent Grade Water Production

Virtually every laboratory in today's research community requires pure water for various applications from the washing of glassware to the standardization of sophisticated laboratory instrumentation. The production of pure water takes various forms from a large central system that provides water to entire buildings or complexes to smaller point-of-use systems located in individual laboratories. The quality of the water available to the researchers very much depends on the approach the manufacturer of the particular water system takes in the design of the system.

Production of pure water for the most critical laboratory applications is an art form depending on certain factors such as material compatibility, purifying media selection, the proper sequence of this media as well as how the various components are incorporated into the system. In short, one needs to look at the total system approach in producing pure water and how it effects the purity of water a system is capable of producing. In the days of ppm detection limits the concerns with the design of a particular water system were not as critical as they are today where most applications require ppb levels and some even go into the ppt range.

Material Compatibility

Pure water has a veracious appetite for impurities that may be a part of the various components utilized in the system. If pure water is allowed to come into contact with certain materials it will leach impurities from that material and will adversely effect the purity of the water produced. A properly designed water system will utilize the most inert plastics available. Examples of these are virgin polypropylene (non-pigmented) and one of the many fluro-polymers such as PVDF (often used for the manufacture of consumable cartridges as shown in fig 1). The use of any other material has the potential for adding a significant amount of impurities, both organic and inorganic, into the water and will adversely effect many critical applications. Even the mold release agent and lubricants utilized in the manufacturing of acceptable plastic components will effect the purity of the water a system is capable of producing.

Filters utilized at the end of most pure water systems, to ensure bacterial free water, can easily contaminate the water the system produces. Various filter materials require the use of wetting agents to allow water to flow through the filter. The wetting agents utilized are organic in nature and will add contaminants, often times producing water that will adversely effect organic determinant analysis such as HPLC. Hollow fiber filter material does not require the use of wetting agents and thus is the material of choice for final filters.

Purifying Media

The heart of any pure water system is the purifying media. Without the proper media and the right sequence of media the ability of a particular system to produce pure water will be severely compromised. Purifying media consists of activated carbon, ion exchange resins and organic extraction material.

Carbon is traditionally used in the first stage to remove both organics and chlorine from the water utilized to feed reagent grade water systems. If these constituants are not effectively removed the ion exchange resins that follow could become irreparably fouled. The proper use of various types of carbon in conjunction with each other has enhanced the ability of particular systems to produce water containing less than 1 ppb of total organic carbon.

Ion exchange resins traditionally follow carbon in the purification process. Most often mixed bed ion exchange resins are utilized to produce water virtually free of all inorganic interference. Most often at least two and sometimes even three mixed bed cartridges are utilized in series to ensure total removal. It is essential that the resins utilized in reagent grade water systems are virgin resins. Every time ion exchange resin is regenerated it looses some of its capacity as well as provides an additional source of potential contaminants. All mixed bed resins are not created equal. Mixed bed resins are generally categorized into three classes. The first is standard and then nuclear grade with the final being semi-conductor. If reagent grade water is required semi-conductor mixed bed resins are recommended. Semi-conductor resins are treated in the manufacturing process to eliminate potential organic carry-over as well as reduce rinse time on new rein cartridges.

In some cases when low organic water is required an organic scavenger cartridge is necessary. This cartridge is unique in its ability to lower the organic level of water while maintaining the inorganic purity required. Carbon alone would not allow the system to reach inorganic quality and mixed bed alone may not allow for organic purity to be achieved. The combination of both organic and inorganic removal in a single cartridge ensures that the water exiting the system will meet the most stringent demands of both organic and inorganic applications.

Not only is it necessary to utilize the correct purifying media to produce high purity water for laboratory applications it is extremely important to configure the media in the proper sequence. The use of carbon in the last position will provide poor quality water for virtually every application. If low organic water is required the use of mixed bed ion exchange resins as the final step will limit your ability to achieve the ppb and ppt levels that certain organic applications demand. It is the responsibility of both the manufacturers of the equipment as well as the end-users to ensure that the cartridges and filters are configured properly within the system.

Component Sequence

The correct sequence of components within the pure water system is instrumental in ensuring that the water the system produces will meet your most stringent demands. Traditionally certain components are utilized to ensure the contaminates that could be detrimental for a particular application are removed and not reintroduced into the water before delivery. The previous section of this article showed how the incorrect placement of purifying media could adversely effect water quality. Not only do we have to concern ourselves with the media we must also concern ourselves with the components of the system.

Examples of this are components such as the UV lamp that is often utilized within a reagent grade water system to oxidize organic molecules. If this lamp is placed at the beginning of the system the components of the system that follow will recontaminate the water prior to delivery. If the UV chamber and lamp is placed at the end of the system the by-products of the oxidation process will lower the resistivity of the water providing water that is clean organically but not inorganically. In a properly designed system the UV chamber is located just before the final purifying cartridge and that final cartridge must be an combination organic scavenger media and high quality mixed bed ion exchange resin.

Ultrafiltration is utilized in reagent grade water systems to remove pyrogens for biological applications. This ultrafilter must be located at the very end of the system just before the water is delivered. If it is located in another position the water can easily be re-contaminated with bacteria and pyrogens by the purifying media that follows. Due to its location at the end of the system it must be treated in such a way as to ensure that any other organic and inorganics contaminants are not present.

Conclusion

It is essential that the total system approach to reagent grade water production be considered when looking at a particular water system. Often high purity water systems utilize up to six different water purification technologies within the same system, if these technologies are not utilized properly the purity of the water the system will produce will limit it’s usefulness for your demanding applications. Remember, often times it’s not as much what you use as how you use it.

Fig 2 Shows a complete Barnstead NANOpure INFINITY reagent grade water system

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