Softener resin and chlorine limitations

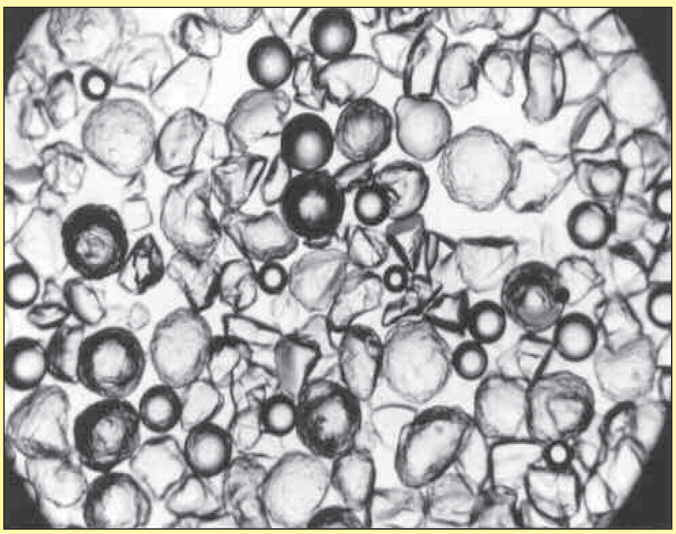
Predicting resin life and the effects of chlorine and chloramine disinfection.

By Frank DeSilva

Chlorine is still the primary disinfectant used in municipal water supplies in the United States and in the near future many more municipalities will be converting from chlorine to chloramines to accomplish disinfection.

These oxidants are detrimental to some POU/POE water treatment processes and equipment.

Ion exchange resin used in softening is basically a plastic and is susceptible to corrosive attack by strong oxidants such as chlorine and chloramines. The presence of chlorine or chloramines will shorten the working life of resin.



The disinfection used in the city water supply dictates resin life.

Predicting resin life

It is difficult to predict the service life of a softening resin due to the many variables involved.

The presence of oxidants such as chlorine or chloramines, temperature effects, regeneration frequency, presence of copper or iron, and exposure to foulants all figure into the estimate.

In many instances, softeners are treating raw city water, so the disinfectant used in the city water supply dictates the resin life.

In most potable city waters, a free-chlorine residual is usually present at 0.5 ppm to 1.0 ppm to maintain disinfection throughout the water distribution network.

In older municipalities — New York City or Boston for example — where the piping distribution system is more than a century old, higher chlorine residuals can be found closer to the point of discharge from the water treatment plant.

There once was an installation in Maryland that was directly across the street from the municipal waterworks. It was not unusual for the softeners at this particular plant to see incoming water with chlorine at 3 ppm to 4 ppm.

Chlorine residuals will damage most ion exchange resins by oxidizing them.

In addition, iron (and other heavy metals) can act as an oxidation catalyst within the resin bead, especially when contacting weak acid cation resins.

Some type of dechlorination is sometimes necessary before ion exchange. The methods available are:

- Activated carbon beds;
- KDF; or
- Introduction of chemicals such as sodium sulfite or sodium bisulfite. Chemical introduction has not been very effective in the removal of chloramines.

Chlorine and resin life

There are several rules of thumb that have been used in the industry to give rough guidelines on resin life in the presence of chlorine. A chlorine level of about 1 ppm will cut resin life in half. Standard softening resin offers moderate oxidation resistance and can have a life of up to 10 years when treating a water with a chlorine level up to 0.5 ppm. The effects of chloramines are not as

Resin composition

Resin is manufactured from styrene and divinylbenzene (DVB). The DVB is called the crosslinker and keeps the styrene from dissolving back into the water. The crosslinking of a resin product determines how resistant it will be to oxidative attack.

Softener resins contain between 7 and 10 percent DVB. The best resin for domestic softening has proven to be the 8 percent crosslinked resin, featuring the most economical combination of oxidation resistance and ability to remove hardness ions.

At times, a 10 percent crosslinked cation resin is used for applications where higher chlorine levels are expected. The resin is more expensive but will give a longer life.

There are resins, such as macroporous cation resins, that have DVB levels greater than 10 percent, but there is a tradeoff of operating capacity and sometimes kinetics when those products are used.

— F.D.

drastic as chlorine.

It is estimated that the oxidative effect is only about half that of free chlorine.

Chlorine removal

When is it necessary to remove the incoming water of chlorine? Some recommended limits are listed below:

Type of Resin	Max. Free Chlorine
Strong acid cation resins	0.5 ppm

In contrast, anion resins and mixed beds are much more susceptible to chlorine, as shown below.

Oxidation of anion resins causes the release of the amine functional site, as opposed to oxidation of cation resins, which attacks the divinylbenzene (DVB) crosslinker (see side, **Resin composition,** page 56).

Type of Resin	Max. Free Chlorine
Type 1 anion resins	0.1 ppm
Type 2 anion resins	0.05 ppm
Weak base anion resins	0.1 ppm
Mixed bed resins	0.1 ppm
Type 2 mixed beds	0.05 ppm

An interesting twist on chlorine removal

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Time for resin replacement?

A noticeable change in resin properties that can be detected in the field is the "squash test." If you can mush the softener resin between your fingers, then the resin has been oxidized and the moisture content has increased. It is time for replacement — don't even bother with formal laboratory tests at this point.

When comparing the moisture content of used resins in the laboratory, it is absolutely imperative to compare the moisture content of the resin when new (but after a few cycles) and that both tests be performed in the same way. Otherwise, the variables are larger than any real differences.

In general, resins that have been oxidized have increased moisture, while resins that are fouled have decreased moisture.

Resin that has undergone oxidative stress can contribute contaminants to the effluent water, including volatile organics and a range of low to high molecular weight organics.

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is that chlorine can be removed sacrificially in a softener by reacting with the resin. The chlorine acts as a sanitizer in the process.

This does shorten the resin life, but the loss of the resin is economically acceptable when the chlorine concentration is about 0.3 ppm to 0.5 ppm.

While ion exchange affects some chloramine removal, it has limitations.

Degradation by oxidation

The primary route of degradation of cation resins as they age is by oxidation, which destroys the DVB crosslinker. The lower DVB level allows the resins to swell and absorb more water. The unevenness of the resulting swelling tends to reduce physical stability, leading to increasing bead breakage, fines and ultimately, higher pressure loss and channeling, which in turn reduces operating capacity and throughput.

In strong acid cation resins there is a direct relationship between total capacity and moisture retention. As the percent moisture increases, the total capacity decreases and remaining life becomes shorter.

References

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2. Meltzer, T., High-Purity Water Preparation, Tall Oaks Publishing, Littleton, CO (1993)

3. Meyers, P., "Ion Exchange and Leachables-A Fresh Look", Water Conditioning and Purification 42 (3), (March, 2000).

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