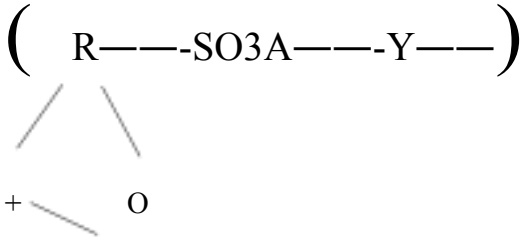
Determining the Proper Conditions for Removing Tritium from Water Using Electrocoagulation (EC) Technology

Scope of Work

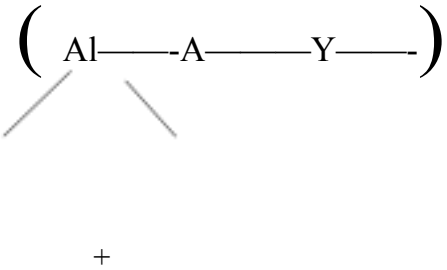
Advanced Waste & Water Technology is determining the effectiveness of electrocoagulation (EC) technology for the treatment of water contaminated with tritium. The EC treatment processes will be installed and operated in a controlled facility utilizing state of the art equipment for analysis and qualified personnel interpreting the results. All steps in the procedure will be properly documented and traceable.

Abstract

The process utilizes electrocoagulation to optimize previously proven treatment processes. Jeppson patented a process utilizing resin, a medium to attach positive cations to attract the tritium as waters of hydration to the cations. His preference was an alumina ion donated from aluminum sulfate to attach to the absorption (R) site open on the regenerated or virgin resin.



This leaves only one open bond to collect a water of hydration. The associated sulfate anion and or the oxygen occupy two of the three positive attachment sites that could be available for more waters of hydration. The sacrificed aluminum ion from the aluminum electrode as the electric direct current is applied with electrocoagulation is released into the influent as an Al+++ ion as a solute. This positive ion does not have the sulfate anion along as excess baggage. This fact is the reason that electrochemistry can shift the equilibrium advantage allowing two positive open bonds.



This reasoning has be tested and documented by Dr. Russell Renk in tests performed at Western Research in Laramie, Wyoming. While it has not been tested and analyzed on this specific issue, logically it should follow previously similar testing. If in fact, this

proves out, it will effectively double the amount of available bonds to attract the tritium.

Let us examine the mechanism for the apparent tritium absorption in the Jeppson Patent. The tritium has to **deal** with radioactive neutrons which are byproducts of the reactors operation becoming attached to the hydrogen atom in the water.

Typical water

H+-O-+H Proton+ from hydrogen and electron- from oxygen.

In typical water the plus of the Hydrogen and the negative of the oxygen cancel each other out leaving a somewhat polar by stable water. With tritium, the hydrogen has 2 neutrons that partially buffer the positive charge.

NPN (hydrogen) limited + -electron from oxygen- +NPN limited +

This structure causes the negative charge on the oxygen to have more strength than the positive hydrogens. Due to the bond angle of the water molecule, it is slightly polar.

H+ (Slightly reduced positive charge

-
O (normal negative charge)
-

H+ (Slightly reduced positive charge

The stronger negative has a preferential attraction to the Al+ positive available site than the balanced typical water, and is therefore more likely to be weak bonded to the tritium than the typical water. This allows the Al+ to hang on to the tritium and the typical water can be drained away by filtration. During regeneration, the heat expands the water molecule and strips it away from the resin. This allows the concentrated tritium water to be available for reuse or disposal. Electrocoagulation permits twice as many Al+ or Al++ to be attraction sites for the tritium. This will certainly increase the efficiency of the accepted Jeppson process.

In an effort to further optimize the process, other absorbent mediums were considered. The resin, according to Jeppson, has 5 to 20 available absorption sites in a resin bead that is about twice the size of the head of a straight pin. The size of the resin is a positive for optimizing filtration, but does increase the volume of the material filtered and sequentially heated to drive off the tritiated water.

Powdered activated carbon (PAC) has hundreds of available sites in a substrate about 5% of the size and volume of the resin. It has been shown to react well with electrocoagulation. Efficiencies of removal have been substantially increased using PAC taking residual copper in vinyl chloride monomer waste streams to single digit parts per billion levels. The residual sludge from this process could be steam stripped like the resin and reused, or burned after drying. The potential is too valuable not to be considered.

Fly ash from coal fired power plants has also been shown by a patent issued to Dr. Russell Renk for removing selenium with electrocoagulation. The potential savings of the cost of using fly ash verses resin or PAC could be significant. The sludge could be dewatered and mixed with concrete for safe disposal.

Procedure

Prepare a known concentration of tritiated water to complete the pilot test. There should be enough volume prepared to complete the entire testing protocol. Take initial sample and analyze to confirm tritium concentration plus the pH of the sample.

First Aliquot of tritiated water:

- Take a known volume and treat with EC utilizing aluminum electrodes
- Obtain a sample of the treated water and analyze to see the concentration of tritium.
- Compare this value with the original concentration obtained to determine the % reduction of tritium.

Second Aliquot of tritiated water:

- Add a measured amount of resin to absorb tritium.
- Take a portion of the water containing the resin and treat with EC utilizing aluminum electrodes at the same parameters previously used.
- Obtain a sample of this treated water and analyze to see concentration of tritium. Compare with original results to see the % reduction of tritium.

Third Aliquot of tritiated water:

- Adjust the pH of the sample one point higher than original.

- Add a measured amount of resin to absorb tritium.
- Take a portion of the water containing the resin and treat with EC utilizing aluminum electrodes at the same parameters previously used.
- Obtain a sample of this treated water and analyze to see concentration of tritium.

Fourth Aliquot of tritiated water:

- Adjust the pH of the sample one point lower than original.
- Add a measured amount of resin to absorb tritium.
- Take a portion of the water containing the resin and treat with EC utilizing aluminum electrodes at the same parameters previously used.
- Obtain a sample of this treated water and analyze to see concentration of tritium.

Compare all results to determine which treatment provided greater % reduction of tritium.

Fifth Aliquot of tritiated water:

- Prepare a sample that rendered the best reduction of tritium
- Take a portion of the water containing the resin and treat with EC utilizing aluminum electrodes at the same parameters previously used.
- Obtain a sample of this treated water and analyze to see concentration of tritium.

Upon determination of the optimal treatment, prepare, treat and analyze the following samples:

- Sample of the tritium water using powdered activated carbon (PAC) to provide the site locations for the aluminum +3 ions and run with best procedure previously proven

- Sample with PAC and Alumina

- Sample using fly ash as an absorbent

- Sample with fly ash and Alumina

All tests should be tested with 2% absorbent, 5% absorbent, and 10% absorbent to see which levels do the best job. Use lowest concentrations first so we can utilize any residual in the next concentration.

Conclusion

Compile all data to determine the most effect treatment to remove tritium.