Filter Prototype Development

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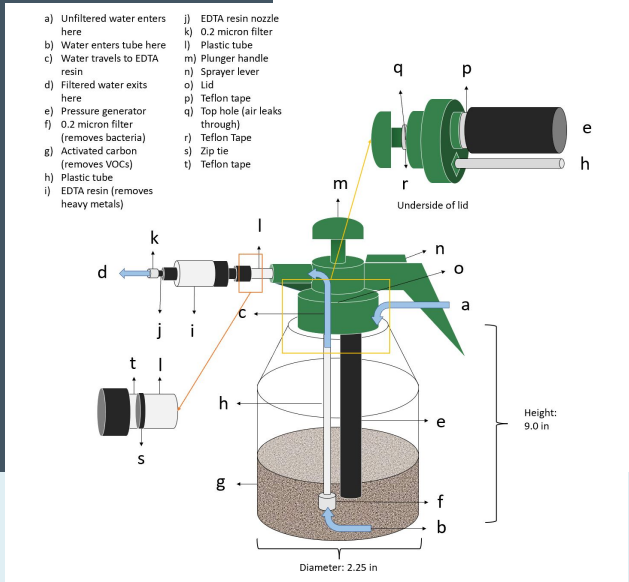


01

Commercial AC Filters

Materials

AC Filter Setup

$CuSO_4$ & Indigo Carmine Solutions

← $CuSO_4$: Before and After

IC + $CuSO_4$: Before and After →

← IC: Before and After

Setup & Procedure

- Using commercial activated carbon (AC) filter, plastic tubes were attached on both sides of lid
- Water entered through top tube and exited through bottom tube
- Poured IC, $CuSO_4$, and IC + $CuSO_4$ solutions though (10 g of each solution was diluted in 1490 g water)
- Observed color change before and after

Pros and Cons

Pros:

- Removal of IC dye through visual assessment: displayed that AC filters were effective in removing dyes

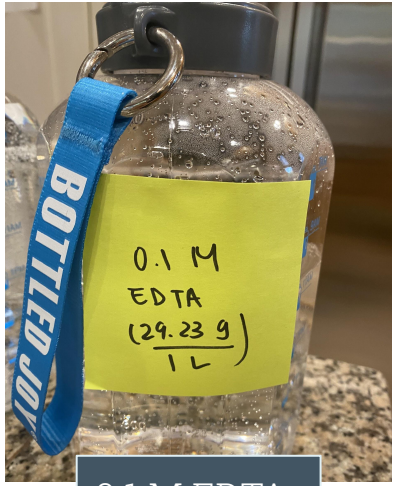
Cons:

- No considerable difference in copper sulfate removal through visual assessment
- Though a preliminary test, showed that AC filters were not effective in removing metals

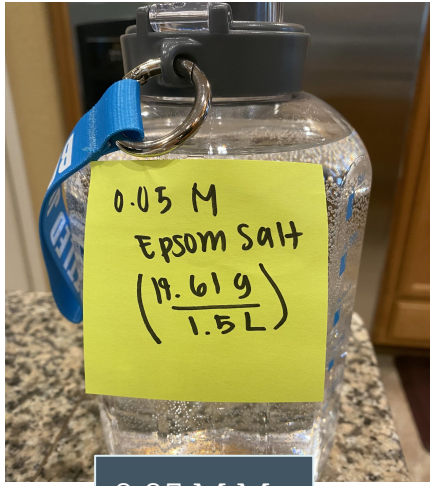
02

Modified Commercial AC Filter with EDTA

Materials & Setup



0.1 M EDTA



0.05 M Mg

- Same as commercial AC setup, except coated AC filter with 0.1 M EDTA
- Used 0.05 M Mg solution as a source of metals in filtration sample

Pros and Cons

Pros:

- Removed around 50% of Mg at maximum

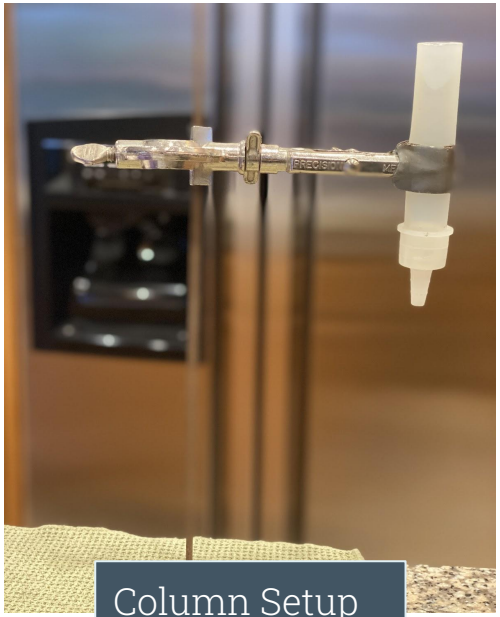
Cons:

- Removed 30% of Mg on average
- Needed more controlled testing where components can be more visible to measure binding and absorption

03

Filter Column with AC and EDTA

Materials, Setup, & Procedure



Column Setup

Setup:

- Poured 10g of AC into the column
- Added a cotton ball to secure the hole at the bottom and prevent any AC from leaking

Procedure:

- Poured 0.05 M Mg though column
- Determined how much Mg was removed using EBT (see Step 4 for more info)

Pros and Cons

Pros:

- Served as a more controlled way to visualize the binding of Mg to EDTA-coated AC

Cons:

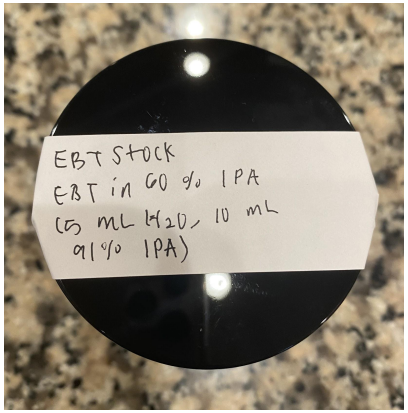
- Still removed around 30% of Mg on average
- Speculated that metals needed more time to bind to the EDTA instead of rushing down the column

04

Batch Testing of EDTA-Coated AC

Materials

EDTA-Coated AC and Magnesium Solution



Eriochrome Black T Solution - Color Indicator

With Metals

Without Metals

Setup & Procedure

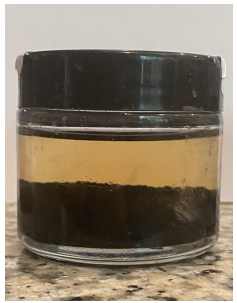
- Soaked AC with EDTA for several days and washed it thoroughly with water
- Poured 0.05 M Mg solution over AC and used Eriochrome Black T as a color indicator to determine whether metals were removed
- Assay for color testing involved 9 mL H_2O, 5 drops EBT and typically 20 drops of water after filtration
- Determined amount of Mg removed by adding 0.1 M EDTA to the color testing assay & higher number of drops meant lower removal of metals

Pros and Cons

Pros:

- At most, was able to remove 0.05 M Mg by 85% using 0.1 M EDTA solution coated to AC

Water Filtered by EDTA and Activated Carbon Turned Yellow →



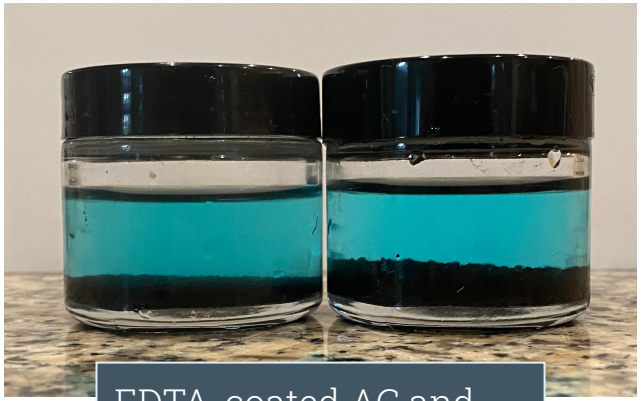
Cons:

- Often faced issues with yellow color, sweet/metallic taste, and leaching of EDTA into filtered water
- Eriochrome Black T was ineffective for detecting changes in smaller concentrations of Mg

05

Batch Testing with Copper & AC

Materials, Setup, & Procedure



EDTA-coated AC and 0.1 M $CuSO_4$

- Left jar: Placed 50 mL of 0.1 M $CuSO_4$ solution in 3.75 g EDTA-coated AC
- Right jar: Placed 50 mL of 0.1 M $CuSO_4$ solution in 3.75 g EDTA-coated AC + 2.5 g AC
- Over time, determined if the supernatant water turned clear due to EDTA-coated AC binding copper

Pros and Cons

Pros:

- No direct pros, but this step served as a transition into developing an actual prototype device

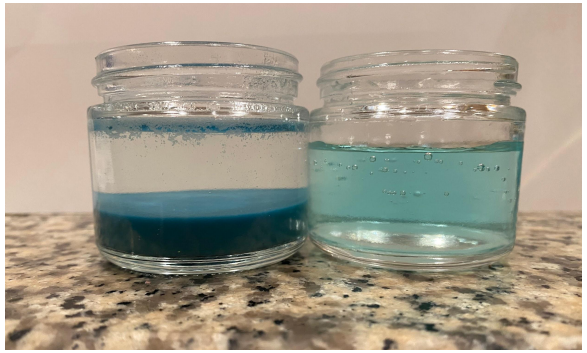
Cons:

- Both solutions did not turn more transparent, meaning copper ions were not binding to the EDTA
- Batch tests did not provide pressure and device needed to perform effective filtration tests

06

Chitosan & Copper Testing

Materials, Setup, & Procedure



$CuSO_4$ Solution + Chitosan

$CuSO_4$ Solution

- Washed 5g of chitosan with 30g distilled water & placed in the right jar
- Using a paper towel, removed the supernatant water to isolate the chitosan
- Placed 30g of 0.05M $CuSO_4$ in both the right and left jar
- Determined if the supernatant water with the chitosan turned clear & compared both jars

Pros and Cons

Pros:

- All of the copper was bound to the chitosan, leaving the supernatant water clear

Cons:

- Though this displayed proof for copper binding, an actual filter will need to be designed with chitosan

07

Katadyn Filter with Chitosan

Materials

Katadyn Filter Setup

Setup (Katadyn Filter)

- Attached tubes to the Katadyn filter
- Placed a container on each side of filter & poured water into container on left side
- Using hand-held pump, generated manual pressure, allowing the water to travel through the system
- Water entered out the other end into right side container

Setup (Katadyn Filter Lid)

- Using a saw, cut off the AC filter connecting to the Katadyn filter lid
- Placed a narrow plastic tubing on the inside (see right side picture on previous slide)
- Measured around 10g of chitosan & washed it over with water
- Placed chitosan in the narrow tubing
- Added cotton balls to the end of the tube so chitosan remains secure
- Filtered 300 mL of 6.25 mM $CuSO_4$ solution though Katadyn filter

Pros and Cons

Pros:

- Conductivity drastically decreased after filtration three times, meaning many of the copper ions were removed

Cons:

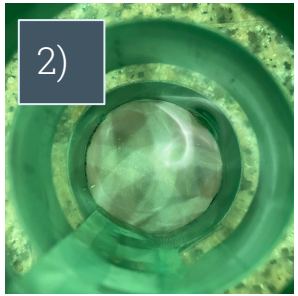
- Conductivity initially did not decrease significantly after only one filtration time
- Smell of chitosan in the water

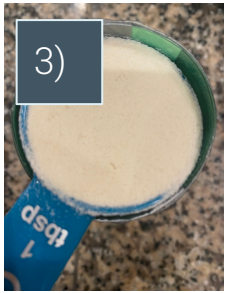
Initial CuSO4 Solution	750 uS
Tap Water	524 uS
Filtered CuSO4 Solution	250 uS
Filtered CuSO4 Solution 2	152 uS
Filtered CuSO4 Solution 3	99 uS

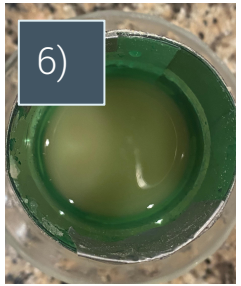
08

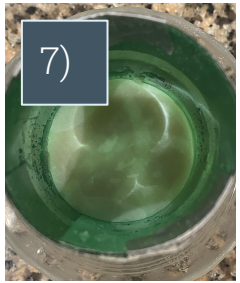
Katadyn Filter with Chitosan, AC, & 0.2µ filter

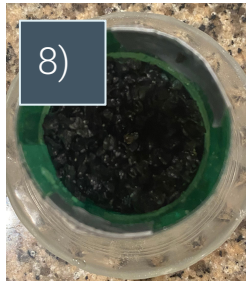
Materials (Bottle)











After Construct Bottle with Chitosan & AC, Place in Katadyn Filter

Setup

1) Construct the bottle using soda bottles, duct tape, and hot glue; poke holes on the bottom for water circulation
2) Place a circle cutout of filter paper on the bottom
3) Measure out 5 tbsp of dry chitosan & place in a bowl
4) Measure ½ tbsp of baking soda (baking soda used to remove chitosan smell)
5) Add water to chitosan, pour in ½ tbsp of baking soda, & mix
6) Add chitosan mixture to column
7) Place a plastic filter cutout over the chitosan
8) Pour in AC to fill bottle (around 5 tbsp)

Materials & Setup (Lid)

- Cut the plastic tube to around 1 inch
- Place the plastic tube on the inside of the lid
- Add a 0.2 micron filter to the bottom surface
- Place cotton balls to secure the 0.2 micron filter

Procedure

- Wash Katadyn filter with bottle using 2-2.5 L of water for filtered water to reach conductivity of tap water (~550 mS)
- Pour 200 mL of 0.075 M $CuSO_4$ solution through Katadyn filter and use conductivity meter to determine how much copper was removed

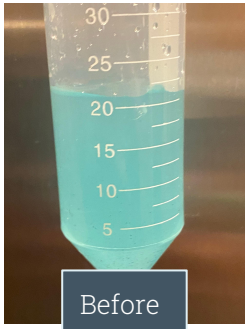
Pros and Cons

Pros:

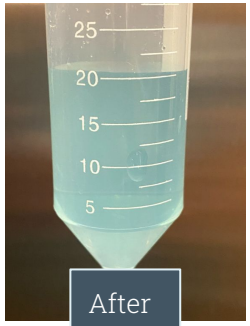
- The filtered solution is slightly more clear (some copper ions are removed) & is less cloudy

Cons:

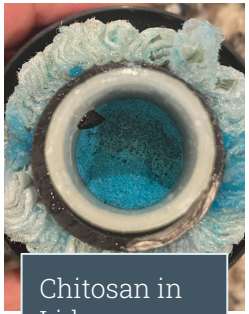
- Remaining conductivity was 0.348 mS, meaning only around half of copper was removed
- Copper did not bind to all of the chitosan in the bottle and chitosan accumulated in the top tube



Before



After


Chitosan in Lid


Chitosan from Bottle

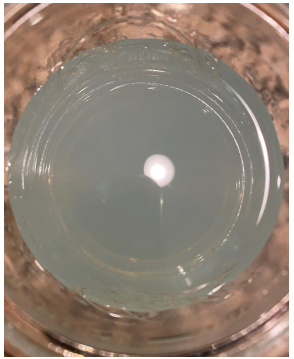
09

Column with AC & EDTA Resin

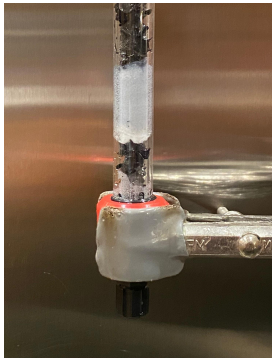
Materials

Invitrogen™ ProBond™ Ni-NTA for EDTA Resin

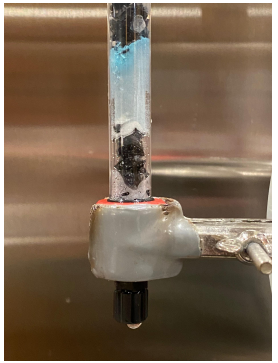
AC Column Attached to Katadyn Filter



0.251 mM $CuSO_4$ Solution



Column Before Filtration



Column After Filtration

Setup

- Poured AC into column (~1 cm of column occupied)
- Added cotton over AC
- Poured EDTA resin in a cup, washed it over with 0.2 M EDTA
- Once mixture turned purple (indicating EDTA-nickel complexes), filtered resin with funnel
- Hydrated resin with distilled water
- Added EDTA resin into column (~1 cm of column occupied)
- Poured AC until column filled
- Column was attached to Katadyn filter through tube, used Katadyn pump to generate pressure for water to flow through

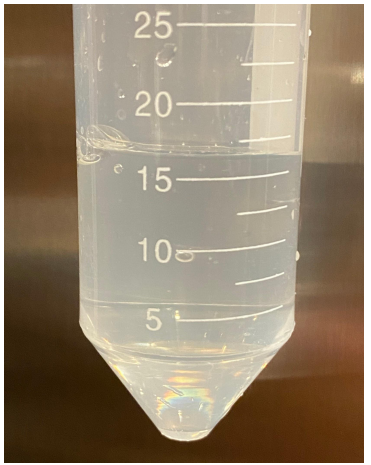
Pros and Cons

Pros:

- Filtered solution was clear
- Removed murkiness from $CuSO_4$ solution

Cons:

- Conductivity after filtration was 0.667 mS, similar to before



Filtered $CuSO_4$ Solution

010

Pump Sprayer with AC, EDTA, & 0.2µ filter (Research Paper)