

Testing Water Hardness Experiment

Introduction:

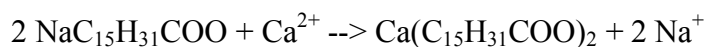
Water from lakes, rivers, or wells that contains significant concentrations of calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) is known as **hard water**. These ions are responsible for an assortment of problems ranging from aesthetic ones, such as bathtub rings and soap scum, to more critical ones like plugged steam lines and damaged hot water heaters. Calcium ions get into water if the water comes in contact with limestone (calcium carbonate); magnesium ions likewise enter water when ground water passes through rocks above and below ground to dissolve minerals that contain magnesium ions. A water softener removes calcium and magnesium from hard water, making it softer. Water with a low level of calcium and magnesium ions is called "soft". When soft water contacts surfaces containing calcium and magnesium, such as plaster swimming pool walls, it dissolves the plaster and may damage the surface.

Description

The concentration of certain dissolved ions such as calcium and magnesium ions that make water hard is determined by a titration procedure using EDTA, ethylenediaminetetraacetic acid.

Background

- Water containing certain ions reacts with soap forming a precipitate called soap scum. For example,



- Contemporary society deals with this problem in two ways. One way is to use detergents whose calcium salts are soluble. Another is to treat the water by softening -- usually replacing calcium and magnesium with sodium.
- Hardness is reported in milligrams of CaCO_3 from the dissolved limestone is the major cause of hardness in most regions. (Dissolved Mg^{2+} and sometimes Fe^{2+} also contribute.)
- Calmagite, an indicator, has a red color when bonded with Mg^{2+} and a blue color when Mg^{2+} when reacted with the EDTA. Ca^{2+} is more tightly bound to EDTA than Mg^{2+} . Consequently, the color change for Mg^{2+} occurs after all Ca^{2+} is reacted.
- The EDTA is a weak acid. A pH 10 buffer is used to keep the acid groups deprotonated.

Chemistry

Materials:

Part A

- Soap
- Tap water and distilled water sample

Part B

- 4 water samples -distilled, filtered, tap, and bottled

Part C

- polyethylene pipets, both graduated and thin-stem
- EDTA solution + buffer
- distilled water
- 4 water samples -distilled, filtered, tap, and bottled of unknown hardness
- beakers 250ml
- 50mL graduated cylinder
- Burette
- Funnel
- Burette clamp and ringstand
- Erlenmeyer flask 250ml

Procedures

Procedure A- Teacher Demo

1. Add 1 full plastic pipette of soap to a water bottle filled one quarter full of tap water
2. Repeat procedure for water bottle one quarter full of distilled water
3. Shake both bottles 10 times at same time
4. Observe which bottle contains the most suds

Procedure B

1. Pour a small amount of each of the 4 water samples into a paper cup
2. Taste each water sample and rank from 1-4 from most favorite to least

Procedure C

Control sample

1. Pipette 20mL of distilled water into a flask for control sample
2. Fill burette with EDTA buffered solution
3. Add 5 drops prepared calmagite solution to water sample. Sample should appear light pink

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4. Slowly titrate sample with EDTA and swirl continuously. Continue adding EDTA until solution turns light blue. Record volume of EDTA used.

Tested samples

1. Pipette 10 mL of each of the 3 water samples and add 10 mL of distilled water to each sample, after rinsing the flask with distilled water three times
2. Add 5 drops prepared calmagite solution to water sample. Sample should appear light pink
3. Slowly titrate sample with EDTA and swirl continuously. Continue adding EDTA until solution just turns light blue. Record volume of EDTA used.

Teacher Lab Prep

Calmagite indicator solution – 0.5g Calmagite dissolved in 500 mL distilled water

Buffer, pH 10 – Dissolve 16.9g ammonium chloride (NH₄Cl) in 143mL conc ammonium hydroxide (NH₄OH). Add 1.25g magnesium salt of EDTA (available commercially) and dilute to 250mL with distilled water.

Pre Lab questions: Read the Introduction and answer the following questions.

1. Describe where water hardness comes from.
2. Explain the difference between hard and soft water.
3. Describe how hard and soft water affects household plumbing fixtures and everyday activities.
4. How do you think water hardness will affect taste of water?
5. List evidence from your home that would lead you to believe that your water has hard, soft or moderate water hardness.

Experimental Data

Procedure A

Ranking of 4 water samples by taste

- 1.
- 2.
- 3.
- 4.

Procedure B

Data table:

	Sample Volume(mL)	Distilled	Sample 1	Sample 2	Sample 3
EDTA	Initial Buret Reading(mL)				
	Final Buret				

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	Reading (mL)				
	Volume Used				

Literature Data- Labels used to describe water hardness:

Concentration (mg CaCO ₃)/L or ppm	Description
0-17	Very soft
17-51	Soft
52-120	Moderately hard
121-256	Hard
257-425	Very hard
426 and above	Rock hard

Calculations

Since the ration of EDTA to calcium ions is 1:1 calculate hardness of water for each of your samples using the equation.

$$\text{Hardness as mg/l (ppm) CaCO}_3 = \frac{A \times B \times 1000}{C}$$

Where A is the titrant volume (mL), B is the conversion factor for calculating mg of Ca equivalent to 1.00mL of the EDTA titrant, since EDTA molarity is 0.01M, B= 1. C is the sample volume.

Analysis Questions

1. How does water hardness affect the sudsing of the soap?
2. Which sample is the hardest water you titrated? Which is the softest? What does it mean for water to be “hard” or “soft”?
3. Compare the water hardness calculated to your ranking by taste. Does water hardness affect taste? Explain
4. What factors may contribute in the differences in the data you recorded for question one?

Chemistry

5. How could you use a flame test to distinguish between hard and soft water?
(HINT: For which ions in hard and soft water have you performed experimental flame-test observation?)
6. List three qualitative tests you can perform at home that would demonstrate whether you have hard or soft water.