Matter and Motion Winter 2016

Lab 4: Titration of Vitamin C

Adapted from P. Pessiki, TESC

Purpose: The amount of ascorbic acid in a number of consumable products will be determined by a redox titration and a pH indicator will be made from natural pigments. ***You may bring in items to test if you'd like. Want to see if 10 mL of lemon juice contains more vitamin C than 10 mL of lime juice? Bring in a lemon and a lime! Want to check the pH of your shampoo? Etc… **Note that anything you bring into lab cannot be taken out of lab!**

Introduction: Vitamins are necessary for healthy life. One definition of a vitamin is: A small organic molecule that is essential in *trace* amounts for proper biological functioning, and must be obtained from the food you eat and drink. The vitamin we are interested in today is vitamin C.

Vitamin C is necessary for healthy life. A description of what a lack of vitamin C causes follows; *"Some did lose all their strength, and could not stand on their feet ... Their mouths became stinking, their gums so rotten, that all the flesh did fall off, even to the roots of the teeth, which did almost all fall out".* This is a quote from Jacques Cartier in 1536 describing the effects of scurvy on his mates while conquering the St. Lawrence River area.

To avoid scurvy eat citrus fruit. Some say this is how and why the British sailors got to be called lymes. Linus Pauling championed the consumption of large doses of vitamin C on a daily basis. Some say he was wrong; it is worth investigating. Vitamin C is ascorbic acid. It is made in plants and some animals starting with glucose as shown in FIGURE 1.

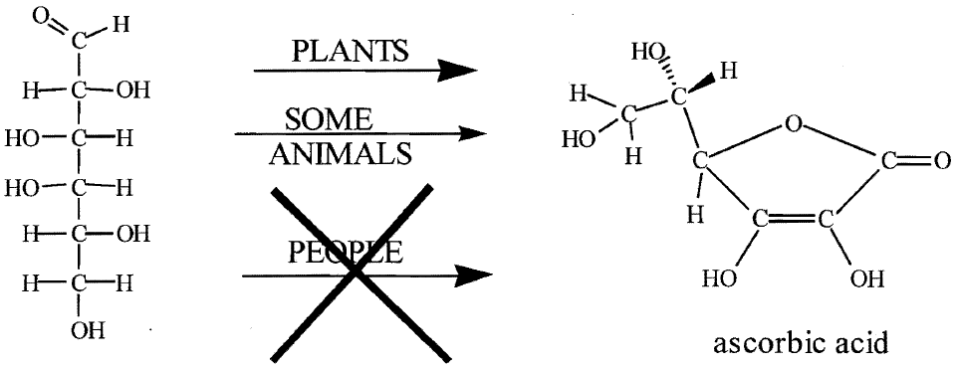


FIGURE 1. The structure of glucose and ascorbic acid (vitamin C).

Our goal today is to quantify the amount of ascorbic acid in things like vitamins and fruit drinks. To achieve this, we need a way to detect the concentration of ascorbic acid. We will do this by performing a redox titration.

In a redox titration two different reactions occur. One is an oxidation and one is a reduction. In our experiment we are looking at the oxidation of ascorbic acid as described in FIGURE 2. The other half reaction, the reduction reaction involves the reduction of the indicator 2,6-dichloroindophenol (DCP). Note that the indicator goes from red to clear, and the vitamin C is always clear.

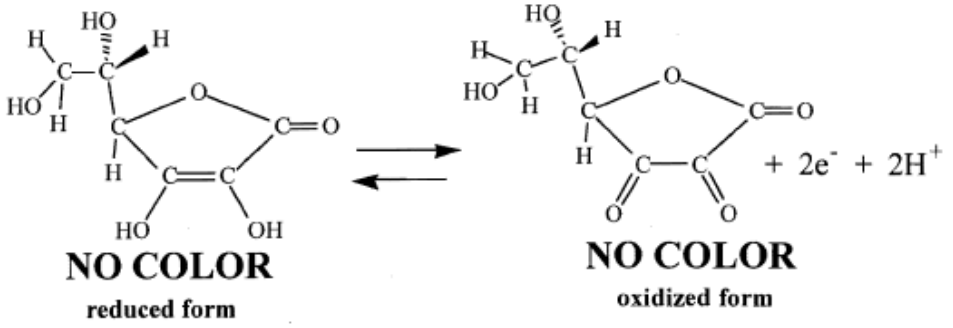


FIGURE 2. Reduced and oxidized forms of ascorbic acid.

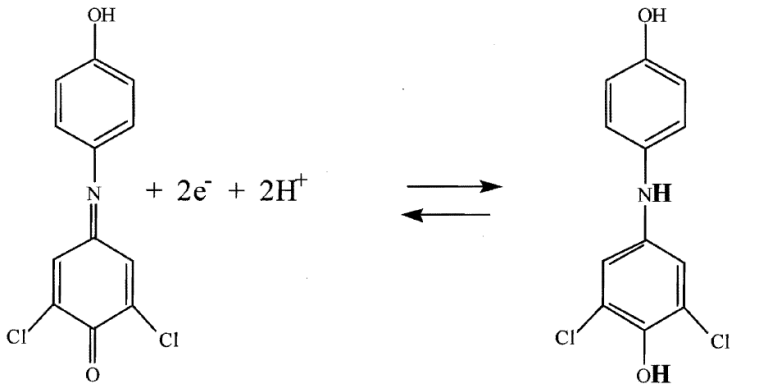
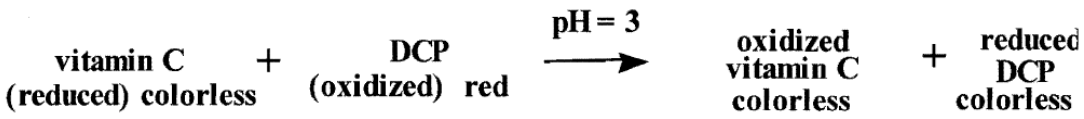


FIGURE 3: The oxidized and reduced forms of the indicator, 2-6-dichloroindophenol (DCP)

The overall redox chemistry between DCP and vitamin C is stated below. The key to this reaction involves the color change of the indicator, DCP.



We will titrate into a vitamin C solution with the indicator (DCP). This indicator is RED and will be in your buret. As the DCP drops into a solution containing vitamin C, the two chemicals react via a redox reaction and the indicator will go from **red to clear**. Recall that the vitamin C is always colorless. As the addition of DCP proceeds, the vitamin C in your sample becomes consumed. As long as some vitamin C remains in the sample, the DCP will turn clear upon mixing in solution. After the vitamin C has been completely consumed, the DCP will no longer be oxidized and the red color will remain in the flask. This indicates the end point of the titration. So, from the titration we get a volume of DCP. If we know the concentration of the DCP (which we will since we standardized it), then it will be possible to determine the amount of ascorbic acid in the original solution.

This procedure works because the indicator is also the oxidizing agent (it is being reduced). The reason a redox indicator is chosen over a pH indicator, for example, has to do with the fact that in real life often more things are present in a sample than just what we are interested in. Many of these are things are more susceptible to acid-base chemistry than a redox reaction. The redox indicator chosen is somewhat selective for ascorbic acid. We should note that some other side reactions are possible.

Prelab

Read the lab carefully (including Postlab!) and then complete the Prelab before coming to lab.

1. Some of the words in this lab may be new to you. Make a list of any new vocabulary and their definitions.
2. The titration today relies on a redox reaction. What is being oxidized and what is being reduced? What is the oxidizing agent and what is the reducing agent?
3. Vitamin C is also known as ascorbic acid. Calculate the molar mass of ascorbic acid.
4. Today's lab involves 4 parts where data is being obtained, including masses and multiple volumes for each trial. Read the lab carefully to determine what needs to be recorded. Prepare for the lab by generating data tables in your lab notebook for Parts 1-4. Note that each titration will include 3 trials and each trial involves 3 volumes (initial, final, and the difference).

Procedure

Note: each group will have a waste beaker for their indicator solution generated during the titration. PLEASE ASK ABOUT THE PROPER DISOPOSAL OF WASTE.

Part I: Making a pH indicator

Many plants contain colored compounds that change color depending on the pH of their environment. The purple color in cabbage is one such compound, in the class of anthocyanins (see Figure 4). Today we will use this natural pigment as a pH indicator. First, finely chop up some cabbage and extract the color by steeping the leaves in boiling hot water for at least 10 minutes. Begin Part II while you wait. After steeping, filter the colored water to remove solids. Obtain at least 4 items that you want to test; try to get two that are acidic, and two that are basic. You should be able to see at least 4 different colors. Use pH paper to test the pH of your sample and then note the color change of the cabbage pigment.

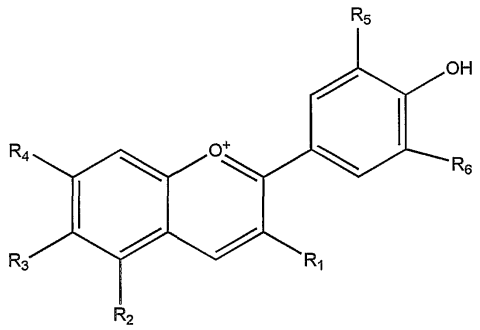


FIGURE 4. General form of anthocyanin. R can be many different attached groups.

Part II: Standardize your DCP Solution

Use the analytical balances to weigh between 40 to 60 mg of ascorbic acid. Record the exact mass. Transfer this to a 100 mL volumetric flask. Add about 50 mL of water to dissolve the vitamin C. Make sure none of the ascorbic acid is lost during the transfer. After all the vitamin C is dissolved, add enough water to bring the final volume to exactly 100 mL. Make sure the solution is well mixed.

Obtain a buret and make sure it is clean and working properly (check that liquid runs through the valve). Rinse it with a few mL of your indicator solution (be conservative, you only have so much DCP!) and allow for some to run through the stopcock. Discard these drainings into your waste beaker. Fill your buret with the DCP solution and record the volume level of the indicator exactly (you need to know the initial volume!).

Use a 10 mL volumetric pipet to transfer exactly 10.00 mL of your ascorbic acid solution into a 250 mL Erlenmeyer flask. Add about 10 mL of DI water and 10.00 mL of the pH = 3 buffer. Repeat twice more so you have a total of three samples. Begin titrating sample 1. This first trial should be done as a “rough” titration; you only need to get an estimate of how much DCP will be needed for the more accurate trials. Start by adding 1-2 mL at a time while swirling your Erlenmeyer – continue to add titrant fairly quickly as long as the solution continues to turn clear. If it appears that the color is persisting, then wait at least 30 seconds to see if the color still remains. Sometimes the color will remain briefly and then disappear due to the kinetics of the reaction.

After the endpoint is obtained for the first run, go back and do the other two samples. These next two should be done very carefully. Use the ballpark estimate of the first trial to speed up these next two trials. For example, if the first trial needed 20 mL to stay red, then you can go quickly to about 18 mL for the next two and then proceed very slowly, adding one drop, or a half drop at time to get 0.01 mL accuracy. Record all initial and final volumes.

Part III: Analyzing the Accuracy of a Vitamin C Tablet.

Obtain a Vitamin C tablet. Note the proposed strength. This tablet has two parts, the vitamin C and everything else. Everything else is binder mostly, which should not interfere with the analysis. Sina may have some tips to share on how best to do the following procedure. For now start by grinding the tablet with mortar and pestle and place in a 250 mL Erlenmeyer. Add about 15 to 25 mL of DI water. Continue to swirl the contents taking care not to splash chemicals. If any solids remain, filter through an available filter. Make sure to rinse with a little DI water to assure complete fluid transfer.

Repeat the titration as done above. Do the first one somewhat rapidly to get you in the ballpark. The other two should be in good agreement. Record all data and observations.

Part IV: Analyzing the Vitamin C content of food.

Obtain a sample of fruit juice. ***Bring a sample of your choice from home if you want. Note it is no longer food after it enters the lab***. You will need about a 10 mL sample. Most juices will need to be filtered. When dealing with the fruit juice you have to watch for two much pulp and variations in color due to pigment in the fruit juice. You will have a hard time seeing a color change in purple grape juice, but it may be possible is pear or lemon juice, for example.

Transfer to 10 mL sample of filtered juice into a 250 mL Erlenmeyer flask. If the solution is too viscous (thick), you may add a small amount of DI water. Do your titration series as before, with the 1st trial being "rough."

CLEAN UP – Please clean your own area and then ask Sina for a community job.

WASTE DISPOSAL – Please ask before dumping your waste beakers.

Continue with the Postlab if time allows (especially #1).

Postlab Assignment – It should be done in your lab notebook and turned in at the beginning of class next Monday, Feb. 1st at 10:00 AM

1. Refer to Part II where we standardized our indicator solution. Use the mass of ascorbic acid used and the proper dilution ratio to calculate the number of moles of ascorbic acid present in 10.0 mL of your standard solution.

2. Use the above result and the stoichiometry of the redox reaction to calculate the number of moles of DCP consumed in each "good" titration and then use the volume of DCP solution used in each titration to calculate the concentration (in Molarity) of your standard solution.

3. Calculate the average concentration of your DCP indicator solution.

4. Calculate the number of moles and then the average mass (in mg) of vitamin C in your vitamin C tablet and compare to the claimed potency. Was the tablet labeled correctly? If not, do you trust your result? Why or why not? What could make it better?

5. Calculate the number of moles of vitamin C in 10 mL of fruit juice and then calculate the mass of vitamin c in one serving (assuming 1 cup) of fruit juice.

6. Use your results from Part I of the lab to draw a cabbage-based pH indicator scale, i.e., colors aligned with pH values.