Cyanide Detection from Naturally Found Precursors in Fruits, Vegetables, Nuts, and Cigarettes

Objectives:
1. Understand why cyanide is found in things we eat.
2. Understand the dangers of cyanide exposure from cigarette smoke.
3. Measure the amount of cyanide in fruits, vegetables, and cigarettes.

Vocabulary:

Cyanide – a molecule that contains a carbon atom triple bonded to a nitrogen atom.

EPA - Environmental Protection Agency - a US government organization that determines standards for allocating and protecting our natural resources.

Glycosides – a natural molecule, often found in the pits of certain fruits and some nuts, made up of sugar units that release small amounts of cyanides when eaten by animals.

Maximum contaminant level – in drinking water, the maximum allowable concentration of a chemical allowed by EPA standards.

Background:

Cyanides are usually found in the form of hydrogen cyanide, a poisonous gas or a volatile liquid with an almond-like smell. Cyanides can also be found in solid salts such as potassium cyanide and sodium cyanide. Cyanide is very toxic and exposure at certain levels can lead to poisoning and even death.

Some bacteria and fungi produce cyanide naturally. Cyanide is found in plants such as cassava, vegetables such as lima beans, and nuts such as almonds. It is also found in the pits or seeds of fruits such as peaches, plums, cherries, apples, and apricots. The cyanide compounds are in the seed and not the fruit itself, so you can still eat all of these foods mentioned without worry.

The cyanides found in these fruit seeds are in the forms of glycosides. This is a natural defense for the seed of the fruit. When the seed is eaten, water and digestive juices (acids) in the stomach of the animal trigger the seed to release the sugars and cyanide to prevent digestion of the seed itself. This way the seed will still be intact when it is released back into the environment and ready to sprout. The glycosides also act as a poison to keep bacteria, fungi, and small insects from entering the seed and preventing decay.

Man produces cyanide compounds for a variety of uses. Cyanide is used as a fumigant or insecticide to poison and kill small insects and rodents that eat our crops and invade our houses. Miners use cyanide to extract certain metals from ores. Cyanides are extensively used in electroplating, picture development, and in making insulation and plastics. Cyanide gas was used in Nazis gas chambers in World War II, and is still used for the execution of condemned prisoners in some states. During the Cold War, USA and Russia developed a number of chemical weapons using cyanide.

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Background Continued:

We are exposed to cyanide pollution daily. Some cyanide compounds are generated by automobile engines in their exhaust. Smokers are directly exposed to significant amounts of cyanide from inhaling cigarette smoke.

All of these uses of cyanide generate cyanide waste that can enter our water supply and pollute our water. Because of the toxic effects of cyanide, the EPA has set the maximum contamination level in drinking water as 0.2ppm cyanide.

Cyanide in cigarette smoke doesn't come from the tobacco itself, but from the burning of the tobacco. Cyanide gas is produced from the burning of carbon material in the presence of Nitrogen. Plant material, like all living organisms, is carbon based and Nitrogen makes up 75% of our air. Therefore, it is common for cyanide gas to be generated from the burning of any material. The cyanide levels in inhaled cigarette smoke range from 0.01-0.40mg of cyanide per cigarette, while the toxic dose of cyanide for a person is 50mg. Our bodies produce a natural defense mechanism that protects us against small amounts of cyanide poisoning.

In large concentrations or with prolonged exposure, cyanide can be very toxic. Cyanide reacts with iron in our bodies in place of oxygen, which prevents oxygen from reaching our central nervous system and brain. A lack of oxygen in nerve cells prevents nerve cells from communicating with each other and cause severe health effects such as loss of feeling and movement of fingers and toes, loss of vision, and even death. Death by cyanide poisoning can occur in as little as 2-3 minutes. The lethal dose of cyanide for a person is 50mg (0.05 grams) of hydrogen cyanide or 375mg of the cyanide salts. Early symptoms of cyanide poisoning include headaches, difficulty breathing, vomiting, anxiety, and nausea.

Cyanide Measurement Kit Materials:

Cyanide ReagentStripsTM, Microcuvettes, 2 Color charts, Instructions, Plastic Pipettes, Instructional CD, and Colorimeter (optional)

What you will need:

- ~2-3 peaches (You will only need the seed in the pit)
- ~2-3 bitter almonds
- ~2-3 apple seeds
- Freshly discarded cigarette butts (obtained under parental supervision)
- Data collection sheet

(ITS does not condone smoking cigarettes or using this information in anyway that could bring harm to a person. Parents please supervise the experiments performed in this science kit. Thank you.)

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Experiment #1:

Objective:
Determine how much cyanide is in your peach seeds? How many peach seeds equal a lethal dose to a person?

Procedure: (Please view the instructional video before performing the test.)

1. Eat the edible fruit part of the peach or another fruit as identified above to obtain the pit.

2. Break the pit open to obtain the seed of the peach. An easy and safe way to is to put pit in vise and slowly squeeze the pit until it is broken open and the seed is revealed.
(Note: The rest of the steps need to be performed in a reasonable time because the cyanide is volatile and will evaporate when exposed to air.)

3. Place 1 peach seed in a bowl and crush into small pieces.

4. Add 50ml (~1/4th cup) of tap water to the bowl and mix well.

5. Using the plastic pipette, draw 2.0mL of the mixture into the pipette and dispense into the cuvette.

6. Dip 1 ReagentStrip™ #1 in the microcuvette with an up and down motion for 30 seconds. (Note: be sure to dip the strip so that the strip will go completely down into the microcuvette). Discard this ReagentStrip into trash.

7. Dip 1 ReagentStrip™ #2 in the same microcuvette with an up and down motion for 30 seconds. Remove the ReagentStrip™ and match the strip to the closest matching color block on the ReagentStrip color chart card. Record the results on the data collection sheet.

8. Wait 10 minutes and then place the microcuvette on the microcuvette color chart card and match to the closest color block by looking directly down the center of the cuvette. Record the results on the data collection sheet.
(Hint: For lower detection levels use the value obtained from the microcuvette color chart card if results appear to be between 0 and 0.5ppm. Use the results obtained from the ReagentStripTM color chart card if results appear to be between 0.5 and 5ppm. If results are above 5ppm, re-dilute your sample and repeat the procedure.)

9. Repeat this experiment using 1 bitter almond. Repeat again using 1 or more apple seed(s).
(Note: As with other tests for cyanide the presence of sulfide, aldehydes, and heavy metals will cause lower results depending on the concentration of these interferences. Thiocyanate interferences result in false positive results. Potassium thiocyanate concentrations of 5.00, 1.00, and 0.05ppml give false positive cyanide readings of 3.00, 0.57, and 0.03ppm respectively.)

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Experiment #1 Continued:

Analysis and application:

1. How much cyanide is present in 1 peach seed?
   Multiply the result from the color chart by 0.05 to find out how many milligrams (mgs) of cyanide are in each seed. *(Note: 1ppm cyanide=1 mg/L cyanide)*

2. How many peach pits would a person have to eat for it to be lethal?
   Divide 50 by the # mgs of cyanide per peach seed (from step 1 above) to determine how many seeds would be a lethal dose to a person.

3. Is it likely that a person would become ill from eating these fruits that contain cyanide in the pit or seeds? Explain.

Extension:

1. In a clean container, take a portion of the fruit of the peach and crush into small pieces. Add 50mL of water to the container and mix. Perform the experiment again to verify that there is no cyanide in the fruit itself.

2. What are some other plant defense mechanisms? What do they protect the plant from?

3. What are some other chemicals produced by plants? What uses do we have for these chemicals?
   (Ex. Aloe is taken from aloe plants to help in healing burns on your skin.)

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Experiment #2:

Objective:
Determine how much cyanide is found in 1 used cigarette butt.

Procedure:
(Please view the instructional video before performing the test.)

1. Take 1 burnt cigarette butt with the filter still attached and place it in your sample cup.

2. Add 25mL of tap water to the sample cup.

3. Using a stirring rod crush the cigarette butt into small pieces for 1 minute. The filter of the cigarette should become at least partially exposed.

4. Using the plastic pipette, draw 2.0mL of the mixture into the pipette and dispense into the cuvette.

5. Dip 1 ReagentStrip™ #1 in the cuvette with an up and down motion for 30 seconds. Discard the ReagentStrip.

6. Dip 1 ReagentStrip™ #2 in the cuvette with an up and down motion for 30 seconds. Remove the ReagentStrip™ and match the strip to the closest matching color block on the ReagentStrip color chart card. Record the results on the data collection sheet.
(Note: For this experiment you will not match the cuvette against its color chart card for color comparison. The yellow color in the cigarette butt will react with the blue color of the indicator producing a green color that does not correspond with the color chart.)

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Experiment #2 Continued:

Analysis and application:

1. How many milligrams of cyanide were trapped in the cigarette butt?
Multiply the result from the color chart by 0.025 to find out how many milligrams (mgs) of cyanide are in each cigarette butt.

2. How many milligrams of cyanide are generated by 1 burnt cigarette if the amount of cyanide trapped by the filter is only 1/10th of the cyanide generated?
Multiply the # mgs in each cigarette butt (from step 1 above) by 10 to find out how many milligrams of cyanide are in each cigarette.

3. If our body absorbed all of the cyanide produced from smoking a cigarette, how many cigarettes equal a lethal dose to a person? *(Remember 50mg of cyanide is a lethal dose to a person.)*
Divide 50 by the # mgs of cyanide produced per cigarette (from step 2 above) to find out how many cigarettes equal a lethal dose to a person.

Extension:

1. What are some other chemicals produced from a burning cigarette?

2. Are you exposed to other chemicals from second hand smoke? What level of exposure do you suspect?

3. Research and find other additives in cigarettes that are harmful to our bodies? Why are they added to a cigarette?

HOME

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Internet Field Trips:

- *www.thetruth.com*
- *www.quitsmoking.about.com*
- *www.emedicine.com*
- *www.encyclopedia.thefreedictionary.com/cyanide*
- *www.epa.gov*

www.sensafe.com