**Exploring Air Pollution Generated by Fossil Fuel Combustion**

**Purpose-** Determine levels of fossil fuels present in vehicular exhaust.

**BACKGROUND**

Fossil fuels are composed of organic carbon matter and are found in three forms- petroleum, natural gas, and coal. Pressure from the earth’s crust, heat, and bacterial processes transform decayed plants and animals into carbon energy. The formation of fossil fuels takes millions of years. Fossil fuels are relatively inexpensive to extract, process, and ship, and their combustion is a straightforward process. A downside to dependence on fossil fuel is that fossil fuels are nonrenewable. In addition, fossil fuel combustion has been linked to global warming, and it negatively impacts air quality.

The components of fossil fuel air pollution include carbon dioxide, carbon monoxide, hydrocarbons, particulate matter, nitrogen oxides, lead, and sulfur dioxide. These by-products of combustion are emitted into the air. They degrade air quality as they mix with other reactants in the atmosphere. Work as a group to investigate some components of fossil fuel air pollution and complete the lab.

**DETECTOR TUBES**

A detector tube is designed to take one sample volume of an air pollutant to measure concentration levels. The tubes contain a chemical that reacts with the air pollutant to produce a color change.

A professional detector pump pulls air through the detector tube at a specific volume. Each stroke will usually pull 100 mL of air through the tube. Because these larger pumps are rare and expensive, we will substitute a 60-mL syringe for the detector pump. You will take two 50-mL samples through the detector tube for every pump stroke specified in the below procedure. Although the detector tubes supplied with this kit are designed for professional air testing, the use of the syringe pumps with the tubes does not constitute a “certified” testing system. (Sorry, you won’t be able to use the results of your test to replace your yearly required emissions test by the state of Tennessee!)

Each type of detector tube has its own unique color change. The carbon monoxide tube’s white packing turns brown and detects carbon monoxide concentrations from 0.5-7 volume-percent. This test requires two pulls of the syringe to the 50-mL mark.

The hydrocarbon test tube also requires analyzing a color change to evaluate your exhaust system. The white packing inside the tube turns brown in the presence of propane and butane. When hydrocarbons have been detected, a color change will occur. Even shades or brown indicate the presence of hydrocarbons, so you should stop pulling air into the tube as soon as you see a color change of the detector tubes.

**MATERIALS**

Each group needs to be furnished with

* 1 carbon monoxide detector tube\*
* 1 hydrocarbon detector tube\*
* 1 syringe pump
* 1 3-way stopcock
* ozone test card
* 1 ½” piece of tubing
* thermometer attachment- share portable reader with class

\* per vehicle to be tested

**PROCEDURE A- Sample Ambient Ozone (ozone in the surrounding area)**

Based on prior knowledge, pick a location that your group believes would have a high ozone reading. Tape the ozone card at eye level, in a location that will stay out of the sun for 1 hour. Record the start time and leave for one hour. After the reaction time is up, record the end time and the ozone ppm indicated by the card reading in your data section.

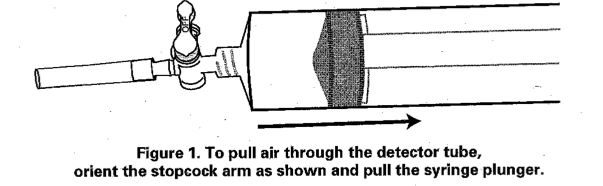
**PROCEDURE B- Sample Ultraviolet Radiation Index**

Hold your card in direct outdoor light for one minute. Observe the color of the indicator and match it to the color scale on the card. Record the time and the UV level in the data section.

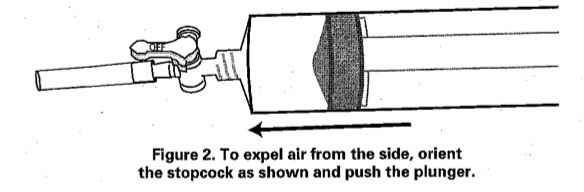
**PROCEDURE C- Measure Carbon Monoxide Emissions**

*Carbon monoxide is tested by taking in two complete, 50-mL syringe strokes.*

1. Connect the CO gas detector tube to the piece of tubing so that the arrow on the detector tube points toward the syringe pump. (See Figure 1)



1. Draw one air stroke sample using the following steps
2. Turn the stopcock arm toward the **unused stopcock stem**.
3. Place the open end of the gas detector tube into the exhaust airstream. At a reasonable rate, draw 50 mL of air into the syringe.
4. Release the plunger- there may be a vacuum effect. If the vacuum is created, the plunger will draw back toward the gas detector tube. Wait until the plunger has stopped moving and then continue to pull back to the 50-mL mark, this time drawing the air sample through more slowly.
5. Turn the stopcock arm toward the tube and expel the air out the **side opening** to clear the pump (make sure the stopcock arm is pointed correctly- air must not pass back through the detector tube). (See Figure 2)



1. Repeat steps 2a-d.
2. Remove the gas detector tube from the piece of tubing.
3. Observe the percent volume at the point where the color change stops. In the data section, record the concentration of the CO. If the color change line is slanted, take the value at the middle of the slanted region.

**PROCEDURE D- Measure Hydrocarbon Emissions**

*Hydrocarbon is tested by taking in exhaust until a color change takes place. The volume of exhaust that brings about the color change is recorded.*

1. Connect the HC gas detector tube to the tubing so that the arrow on the detector tube points toward the syringe pump.
2. Turn the stopcock arm toward the unused stopcock stem. Place the open end of the gas detector tube into the exhaust airstream. At a reasonable rate, draw air into the syringe until you see a color change.
3. In the data section, record the volume of air that was needed to see the brown color indicator.

**PROCEDURE E- Record Outdoor Air Temperature**

Hook your temperature sensor to the portable PASCO sensor and record the temperature, in Celsius. Record this in your data section.

**DATA SECTION**

**Make, Model, and Year of Car Tested \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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| **Fossil Fuel Combustion Lab Data** | | |
| **Variable** | **Concentration or Degree** | **Time** |
| Ozone (ppm) |  |  |
| UV Radiation (index) |  | x |
| Carbon Monoxide (ppm) |  | x |
| Hydrocarbons (mL) |  | x |
| Outdoor Temperature (Cel) |  |  |

**DATA ANALYSIS**

1. Convert the carbon monoxide reading to ppm (1 volume-percent = 10,000 parts per million)
2. How many times higher is the CO in your sample than at the upper limit of CO in good air as defined by the Air Quality Index chart? (hint- your ppm ÷ 4.4 ppm = times greater)
3. Compare the typical results from the lab with another fossil fuel engine, a lawnmower.

|  |  |  |
| --- | --- | --- |
| **Pollution Source** | **Carbon Monoxide** | **Hydrocarbons** |
| Car exhaust | 0.5-1.5% | 5-300 mL |
| Lawn Equipment | 0.50% | 100 mL |

1. Why are the air pollutant concentrations similar for a car and a lawn mower?
2. Name a factor that may influence the amount of pollution in vehicle exhaust.
3. Ground ozone and UV levels vary depending on location and human activity.
4. Did your results indicate a relationship between UV intensity and ozone levels? If so, what is it?
5. Provide factors that could have affected the UV intensity during the lab.
6. You can calculate the AQI of a pollutant if you know its concentration. In Table 3, find the AQI range for a CO measurement of 6 ppm. In the below table, the exact AQI is calculated.

|  |  |  |
| --- | --- | --- |
| **Breakpoints for AQI (parts per million)** | | |
| **CO ppm** | **Ozone ppm** | **AQI** |
| 0.0-4.4 | x | 0-50 |
| 4.5-9.4 | x | 51-100 |
| 9.5-12.4 | 0.125-0.164 | 101-150 |
| 12.5-15.4 | 0.165-0.204 | 151-200 |
| 15.5-30.4 | 0.205-0.404 | 201-300 |
| 30.5-50.4 | 0.405-0.604 | 301-500 |

The general formula for calculating the AQI is

[(upper AQI value – lower AQI value) ÷ (pollutant concentration at upper AQI value – pollutant concentration at lower AQI value)] x (observed pollutant concentration – pollutant concentration at lower AQI value) + AQI value at lower pollutant concentration

*For example*

AQI of air whose CO concentration is 6 ppm:

AQI = [(100-51)] ÷ (9.4 ppm – 4.5 ppm)] x (6.0 ppm – 4.5 ppm) + 51

= 63.38 (which would give us an AQI rating of “Moderate”)

1. Calculate the AQI value for your vehicle’s carbon monoxide emission level.
2. Calculate the AQI value for your group’s measured ozone level.
3. Draw a diagram that shows the interactions that produce smog in an area. Include in your diagram human activities, specific air pollutants (written in molecular form), and other conditions required for smog formation.