Studying the Effects and Importance of Fuel Line Antifreeze

Background
Automobiles are an integral part of our culture. They provide a reliable and efficient means to go from here to there. As the culmination of years of mechanical evolution, every part of these vehicles has been intentionally designed for a specific purpose. From the design of the passenger cage for safety in a crash to the design of the seats for safety and comfort to the aesthetic and aerodynamic shape of the body, every aspect has been deliberately and carefully considered to provide a safe and enjoyable experience for the rider.

Among the many systems in a car, the fuel system is one of the more important. The fuel system has to store fuel safely and convey it to the engine to power the vehicle. Any failure in the fuel system means that the car won’t go. In northern climates in winter, water in the fuel tank can freeze and cause blockages in the fuel lines, preventing the engine from receiving fuel to run. Chemicals can be added to the fuel tank to prevent freezing.

In this experiment you will be investigating fuel line antifreeze to understand how this additive prevents fuel line freezing.

Pre-lab Questions (Answer these questions before coming to class)
1. Gasoline is a complex mixture of compounds. What class of compounds generally comprises gasoline?
2. In chemistry, what is an alcohol?
3. Draw the chemical structures of methanol, ethanol, and 2-propanol. Circle the atoms that define each of these substances as an alcohol.
4. What is the density of gasoline?
5. What is the density of water?
6. What is the density of methanol?

Problem
How does fuel line antifreeze work to prevent water from freezing in the gas tank or fuel line?
Materials
- Hexane (or substitute)
- Water (distilled or tap water is acceptable)
- Methanol, ethanol, or 2-propanol
- Blue and yellow food coloring
- Test tubes, one for each alcohol to be tested plus one extra
- Rubber stoppers to fit test tubes
- Test tube rack
- Beral pipets, one for each alcohol to be tested plus one extra
- 10-mL graduated cylinder
- Beaker, 400- or 600-mL
- Crushed ice
- Sodium chloride (table salt)
- Thermometer

Safety
- Use these materials with adequate ventilation and keep away from sparks or flame.
- Avoid skin contact.
- Always wear safety goggles when handling chemicals in the lab.
- Wash hands thoroughly before leaving the lab.
- Follow teacher instructions on clean up and disposal of chemicals at the conclusion of the lab.

Procedure
1. Collect the required materials. You will need 5 mL of hexane for each alcohol you plan to test.
2. Label the test tubes with the name of each alcohol you plan to test. Label one test tube "no alcohol."
3. Using the 10-mL graduated cylinder, measure 5 mL of hexane and add it to each test tube.
4. Color your sample of water blue and your alcohol(s) yellow using 1-3 drops of the appropriate food coloring in each.
5. Using the Beral pipet (plastic dropper), add 5 drops of colored water to the hexane in each test tube. Cap each test tube with a rubber stopper and place it in the test tube rack.
6. Record your observations of the test tubes on below.
7. Making sure the stopper is firmly in place, shake a test tube containing hexane and water. Observe the test tube immediately after shaking and again after 1 minute. Record your observations on your worksheet.
8. Prepare an ice bath by filling your 400- or 600-mL beaker three-quarters full with crushed ice. Add sodium chloride to the beaker, about 100 g to a 400-mL beaker or 120 g to a 600-mL beaker. Mix the salt in the ice and check the temperature with the thermometer.
9. Using a different Beral pipet for each alcohol, add 10 drops of the appropriate alcohol to each test tube. Replace the stoppers and shake the tubes. Observe the test tubes immediately after shaking and again after 1 minute. Record your observations on your worksheet.
10. Record the temperature of the ice bath on your worksheet.
11. Place all test tubes into the ice bath, making sure they are well immersed in the cold mixture. Periodically swirl the contents of the tubes and keep them in good
Contact with the ice mixture.

12. Check the tube that does not contain alcohol for evidence of freezing. When freezing occurs, check the water/alcohol drops in the other tubes to see if they have frozen. Record your observations on the worksheet.

Observations

Appearance of test tube(s) after adding hexane and water:

Appearance of test tube(s) immediately after shaking:

Appearance of test tube(s) one minute after shaking:

Appearance of test tube(s) after adding alcohol to hexane and water immediately after shaking:

Appearance of test tube(s) one minute after shaking:

Temperature of ice bath:

Observation of water/alcohol drops after water drop freezes:

Analysis

Using complete sentences, answer each of the following questions:

1. Explain why the water stayed at the bottom of the test tube rather than floating on top of the hexane.
2. Explain the appearance of the tube of hexane after adding the drops of water considering the types of intermolecular forces between water molecules, between hexane molecules, and between water and hexane molecules and the densities of water and hexane.

3. When you added alcohol to the test tube, did the alcohol dissolve in the hexane or in the water? How do you know? Explain why, again considering the intermolecular forces involved.

4. How did the presence of alcohol in water affect the freezing of the water?

5. Modern fuels often contain 10-15% alcohol mixed with the gasoline. If a 60-L fuel tank is filled with fuel containing 10% alcohol, how many liters of alcohol are in the tank?

6. Given your answer to number 5, is it likely that adding 500 mL of alcohol to a fuel tank will have a large effect on the tendency of fuel to freeze?
Conclusion
Write a one- to two-paragraph summary of what you did in this experiment and what you learned.