Training Guidelines for the Fire Debris Analyst

Lesson Plan (Module) 2

Date: November 2009 **Instructor:** Qualified Instructor

Subject: Chemical Composition of Petroleum Products **Total Time:** 9 hours

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Learning Objectives

- Understand the history of petroleum products in relation to fire investigation.
- Understand the importance of chemical composition of petroleum products in the classification and identification of ignitable liquids.
- Understand the relationship between carbon number(s) in homologous series and physical properties.
- Describe the main chemical groups of hydrocarbons and oxygenates.
- Understand the difference between petroleum products and petroleum distillates.

Suggested Reading

1. Baum, Hill J., and R. Scott-Ennis. Chemistry and Life: An Introduction to General, Organic, and Biological Chemistry. Prentice-Hall, 1999.
2. Morrison, R. T., R. N. Boyd, and R. K. Boyd. Organic Chemistry. Englewood Cliffs: Prentice-Hall, 1992.
3. Black Gold: The Story of Oil (part of the Empires of American Industry Series) Video. The History Channel.
4. Speight, J. G. The Chemistry and Technology of Petroleum (Chemical Industries).Vols 76. New York: Marcel Dekker Inc, 1999.
5. Kirk-Othmer Encyclopedia of Chemical Technology Petroleum (Refinery Process, Survey), and Petroleum Products. John Wiley & Sons Inc, 1974.
6. Speight, J. G., and B Ozum. Petroleum Refining Processes. New York: Marcel Dekker Inc, 2002.
7. Speight, J. G., Handbook of Petroleum Analysis.John Wiley & Sons Inc, 2001.
8. Petroleum. 25 Feb. 2009 <http://en.wikipedia.org/wiki/Petroleum>.
9. "Composition and Refining of Petroleum." infoplease. 2004 <http://www.infoplease.com/ce6/sci/A0860338.html>.
10. Leffler, W. L. Petroleum Refining in Non-Technical Language. Tulsa: PennWell Corp., 2000.
11. Potter, Thomas, and Kathleen Simmons. Composition of Petroleum Mixtures (Total Petroleum Hydrocarbon Criteria Working Group Series). Amherst Scientific Publishing, May 1998.
12. DeHaan, John D. "Our changing world. Part 1: furnishings." Fire and Arson Investigator (Dec. 2002): 16-17.

Introduction

Petroleum products constitute a high percentage of identified ignitable liquids in fire debris analysis. These products are generally made of complex mixtures of aliphatic and aromatic hydrocarbons. A knowledge of chemical compositions is fundamental in understanding the separation and identification of ignitable liquids from submitted evidence.

Outline

1. Alkanes
    a. Definition
    b. Properties
    c. IUPAC nomenclature for aliphatic hydrocarbons
    d. Common names of alkanes /alkyl derivatives
    e. Number of carbons vs. boiling and flash points in a homologous series

2. Aromatics
    a. Definition
    b. Properties
        i. Resonating double bond, provides stability
        ii. Aromatic (sweet) odor
    c. Nomenclature
        i. Naming, substitute first followed by benzene or Ph, for phenyl
        ii. When more than one group is added to a ring, the name of the position on the ring is stated as ortho (-o), meta (-m), or para (-p)
    d. Isomers of substituted benzene rings
    e. Polynuclear aromatics

3. Cycloalkanes
    a. Definition
    b. Properties
    c. Examples

4. Alkenes
    a. Definition
    b. Properties
    c. Examples

5. Alkynes
    a. Definition
    b. Properties
    c. Examples
        i. acetylene

6. Indanes/Indenes
    a. Definition

b. Properties
c. Examples

7. Oxygenates
   a. Definition
   b. Properties
   c. Examples
      i. Alcohols
      ii. Ketones
      iii. Ethers
      iv. Fatty acids

8. Light, Medium and Heavy Petroleum Products
   a. Definition
   b. Properties
   c. Examples

9. Miscellaneous Products
   a. Definition
   b. Properties
   c. Examples
      i. wax
      ii. asphalt
      iii. petroleum jelly
      iv. oils

Teaching Aids

Handout
PowerPoint presentation
http://chemed.chem.purdue.edu/genchem/topicreview/bp/1organic/coal.html#petroleum
http://www.chemistry-school.info/what_are_alkanes.htm

Summary

Knowledge of petroleum product chemical composition will aid laboratory examiners in understanding the components of the majority of ignitable liquids and how they may be affected by fire and suppression activities. This module serves as a refresher for basic organic chemistry, nomenclature and other physical properties.

Test Questions

1. An n-alkane is the same as:

a. naphthalene
b. olefin
c. n-paraffin
d. indane

2. What was the first commercial petroleum product in wide-spread use?
a. kerosene
b. gasoline
c. diesel
d. asphalt
e. none of the above

3. A monounsaturated hydrocarbon with 10 carbons should have how many hydrogen atoms:
a. 10
b. 20
c. 22
d. 18

4. How many double bonds does cyclohexane have?
a. 0
b. 1
c. 2
d. 3

5. An o-disubstituted benzene ring is substituted in which positions:
a. 1,2
b. 1,3
c. 1,4
d. 2,3

6. Which oxygenates are found in petroleum?
a. alcohols
b. ketones
c. ethers
d. none of the above

7. Indene is a flammable polycyclic hydrocarbon with a structure composed of:
a. **one benzene ring fused with a cyclopentene ring**
b. one cyclohexane ring fused with a cyclopentene ring
c. two fused benzene rings
d. one benzene ring fused with a cyclohexene ring

8. Place the following in ascending order of boiling range:
a. asphalt, wax, heating oil, petroleum jelly
b. heating oil, petroleum jelly, wax, asphalt

c. heating oil, wax, petroleum jelly, asphalt
d. petroleum jelly, heating oil, asphalt, wax