PETROLEUM AND ITS PRODUCTS

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Petroleum

- Petroleum is a form of *bitumen* composed principally of hydrocarbons and existing in the gaseous or liquid state in its natural reservoir. “The word *petroleum* originates from the Latin *petra* (“rock”) and *oleum* (“oil”).
- Petroleum is composed almost entirely of the elements hydrogen and carbon, which is in the ratio of about 1.85 hydrogen atoms to 1 carbon atom in crude oil. The minor elements sulfur, nitrogen, and oxygen constitute less than 3% of most petroleum. Traces of heavy metals such as vanadium and nickel also are present.

Specific Gravity of Oil

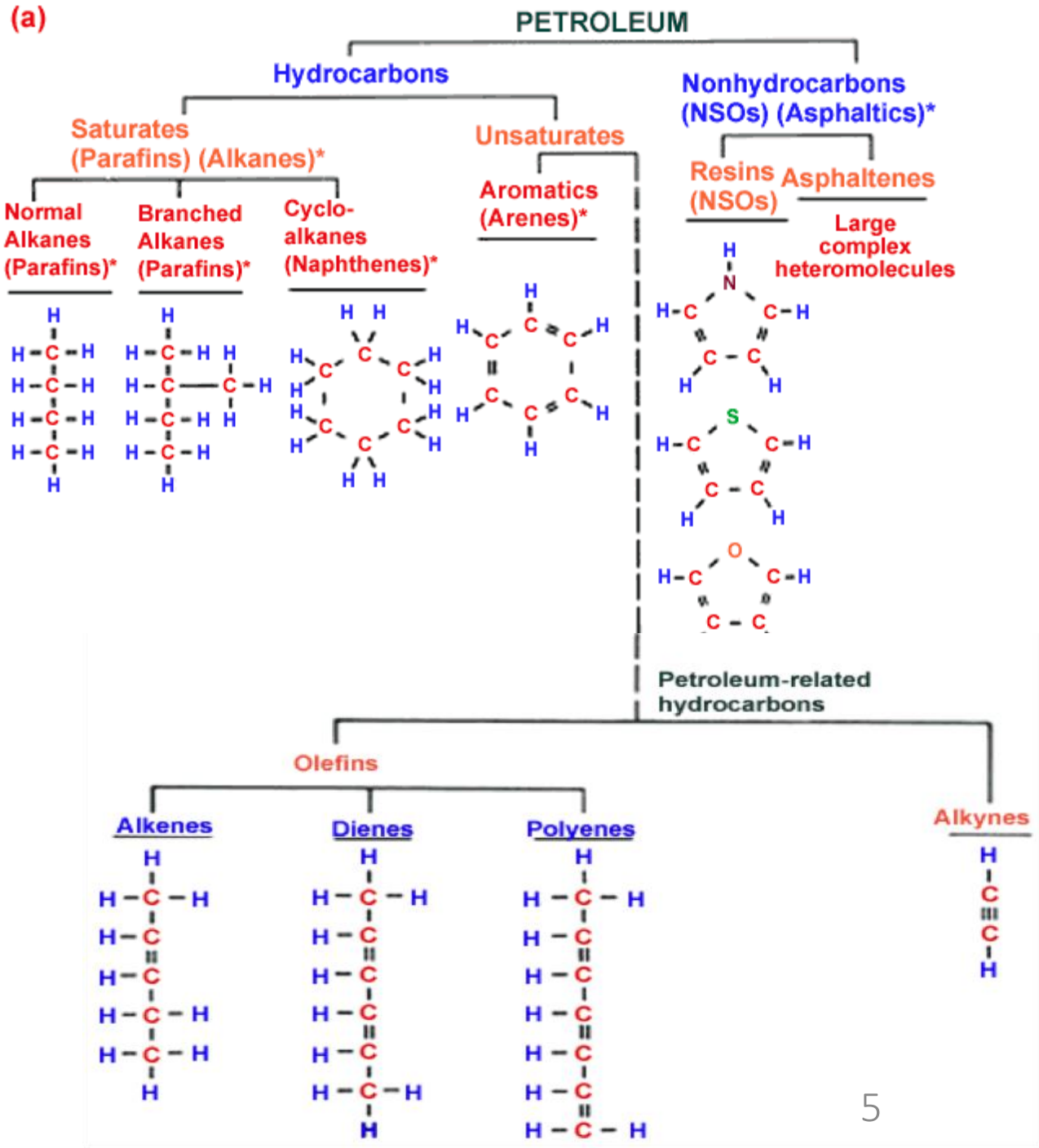
- The origin of petroleum from kerogen depends on many factors, but *the quantity of petroleum generated is determined mainly by the hydrogen content of the kerogen. A high-hydrogen kerogen* (7 to 10% H) generates far more oil and gas than does a low-hydrogen kerogen (3 to 4%).
- Since hydrogen is a much lighter element than the other elements, oils with a higher hydrogen content have lower specific gravities.
- Some oils have much higher contents of nitrogen, sulfur, and oxygen (NSO). This gives the oil a higher specific gravity, since these elements are heavier than carbon or oxygen.

Nitrogen, Sulfur, and Oxygen Compounds (Asphaltics)

- The fifth molecular type is the nonhydrocarbon, that is, compounds containing atoms of nitrogen, sulfur, or oxygen in the molecule. Although these elements are present in small amounts, they disproportionately increase the nonhydrocarbon fraction of a crude oil by being incorporated in the molecules. For example, if an asphalt were composed having the formula $C_{30}H_{60}S$, it would contain by weight 80% carbon, 13% hydrogen, and 7% sulfur.
- Small amounts of nonhydrocarbons are scattered through the entire boiling range of crude oil. Sulfur compounds include thiols, sulfides, thiophenes, and benzothiophenes. Nitrogen compounds include pyrroles, indoles, pyridines, quinolines, and carbazoles. Oxygen compounds are mainly chain or ring acids. Carboxylic (chain or ring) acids and phenols represent 3.5% of the Midway Sunset, California, crude oil.

Principal Subdivisions of Petroleum

Hydrocarbon and nonhydrocarbon fractions can be subdivided into four chemically distinct groups based on molecule types present

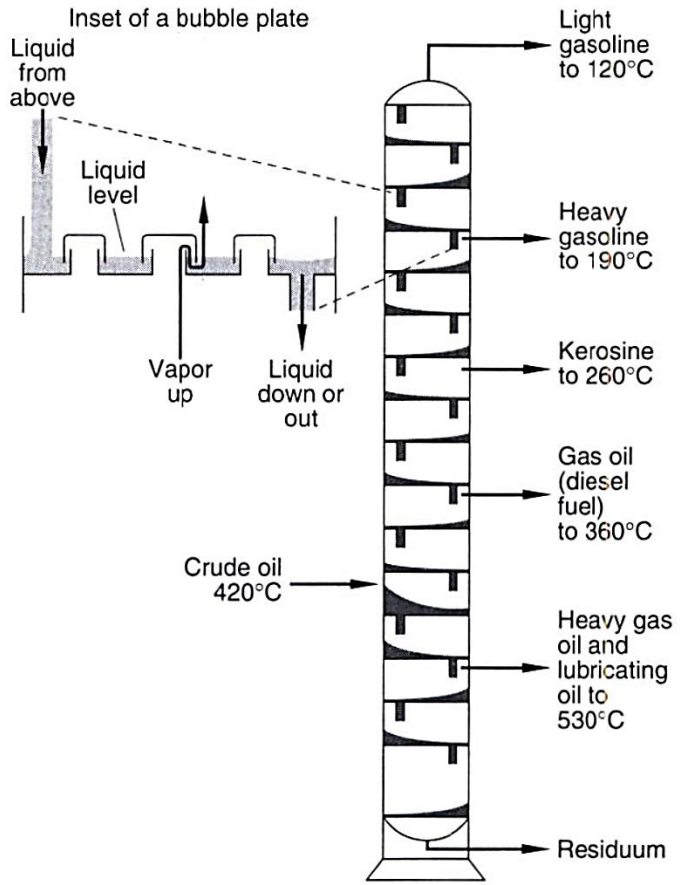


The Composition and Uses of Petroleum

- Distillation is the principal method for separating crude oil into useful products. When promoters were trying to raise money to drill the Drake well in 1859, they submitted a sample of the oil from the Titusville seep to Professor Benjamin Silliman of Yale so that he could determine its value. Silliman placed the oil in a distillation flask and boiled off eight fractions, each of which he described in detail. His results showed that the seep would make and illuminating oil that would be superior to most of the oils then available. This ensured the financing of the Drake well.
- Today a modern refinery distills thousands of barrels of oil a day through continuously operating distillation towers that are based on the same principle as Silliman's distillation flask. A refinery tower is equivalent to a series of individual distillation flasks, in which the distillate from the first flask is condensed in the second flask and redistilled to produce a distillate for the third flask.

A Distillation Tower

- Instead of flasks, the tower has condensation plates. The vapor distilled from one of the chambers rises to the chamber above and passes through the condensed liquid of that chamber. Each overlying chamber in the tower condenses successively lighter and smaller molecules, until only the light gasoline escapes from the top. At the bottom of the tower are those molecules that are so large and heavy that they cannot penetrate as gases through the first plate and so end up in the residuum. Refining towers may have different internal designs for condensing the vapors, but the efficiency of all of them is measured in terms of the number of plates, each bubble plate being the equivalent of the original distillation flask.



Gravity of Crude Oil

- The specific gravity of a substance is the ratio of its mass to the mass of an equal volume of water at a specified temperature. The specific gravity of oil fractions is generally determined at 15.6° C (60° F).
- Many years ago, the American Petroleum Institute (API) developed a linear gravity scale to determine gravity by reading a simple hydrometer floating in oil. This API gravity was calculated to give water the value of 10° API for a specific gravity of 1

$$\text{Gravity, °API} = \frac{141.5}{\text{specific gravity } 60°/60°\text{F}} - 131.5$$

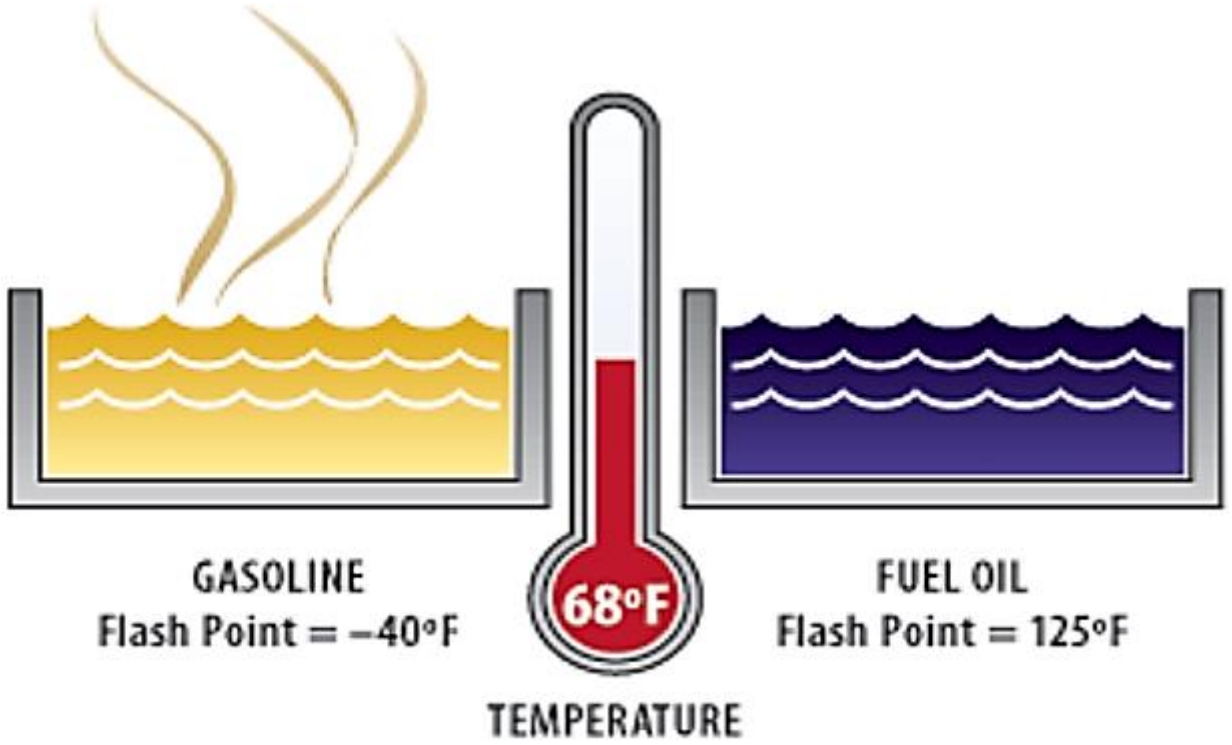
- Water has about the same viscosity as gasoline, but its gravity is comparable to that of residuum. This is because the oxygen atoms in water make it much heavier than any hydrocarbon molecules. Likewise, if nitrogen, sulfur, or oxygen atoms are introduced into a petroleum fraction, they will increase the specific gravity, thereby decreasing the API gravity.

Properties of Petroleum Products and Water

	API gravity	*Specific gravity*	*Viscosity (millipoise)*
Gasoline	60	0.74	6
Kerosine	50	0.78	20
Diesel fuel	45	0.79	100
Lubricating oil	30	0.85	500
Residuum	10	1	$>10^5$
Water	10	1	10

Flash Point

- Flashpoint is defined as: “the lowest temperature that a liquid emits vapors that may be ignited”.
- The lower the flashpoint the more flammable the material.



Upper and Lower Explosive Limits

- Lower Explosive Limit (LEL)

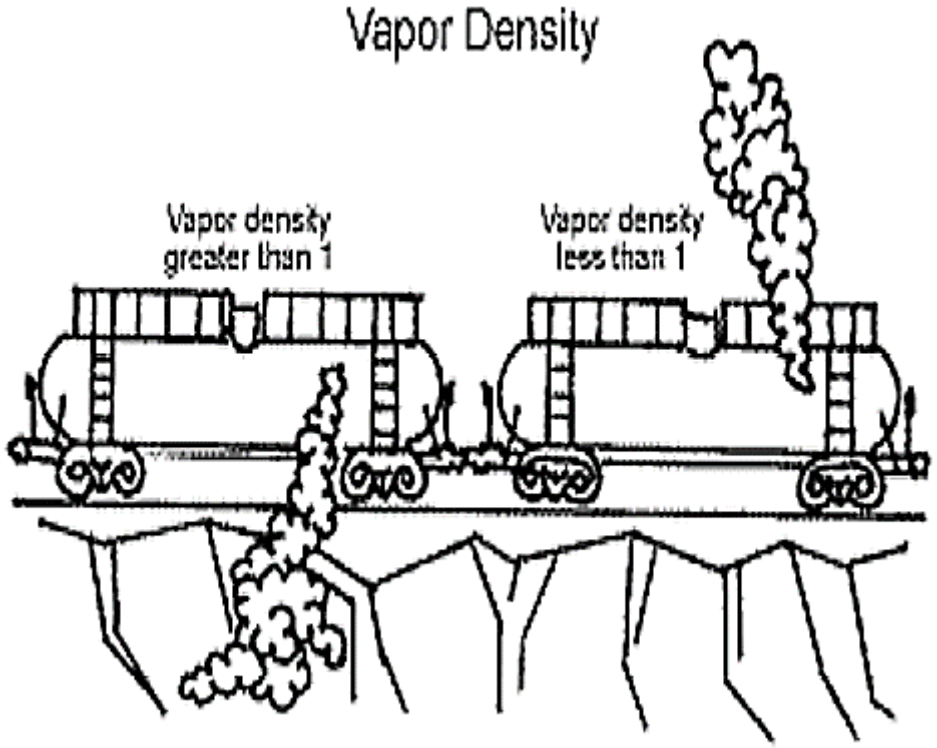
  The lowest concentration of vapors in the air capable of producing a flash fire in the presence of an ignition source

- Upper Explosive Limit (UEL)

  The highest concentration of vapors in the air capable of producing a flash fire in the presence of an ignition source

Vapor Density

- Weight of a unit volume of gas or vapor compared to the weight of an equal volume of air
- As such vapors can accumulate in low or depressed areas
- These vapors can be both flammable and toxic

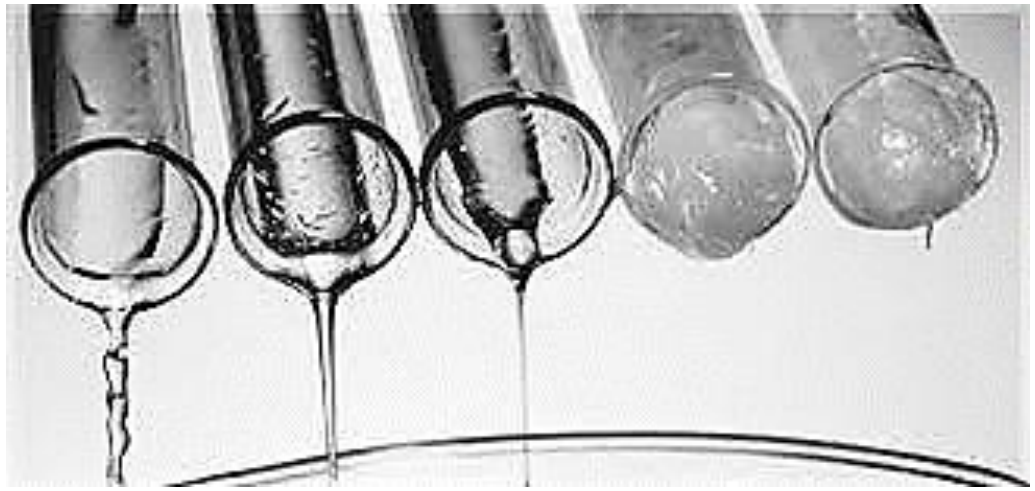


Vapor Pressure

- Vapor Pressure is the pressure exerted by a vapor at a given temperature in a closed system
- A liquid with a high vapor pressure is called a volatile liquid
- Vapor Pressure is directly related to temperature
- Increasing Temperature = Increased Vapor Pressure

Pour Point

- The pour point of an oil is the lowest temperature at which the oil will just flow, under standard test conditions. The failure to flow at the pour point is usually attributed to the separation of waxes from the oil, but can also be due to the effect of viscosity in the case of very viscous oils.



Marketing Crude Oils' Classification

- The terms *light* and *heavy* are used in marketing crude oils. The price of light, sweet crude is quoted in the newspapers. Currently, light is greater than 31.1° API gravity; medium is 22.3 to 31.1° API; heavy is 10 to 22.3° API; and extra heavy is less than 10° API gravity.

Condensates

- Reservoir gases under very high pressure are able to dissolve large amounts of liquid hydrocarbons. When such gases are produced, the liquid condenses and is collected in a separator. The condensate generally has an API gravity higher than 55°. Most condensates are composed of saturated hydrocarbons in the light gasoline range (butanes, pentanes, and hexanes) which causes the high API gravities. This gives them inferior octane numbers for gasoline. Since the condensates require reforming, they sell for less than 40° API crude oil.
- A condensate is distinguished from a light oil in that the former usually, but not always, has a gas-oil ratio greater than 5000 cubic feet of gas per barrel of oil. In addition, a condensate must exist in the gaseous state in its reservoir.