KEROSENE

Kerosene (*kerosine*, *paraffin oil*; approximately boiling range: 205 to 260°C, flash point: approximately 25°C) is a flammable pale-yellow or colorless oily liquid with a characteristic odor. The term *kerosene* is also too often incorrectly applied to various fuel oils, but a fuel oil is actually any liquid or liquid petroleum product that produces heat when burned in a suitable container or that produces power when burned in an engine.

Kerosene is a mixture of hydrocarbons ($>C_{12}$ and higher) that was first manufactured in the 1850s from coal tar, hence the name coal oil is often applied to kerosene, but petroleum became the major source after 1859. From that time, kerosene fraction has remained a product of petroleum. However, the quantity and quality vary with the type of crude oil, and although some crude oils yield excellent kerosene quite simply, others produce kerosene that requires substantial refining.

Kerosene is now produced from petroleum either by distillation or by cracking the less volatile portion of crude oil at atmospheric pressure and elevated temperatures.

Kerosene is used for burning in lamps and domestic heaters or furnaces, as a fuel or fuel component for jet engines, and as a solvent for greases and insecticides.

KEVLAR

See ***Polyamides.***

KRYPTON

See ***Rare Gases.***

LACTIC ACID

Lactic acid (2-hydroxypropionic acid, $CH_3CHOHCO_2H$, boiling point: 122°C, melting point: 18°C, density: 1.2060) is one of the oldest known organic acids. It is the primary acid constituent of sour milk and is formed by the fermentation of milk sugar (lactose) by *Streptococcus lactis*.

Commercially, lactic acid is manufactured by controlled fermentation of the hexose sugars from molasses, corn, or milk. Lactates are made by synthetic methods from acetaldehyde and lactonitrile, a by-product acrylonitrile production.

LEAD AZIDE

See ***Explosives.***

LEAD CARBONATE

Lead carbonate ($PbCO_3$) forms colorless orthorhombic crystals and it decomposes at about 315°C. It is nearly insoluble in cold water, but is transformed in hot water to the basic carbonate, $2PbCO_3 \cdot Pb(OH)_2$. Lead carbonate is soluble in acid and alkali, but insoluble in alcohol and ammonia.

Lead carbonate is prepared by treating an aqueous slurry of lead oxide with acetic acid in the presence of air and carbon dioxide:

$$PbO + CO_2 \rightarrow PbCO_3$$

or by shaking a suspension of a lead salt less soluble than the carbonate with ammonium carbonate at a low temperature to avoid formation of basic lead carbonate.

Basic lead carbonate (white lead, $2PbCO_3 \cdot Pb(OH)_2$) forms white hexagonal crystals; it decomposes when heated to 400°C. Basic lead carbonate is insoluble in water and alcohol, slightly soluble in carbonated water, and soluble in nitric acid.

It is produced by several methods, in which soluble lead acetate is treated with carbon dioxide. For example, treatment of an aqueous slurry of finely divided lead metal or monoxide, or a mixture of both, with acetic acid in the presence of air and carbon dioxide produces very fine particle-size basic lead carbonate and ranges in carbonate content from 62 to 65% (theoretical: 68.9% $PbCO_3$).

Lead carbonate has a wide range of applications. It catalyzes the polymerization of formaldehyde to high molecular weight crystalline poly(oxymethylene) products. It is used in poly(vinyl chloride) friction liners for pulleys on drive cables of hoisting engines. To improve the bond of polychloroprene to metals in wire-reinforced hoses, 10 to 25 parts of lead carbonate are used in the elastomer. Lead carbonate is used as a component of high-pressure lubricating greases, as a catalyst in the curing of moldable thermosetting silicone resins, as a coating on vinyl chloride polymers to improve their dielectric properties, as a component of corrosion-

resistant, dispersion-strengthened grids in lead-acid storage batteries, as a photoconductor for electrophotography, as a coating on heat-sensitive sheets for thermographic copying, as a component of a lubricant-stabilizer for poly(vinyl chloride), as a component in the manufacture of thermistors, and as a component in slip-preventing waxes for steel cables to provide higher wear resistance.

Basic lead carbonate has many other uses, including as a catalyst for the preparation of polyesters from terephthalic acid and diols, a ceramic glaze component, a curing agent with peroxides to form improved polyethylene wire insulation, a pearlescent pigment, color-changing component of temperature-sensitive inks, a red-reflecting pigment in iridescent plastic sheets, a smudge-resistant film on electrically sensitive recording sheets, a lubricating grease component, a component of ultraviolet light reflective paints to increase solar reflectivity, an improved cool gun-propellant stabilizer that decomposes and forms a lubricating lead deposit, a heat stabilizer for poly(vinyl chloride) polymers, and a component of weighted nylon-reinforced fish nets made of poly(vinyl chloride) fibers.

LEAD CHROMATE

Basic lead chromate [$PbCrO_4 \cdot Pb(OH)_2$] may be used as an orange-red pigment; it is an excellent corrosion inhibitor. It is manufactured by boiling white lead ($PbCO_3$) with a solution of sodium dichromate.

LEAD STYPHNATE

See ***Explosives.***

LIGNIN

Lignin occurs as a large percentage of the noncellulosic part of wood. Newer laboratory processes yield quality lignin with molecular weights of 200 to 1000, but kraft process lignin has a molecular weight of 1000 to 50,000 and is altered chemically by sulfonation.

Presently it is mostly used as a fuel, but as petroleum becomes increasingly scarce and expensive, proposals and experimental plants for using this material begin to appear. One such process uses fluid-bed hydrocracking and dealkylation to produce phenols and benzene.

Lignin derivatives, sulfonated alkali lignin and sulfite lignosulfonates, are being used to increase tertiary oil recovery in *pumped out* oil wells replacing more expensive synthetic detergents.

Lignosulfonates are metal salts of the sulfonated products of lignin and are a by-product of the pulp and paper industry. Pulping of wood with a sulfite solution dissolves the lignin portion, leaving behind the cellulose fibers that are processed into paper. The sulfite solution is concentrated and the resulting solids sold as lignosulfonates. Only a small amount of the spent sulfite liquor solids is used each year. The rest is burned to recover heat. Liquor from an alkaline sulfate pulping process can be concentrated to give a solid called alkali lignin, but little of this is used except as fuel.

See ***Lignosulfonates.***

LIGNOSULFONATES

Lignosulfonates are metal salts of the sulfonated products of lignin and are a by-product of the pulp and paper industry. Pulping of wood with a sulfite solution dissolves the lignin portion, leaving behind the cellulose fibers that are processed into paper. The sulfite solution is concentrated and the resulting solids sold as lignosulfonates. Only a small amount of the spent sulfite liquor solids is used each year. The rest is burned to recover heat. A molecular weight of 250 for the lignosulfonate monomer is approximate, but the product may contain material with a molecular weight as high as 100,000. Liquor from an alkaline sulfate pulping process can be concentrated to give a solid called alkali lignin, but little of this is used except as fuel.

The uses of lignosulfonates include the manufacture of binders, adhesives, surfactants, animal feed additives, and vanilla.

See ***Lignin.***

LIME

See ***Calcium Oxide.***

LINEAR ALPHA OLEFINS

Linear hydrocarbons with a double bond at the end of the carbon chain are produced by the polymerization, or more correctly, the oligomerization of ethylene.

$$(n+2)CH_2{=}CH_2 \rightarrow CH_3CH_2(CH_2CH_2)_nCH{=}CH_2$$

Compounds with 6 to18 carbons are the most common alpha olefins (α-olefins) and Ziegler catalysts are used in this process. Certain olefins such as nonene (C_9) and dodecene (C_{12}) can also be made by cracking and dehydrogenation of *n*-paraffins, as practiced in the petrochemical section of a refinery.

Linear alpha olefins can be copolymerized with polyethylene to form linear low-density polyethylene (LLDPE) and 1-hexene (C_6) and 1-octene (C_8) are especially useful for this purpose. In addition, linear alpha olefins are used to make detergent alcohols, oxo alcohols for plasticizers, lubricants, lube oil additives, and surfactants are other important products from linear alpha olefins.

LIQUEFIED PETROLEUM GAS

Liquefied petroleum gas (LPG) is used for domestic and industrial heating, flame weeding, tobacco curing, grain drying, and in motor vehicles, as well as for the petrochemical industry.

The constituents of liquefied petroleum gas [propane ($CH_3CH_2CH_3$) and/or butane ($CH_3CH_2CH_2CH_3$)] occur as constituents of *wet* natural gas or crude oil or as a by-product from refining. For example, a natural gasoline plant treats raw *wet* natural gas through absorption by *washing* with gas oil and fractionating out the usable fraction.

Butane can be used for the manufacture of maleic acid (thence to maleic anhydride), from which tetrahydrofuran is made by hydrogenation. Liquefied petroleum gas is also a feedstock for aromatics production (Fig. 1).

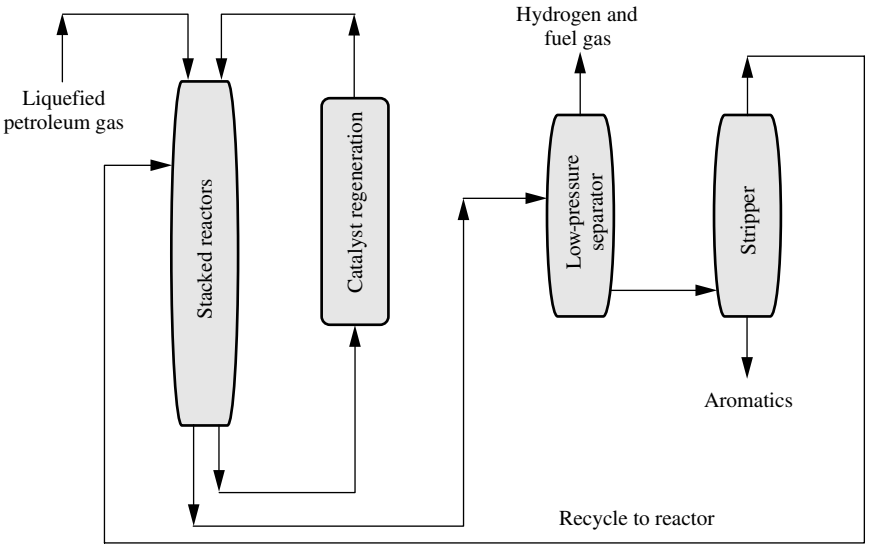

FIGURE 1 Manufacture of aromatics from liquefied petroleum gas.

LITHIUM SALTS

Spodumene is by far the most important lithium-containing ore and is used in the manufacture of lithium carbonate. Spodumene ore (beneficiated to 3 to 5% Li_2O) is converted from the alpha form to the beta form by heating to over 1000°C, since the alpha form is not attacked by hot sulfuric acid. The water-soluble lithium sulfate is leached out and reacted with sodium carbonate to yield lithium carbonate from which various salts are derived.

Lithium carbonate (Li_2CO_3), the most widely used of the compounds, is employed in the production of lithium metal and frits and enamels. Together with lithium fluoride (LiF), it serves as an additive for cryolite in the electrolytic pot line production of primary aluminum.

Lithium-base greases, especially the stearate, are efficient over an extremely wide temperature range up to 160°C. Lithium hydroxide (LiOH) is a component of the electrolyte in alkaline storage batteries and is employed in the removal of carbon dioxide in submarines and space capsules. Lithium bromide (LiBr) brine is used for air conditioning and dehumidification. Lithium hypochlorite (LiOCl) is a dry bleach used in commercial and home laundries. Lithium chloride (LiCl) is in demand for low-temperature batteries and for aluminum brazing. Other uses of lithium compounds include catalysts, glass manufacture, and, of course, nuclear energy.

LITHOPONE

Lithopone is a mixed zinc sulfide–barium sulfate brilliant white pigment that contains about 30% zinc sulfide. The original light sensitiveness of this pigment has been mitigated by purification and by the addition of such agents as polythionates and cobalt sulfate.

Lithopone is manufactured by a process (Fig. 1) in which barium sulfide solution is prepared by reducing barite ore ($BaSO_4$) with carbon and leaching the resulting mass.

$$BaSO_4 + 4C \rightarrow BaS + 4CO$$

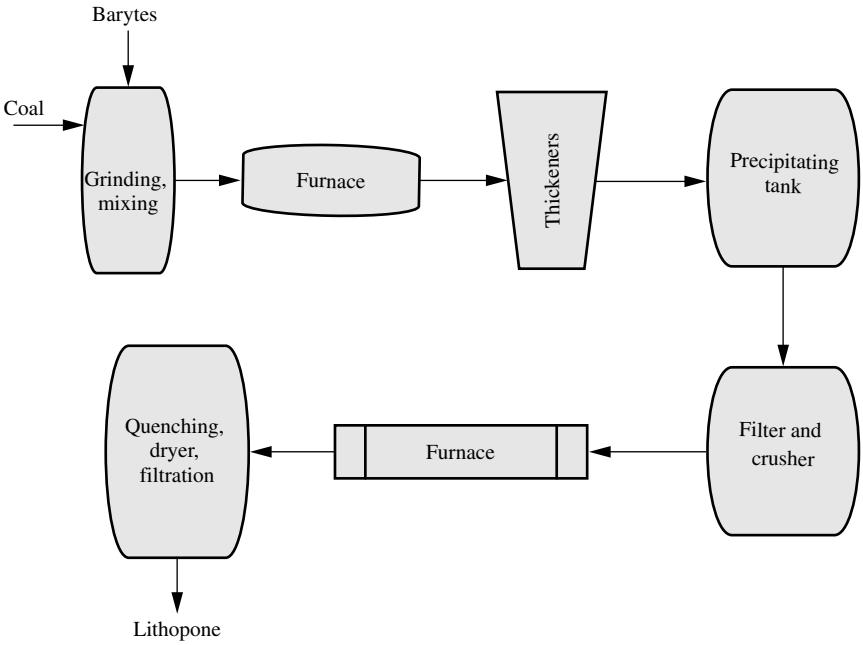

FIGURE 2 Manufacture of lithopone.

Scrap zinc or concentrated zinc ores are dissolved in sulfuric acid, the solution is purified, and the two solutions are reacted. A heavy mixed precipitate results that is 28 to 30% zinc sulfide and 72 to 70% barium sulfate.

$$ZnSO_4 + BaS \rightarrow ZnS + BaSO_4$$

This precipitate is not suitable for a pigment until it is filtered, dried, crushed, heated to a high temperature, and quenched in cold water. The second heating in a muffle furnace at 725°C produces crystals of the right optical size.

Lithopone is used in water-based paints because of its excellent alkali resistance. It is also used as a whitener and reinforcing agent for rubber and as a filler and whitener for paper.