

Petroleum Products

Petroleum products are made by refining crude oil in a refinery. A refinery is an industrial unit where crude oil is heated and then guided to a fractional distillation column where it is treated at atmospheric pressures or vacuum conditions and turned into fractions. These fractions are called strait run fractions and some are sold as final products (furnace oil), but they mostly undergo further refining through operations such as catalytic reforming, viscosity breaking or solvent bleaching before they are considered marketable. Crude oil can be refined into two thousand end products but the most important are those listed below:

Product	No. of carbon atoms	Boiling point range (Degrees Celsius)	Usage
Gas	1-4	Lower than 30	Liquid gas, petrochemical unit feed
Light naphtha	4-6	30-90	Petrochemical unit feed for producing chemicals
Heavy naphtha	6-11	90-205	Production of high octane gasoline, solvents
Gasoline	6-12	38-210	Car gasoline, production of solvents
Kerosene	10-16	150-275	Fuel for heating, jet engines, production of solvents, paraffinoids
Diesel fuel	15-25	250-385	Fuel for diesel engines, cracking unit feed
Lubcut	20-50	300-500	Industrial and engine lubricants, greases, waxes
Furnace oil	30-70	350-600	Fuel for ships, plants and factories
Residue	Higher than 70	Higher than 600	Bitumen (for road surfaces and roofs), petroleum coke

Base Oil

This product is made by passing a lubcut through processes of solvent refining, dewaxing and finally hydrofinishing. Base oil is good enough for application as lubricating film. To be used in modern engines, however, additives should be added

to base oil. Depending on usage and grade, from 2% to 15% (weight percentage) of additives are added before the oil is put to its specific use.

American Oil Association has divided base oil into the following five types based on composition and the refining processes involved:

Method	Saturate%	Sulphur%	Viscosity Index	Group
I	<90		80-119	Solvent Refining
II	90</=	0.03<	80-119	Hydrocracking
III	90>/=		+120	Severe Hydrocracking Hydroisomerization
IV	Polyalpha Olefines (PAO)			Oligomerization
V	Other Base Oils			Various

Group 4 are synthetic oils which are produced chemically. Esters, Glycols, and other base oils which don't fit in the first four groups are classified as group 5. Among these are Naphthenic oils, which, due to low content of paraffinoids, have very low viscosity. Naphthenic oils are devoid of paraffin and rich in naphthenic material (saturated cycles). Naphthenic crude oil is a rare commodity produced in only a few oil fields. Middle East oil is highly paraffinic, and base oil made from them is paraffinic too. Naphthenic base oils have very low pour points and hence are used in the formulation of oils used in chillers. It is noteworthy that those base oils of group 3 which are produced through intense hydrocracking or hydroisomerization have similar characteristics to synthetic base oils of group 4 and can be commercially distributed as synthetic base oil.

Group 1 base oils are commercially named as SN or solvent neutral, examples are: SN650, SN100, SN350, SN500, SN150.

Group 2 are commercially named as N or neutral, examples are: N600, N100, N150, N60.

Group 3 are named based on viscosity: cST4, cST6.

Bright Stock

This is a heavy base oil which can have naphthenic or paraffinic base. It is used to formulate heavy grade engine or industrial oils or special-purpose oils.

Furfural Extract (RPO)

This is an aromatic byproduct of solvent extraction units in oil refineries. In the process, lubcut feed enters the unit and is mixed with furfural solvent. The solvent separates all aromatics from the lubcut. In a separate process, aromatics are separated from furfural and furfural is recycled.

Quality of furfural extract largely depends on solvent-to-lubcut proportion and the duration of mixing.

Separated aromatics which are known as furfural extract (also as RPO or Rubber Process Oil) are sold in bulk quantities or barrels, and are used in rubber production or production of low quality fuels.

Furfural extracts are usually classified based on their combustion points.

Liquid Gas

Liquid Petroleum Gas or LPG is essentially a combination of propane (C_3H_8) and butane (C_4H_{10}). Other chemicals including propane, normal butane, propylene, butylenes and isobutene can be present in varying but limited proportion. LPG is a byproduct of natural gas refining and production and of crude oil refining. It has no color or taste or smell. It is harmful only if breathed in high volumes. To be identifiable, a sulfur compound known as mercaptan (usually a combination of ethyl mercaptan and methyl mercaptan) is added to LPG. Propane to butane proportion is an important factor. In Iran, depending on season, LPG may contain 50% to 90% butane, 10% to 50% propane, and up to 2% of heavier hydrocarbons such as pentane. Due to lower emissions and better combustion, LPG is a growing trend and its use is supported by many countries.

Naphtha

This is the lightest product made in oil refineries. There are two types of naphtha, the lighter and the heavier type. It is usually colorless but may have a brownish or reddish tint. Naphtha is used in producing aromatics and high octane gasoline (through catalytic modification), also for producing olefins in water vapor cracking units, and as solvent in petrochemical industry. The word is probably derived from

Avestan *Nepta*, meaning tar or liquid fuel. A very similar word was used to denote tar or petroleum in old Greek language.

Gasoline

This is the fuel used in internal combustion engines. There are two types: car gasoline and airplane gasoline. The first is marked by its slow burning. Burning speed is indicated by octane. Car gasoline types are also divided based on their octane, even though there are other differences such as additives, volatility, and chemical composition. Additives such as plumb tetraethyl or plumb tetra methyl increase gasoline octane.

Kerosene

This is a collective name for compounds with 10 to 16 carbons which are produced at 150 to 300 Celsius in crude oil distillation process. Kerosene is known as lantern oil and has traditionally been used for lighting houses. Kerosene is used as fuel for turbine engines, tractors, and airplanes. It is also used as the base of jet engine fuel; with the added benefit that, due to its low volatility, it seldom causes clogging. Kerosene is a colorless, mid-distillation product of oil refineries.

Diesel fuel/Gas Oil

This is a collective name for compounds with 15 to 25 carbons, heavier than kerosene, with boiling points between 250 and 370 Celsius. As the name indicates, their main usage is in diesel engines and heating installations. Diesel engines are designed to withstand high compression, and they have higher efficiency and better longevity; and these characteristics make them ideal for heavy vehicles and agricultural/industrial machinery.

Lubcut

Crude oil refining products include some very heavy hydrocarbons, with 20 to 50 carbon atoms. These are useful as lubricants. Hydrocarbons with 15 carbon atoms or lower aren't good lubricants because of their high volatility, low viscosity, and low combustion points. Lubcut is primary material for producing base oil, waxes, grease, and other lubricants. Base oil produced from lubcut comprises, on average, more than 95 weight percent of industrial and engine oil.

Mazut (Boiler Fuel)

This is a heavy product of crude oil refineries. Mazut is mainly used as fuel for industrial boilers, power plants, and large ship engines. It has better heating efficiency and generates lower emissions in comparison with coal. In the U.S and some European countries mazut use is in decline and it is usually turned into coke. In Iran, mazut is not only used as fuel for small and large industrial units, but also is a main export of the country. Mazut is produced both by refining crude oil in fractional distillation column and by performing viscosity reduction and catalytic cracking of fractional distillation column residue. Mazut is produced in many different types depending on environmental conditions and market demand. Three main mazut types are light mazut, regular mazut, and heavy mazut.

Bitumen

This is the heaviest cut in fractional distillation of crude oil. Bitumen is extracted from fractional distillation column residue and is produced in three main types: solid bitumen, semi-solid bitumen, liquid bitumen.

Semi solid or direct refined bitumen: It is essentially a fractional distillation column residue, processed in vacuum, and sometimes through mixing with oil, washing, and aeration, under specific temperature and conditions. Major application of this type of bitumen is in road surface construction, building, storage, swimming pools and dams to create surface insulation against moisture. 60/70 and 85/100 bitumen types are also called road surface bitumen and roof top bitumen.

Solid or blown bitumen: When the quality or characteristics of raw material for bitumen don't meet the intended purpose, hot air at 190 to 200 Celsius is blown on it, oxidizing the raw material; bitumen modified in this way is usually solid and hence is called solid or blown bitumen (sometimes oxidized bitumen) and the process is called bitumen oxidation.

Liquid bitumen: This is usually produced by solving pure bitumen in base oil or another solvent. Solvent weight percentage of the solution can be between 10% and 50%; and the higher this percentage the lower the viscosity will be. There are three types of liquid bitumen:

- Rapid curing cutback bitumen: This is produced by solving 60/70 or 85/100 bitumen in naphtha; the solvent rapidly evaporates and it makes this type suitable for colder environments.
- Medium curing cutback bitumen: This is produced by solving 60/70 or 85/100 bitumen in kerosene; the solvent evaporates rather slowly and hence the bitumen remains fluid enough for enough time to permeate into nooks and crannies. This type is mostly used in road surface construction in temperate environments.
- Slow curing cutback bitumen: This is produced by solving pure bitumen in heavy diesel fuel; because the solvent takes very long to evaporate this type is used to prevent dust in dust roads of warm and arid environments.

Petrochemical Products

Petrochemical products are produced by turning hydrocarbons in crude oil or natural gas into chemical products. The word petrochemical is derived from petroleum (crude oil) and chemistry. Today, petrochemical industry is a huge business which involves tens of thousands of products; including fertilizers, monomers, polymers, acids, bases, aromatics, and raw material for the chemical industry.

Petrochemical units use a wide range of feed, from natural gas to wax and the fractional distillation column residue extracted in vacuum conditions. Here is a brief list of the feed used by different petrochemical units.

- Naphtha (with diesel fuel): Lighter olefins such as ethylene, propylene, and butylenes can be produced by breaking down Naphtha molecules (in the vicinity of diesel fuel molecules). pyrolysis gasoline, acetylene, and syngas are also made from naphtha.
- Reformate and platformate: These are made in the process of transformation of naphtha; reformate is used for producing aromatics such as benzene, toluene, and xylene. Aromatics are also made by hydrogenation of pyrolysis gasoline.
- Refinery gases: Lighter olefins and paraffin such as ethane, propane, and butane can be extracted from the gas produced during crude oil refinery processes.
- Natural gas: This is a main source of methane and ethane, propane, and butane can also be extracted from it. Lighter olefins can be produced by breaking down the molecules of the three named paraffin.

- Petroleum wax: Heavier olefins (with 6 to 18 carbon atoms) can be produced by breaking down the molecules of petroleum wax. They can be extracted from normal paraffin and/or kerosene as well.
- Furnace oil: Syngas is produced by breaking down the molecules of furnace oil.
- Condensates and gas distillates: These are good sources for extracting ethane and naphtha.

After entering the petrochemical unit, the feed undergoes one or more of processes such as cracking, dehydrogenation, and solvent extraction; the result would be one or more of many thousand petrochemical products which range from textile to sanitary goods. As diverse as petrochemical products are, they can be divided into the following three main categories:

- Main (basic) products; from which other products are made. These include ethylene, propylene, sulfur, ammonium, benzene.
- Intermediate products; these are used by factories to produce consumers' goods and items. These include polyvinyl chloride (PVC) and melamine.
- Final products; these are either consumer products or used in consumer products. These include synthetic fiber, plastic items, fertilizers, rubber.

In petrochemical units, through processes such as cracking, hydrocarbons of distillation column sidecuts and natural gas are turned into basic chemicals. These basic chemicals are of two main types: olefins (such as ethylene, propylene, butylene, butadiene), and aromatics (such as benzene, toluene, and xylene). Later, in chemical transformation units, these basic chemicals are turned into any of the following four groups of chemical products:

1- Industrial chemicals

2- Plastics

3- Resins

4- Elastomers