Petrochemicals

Saudi Arabian petrochemical plant. Source: Creative Commons

(Source: Alan Clements)
Complete petrochemical plant at Teesside, England.

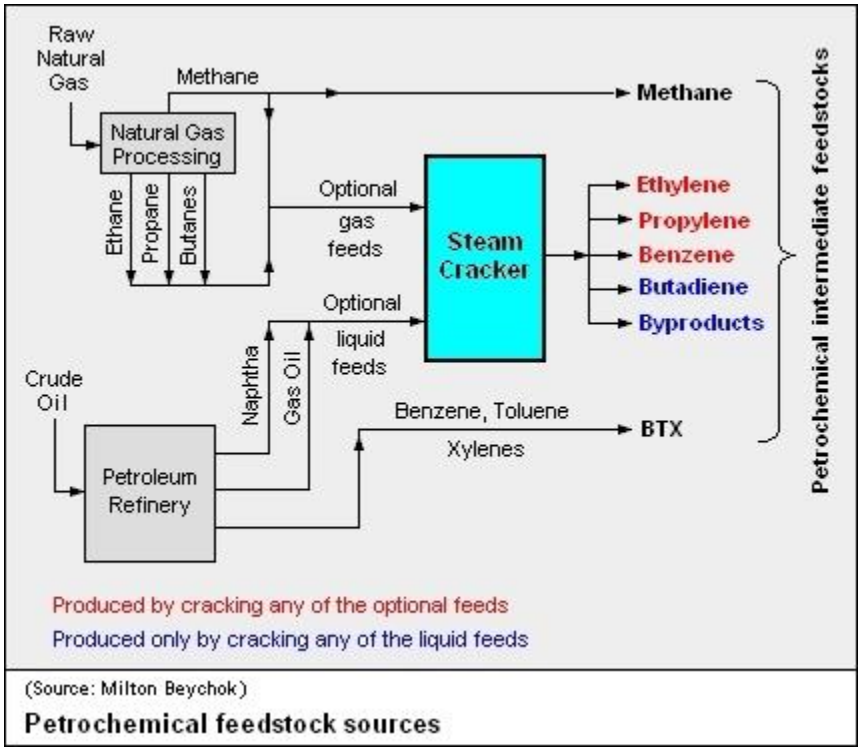
Petrochemicals are chemical products made from thehydrocarbons present in raw natural gas and petroleum crude oil. The largest petrochemical manufacturing industries are to be found in the USA, Western Europe, Asia and the Middle East.

A relatively small number of hydrocarbon feedstocks form the basis of the petrochemical industries, namelymethane, ethylene, propylene, butanes, butadiene, benzene, toluene and xylenes.[1][2]

As of 2007, there were 2980 operating petrochemical plants in 4320 locations worldwide.[3] The petrochemical end products from those plants include plastics, soaps, detergents, solvents, paints, drugs, fertilizer, pesticides, herbicides, explosives, synthetic textile fibers and rubber, flooring and insulating materials and more.

Petrochemicals are found in such common consumer products as aspirin,automobiles, clothing, compact discs, video tapes, electronic equipment, furniture, and a host of others.[4]

Feedstock sources



The adjacent block flow diagram schematically depicts the major hydrocarbon sources used in producing petrochemicals:

- ***Methane, ethane, propane and butanes:*** Obtained primarily fromnatural gas processing plants.
- ***Naphtha:*** Obtained primarily frompetroleum refineries.
- ***Benzene, toluene and xylenes, as a whole referred to as BTX:*** Primarily obtained from petroleum refineries by extraction from the reformate produced in catalytic reformers.
- ***Gas oil:*** Also obtained primarily from petroleum refineries.

Methane and BTX (benzene, toluene and xylenes) are used directly as feedstocks for producing petrochemicals. However, the ethane, propane, butanes, naphtha and gas oil serve as optional feedstocks for steam-assisted thermal cracking plants referred to as *steam crackers* that produce these intermediate petrochemical feedstocks:[5][6]

- ***Ethylene***
- ***Propylene***
- ***Benzene***
- ***Butenes and butadiene***

In 2007, the amounts of ethylene and propylene produced in steam crackers were about 115 Mt (megatonnes) and 70 Mt, respectively.[7] The output ethylene capacity of large steam crackers ranged up to as much as 1.0 – 1.5 Mt per year.[8][9].

Steam crackers are not to be confused with steam reforming plants used to produce hydrogen and ammonia.

Worldwide usage of optional steam cracking feedstock sources

As of 2004, the percentage of the worldwide steam cracking plants using each of the optional steam cracking feed sources was:[10]

- Ethane: 35%
- Propane: 9%
- Butanes: 3%
- Naphtha: 45%

- Gas oil: 5%
- Other: 3 %

The effect of feedstock on the steam cracking yields of intermediate petrochemical products

The effect of feedstock selection upon the yields of steam cracking products is summarized in the table below:

Steam cracking feedstocks versus yields of intermediate petrochemical products

	Product Yields				
Feedstock source	**Ethylene weight %**	**Propylene weight %**	**Butadiene weight %**	**Aromatics [a] weight%**	**Other [b] weight %**
Ethane	84.0	1.4	1.4	0.4	12.8
Propane	45.0	14.0	2.0	3.5	35.5
Butane	44.0	17.3	3.0	3.4	32.3
Naphtha [c]	34.4	14.4	4.9	14.0	32.3
Gas oil [d]	25.5	13.5	4.9	12.8	43.3

(a) Includes benzene, toluene, xylenes and any other aromatics.

(b) Includes hydrogen, methane, butenes, non-aromatic portion of pyrolysis gasoline and fuel oil.

(c) Full-range naphtha (as differentiated from light or heavy naphtha).

(d) The portion of petroleum crude oil that has a boiling range of about 250 to 550 °C. That encompasses the boiling range of atmospheric gas oil (AGO) produced by the atmospheric distillation of petroleum crude oil and the boiling range of vacuum gas oil (VGO) produced by the vacuum distillation of petroleum crude oil.

Feedstocks and example petrochemical products

The table below includes some representative examples of the petrochemical end products produced from the eight hydrocarbon feedstocks – methane, ethylene, propylene, butenes, butadiene, benzene, toluene and xylenes:

Feedstocks and example petrochemical products

methane	ethylene	propylene	butenes and butadienes	benzene	toluene	xylenes
hydrogen	polyethylene	polypropylene	styrene-butadiene rubber (SBR)	styrene	benzoic acid	phthalic anhydride
ammonia	ethanol	isopropanol	methyl *tert*-butyl ether (MTBE)	polystyrene	toluene diisocyanate	polyesters
methanol	ethylene glycol	propylene glycol	polybutadiene	phenol	polyurethanes	dimethyl terephthalate
methyl chloride	vinyl acetate	allyl chloride	acrylonitrile-butadiene-styrene (ABS)	cumene	caprolactam	terephthalate acid
carbon black	perchloroethylene	acrylonitrile	polybutenes	aniline	nylons	polyethylene terephthalate
acetylene	polyvinyl acetate	acrylic acid	methyl ethyl ketone (MEK)	adipic acid	polyureas	dioctyl phthalate
formaldehyde	glycol ethers	epoxy resins	*tert*-butanol	nylons		

References

1. ^Sami Matar and Lewis F. Hatch (2001), *Chemistry of Petrochemical Processes*, Gulf Professional Publishing, ISBN 0-0-88415-315-0.
2. ^Staff (March, 2001), "Petrochemical Processes 2001", *Hydrocarbon Processing*, pp. 71-246, ISSN 0887-0284.
3. ^Petrochemical Industry – Worldwide.
4. ^Petrochemicals Chart From the website of the National Petrochemical & Refiners Association.
5. ^SBS Polymer Supply Outlook
6. ^Editor: Jean-Pierre Favennec (2001), *Petroleum Refining: Refinery Operation and Management*, Editions Technip, ISBN 2-7108-0801-3.
7. ^Editors: Hassan E. Alfadala, G.V. Rex Reklaitis and Mahmoud M. El-Halwagi (2009), *Proceedings of the 1st Annual Gas Processing Symposium, Volume 1: January, 2009 - Qatar*, 1st Edition, Elsevier Science|pages, pp. 402-414, ISBN 0-444-53292-7.
8. ^Cracker capacities From the website of the Association of Petrochemicals Producers in Europe (APPE).
9. ^Ethylene Production (pdf page 3 of 12 pdf pages).
10. ^Richard Meyers (2003), *The Basics of Chemistry*, Greenwood Press, ISBN 0-313-31664-3.