Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering Department

Petroleum Refining Processes

Fourth Class

Lecture 17

By

Jasim I. Humadi

Isomerization Process (Light Naphtha)

Isomerization is the process in which light straight chain paraffins of low RON (C6, C5 and C4) are transformed with proper catalyst into branched chains with the same carbon number and high octane numbers. The hydrotreated naphtha (HTN) is fractionated into heavy naphtha between 90–190 °C (190–380 F) which is used as a feed to the reforming unit. Light naphtha C5 - 80 °C (C5 - 180 F) is used as a feed to the isomerization unit. There are two reasons for this fractionation: the first is that light hydrocarbons tend to hydrocrack in the reformer. The second is that C6 hydrocarbons tend to form benzene in the reformer. Gasoline specifications require a very low value of benzene due to its carcinogenic effect.

Reactor operating conditions

- Reaction temperature = 95–205°C.
- Reaction pressure = 1725–3450 kPa.
- Hydrogen to hydrocarbon molar ratio = 0.05:1

Hydrogen is used to minimize carbon deposits on the catalyst but hydrogen consumption is negligible.

Typical feed and product composition of an isomerization unit

LSR component	Feed weight	Product weight	RONC (unleaded)
Isopentane	22	41	92
Normal pentane	33	12	62
2,2-Dimethybutane	1	15	96
2,3-Dimethybutane	2	5	84
2-Methylpentane	12	15	74
3-Methylpentane	10	7	74
Normal hexane	20	5	26
Total	100	100	

Isomerization Catalysts

The most common catalyst for isomerising n-butane is platinum (Pt) on alumina promoted by chloride. The high activity of this catalyst allows operation at relatively low temperature. This is beneficial because the reaction is controlled by equilibrium; at low temperature, equilibrium favors isobutane. Pt/alumina catalysts can't be regenerated, and they are highly sensitive to water and other contaminants. In units that isomerize n-pentane and n-hexane, the reactions are catalyzed either by Pt/alumina or Pt on zeolite. The zeolite catalysts require higher temperatures, but they are less sensitive to water. As with butane isomerization, the reactions are controlled by equilibrium, so lower reaction temperatures favor branched isomers. The high temperatures required by zeolite catalysts reduce the octane of the product relative to products made at lower temperatures with chlorided alumina catalysts. A comparison of the operating conditions for the alumina and zeolite processes is shown in Table below

Comparison of operating conditions of isomerization

Operating condition	Pt/Chlorine Alumina catalyst	Pt/Zeolite catalyst
Temperature (°C)	120–180	250–270
Pressure (bar)	20–30	15–30
Space velocity (h^{-1})	1–2	1–2
H_2/HC (mol/mol)	0.1–2	2–4
Product RON	83–84	78–80

Isomerization Reactions

Isomerization is a reversible and slightly exothermic reaction:

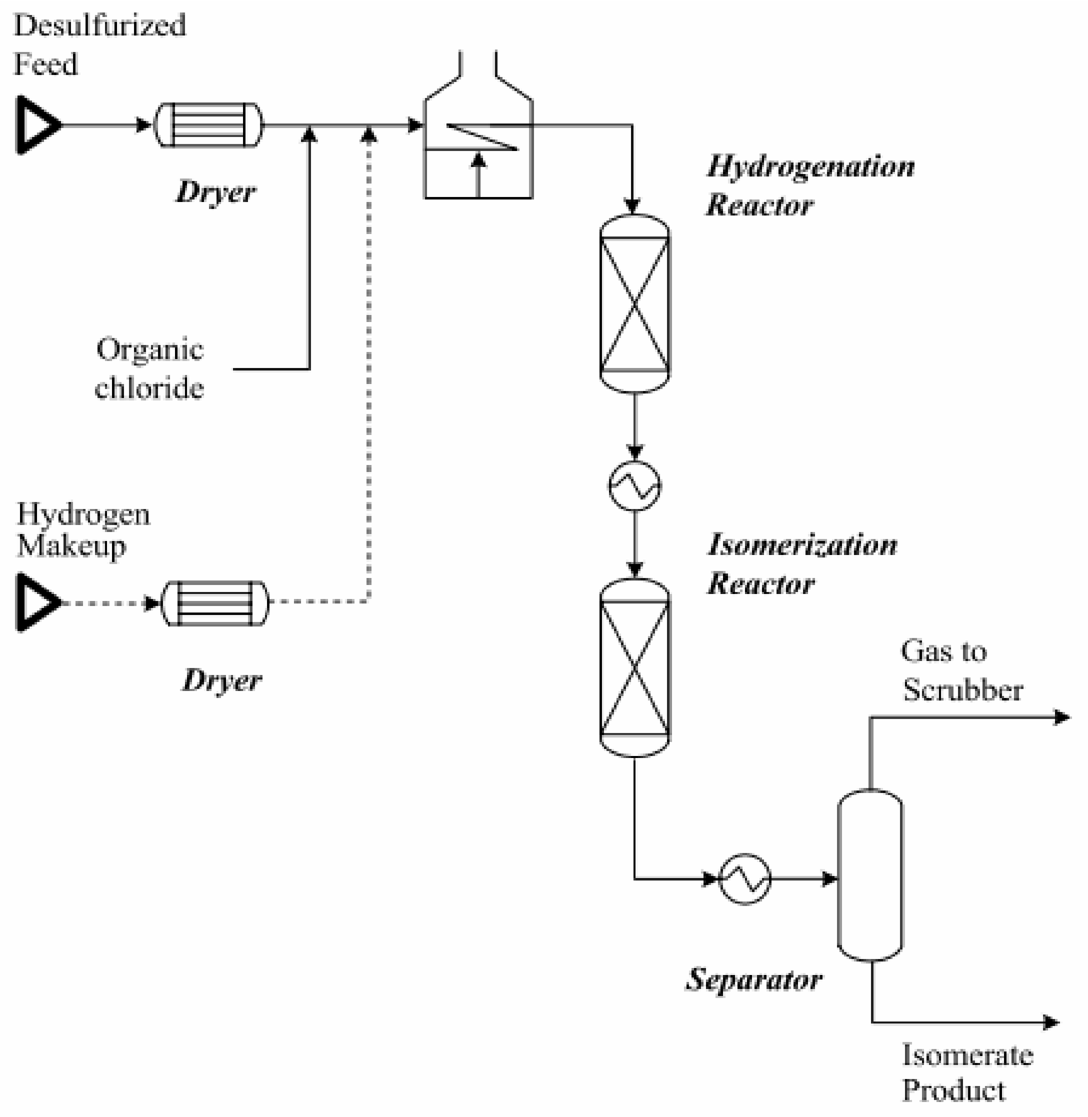
$$n\text{-paraffin} \rightleftharpoons i\text{-paraffin}$$

The conversion to iso-paraffin is not complete since the reaction is equilibrium conversion limited. It does not depend on pressure, but it can be increased by lowering the temperature. However operating at low temperatures will decrease the reaction rate. For this reason a very active catalyst must be used.

Process Flow: C5 C6 Isomerization (Process description)

Pentane/hexane (C5 C6) isomerization processes increase the octane of light gasoline. In a typical unit, dried, hydrotreated feed is mixed with a small amount of organic chloride and recycled hydrogen, then heated to reaction temperature. Process objectives determine whether one or two reactors are used. In two-reactor units

(Figure below), the feed flows first to a saturation reactor, which removes olefins and (to a large extent) benzene. After saturation, the feed goes to an isomerization reactor, where normal paraffins are converted to isoparaffins. The reactor effluent flows to a product separator, where hydrogen is separated from the other reaction products. Recovered hydrogen can go to a recycle compressor, which returns it to the reactors, or it can be treated and sent to the fuel gas system. Separator liquids go to a stabilizer column, which removes light gases and remaining dissolved hydrogen. The stabilized liquid goes to storage or gasoline blending. If sent to a fractionator, n-pentane and n-hexane can be recycled to the isomerization unit for increased conversion.



C_5C_6 isomerization: two reactors, once-through hydrogen

Isomerization Yields

The reformate yield from light naphtha isomerization is usually very high (>97 wt%). Typical yields are given in Table below:

Isomerization yield

Component	Yield (wt%)
C_3	0.348
iC_4	0.619
nC_4	1.770
C_5^+	97.261

Example: **light naphtha with a specific gravity of 0.724 is used as a feed to the isomerization unit at a rate of 100 m3 /h. Find the product composition.**

Solution: **Appling the yield guidelines of Table above, the product composition are presented in Table below.**

Isomerization yields

	wt%	kg/h
Feed	100	72,400
Product		
C_3	0.348	251.9
iC_4	0.619	448.2
nC_4	1.770	1281.5
C_5^+	97.261	70,417
Total		72,399