Production of Cumene from Benzene and Propylene

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Background

Cumene, also known as isopropylbenzene, is used as a thinner in paints, lacquers and enamels. It is a component of high octane motor fuels. Cumene is used to manufacture other chemicals such as phenol, acetone, acetophenone and methyl styrene. It is also in used in the manufacture of rubber, iron & steel, and pulp & paper.

The production of Cumene involves reaction of benzene with propylene in a high temperature, high pressure gas phase reactor:

$$C_6H_6 + C_3H_6 \rightarrow C_9H_{12}$$

There is also a sequential reaction of cumene and propylene to form undesirable product, *p*-diisopropylbenzene:

$$C_9H_{12} + C_3H_6 \rightarrow C_{12}H_{18}$$

Both these reactions are irreversible.

Description

Fresh feed streams of benzene and mixed C3 enters the process as liquids. Feed streams after being mixed are fed to the vaporizer and leaves at 483.15 K and 25 bar. It is pre-heated in two heat exchangers. The first recovers heat from the hot reactor effluent at 692.15 K. The second adds additional heat to bring the reactor inlet temperature up to 647.15 K. Then the stream enters a tubular reactor which leaves as reactor effluent at 692 K and is cooled to 607K through feed-effluent heat exchanger.

The reactor effluent is further cooled down to 363 K using a condenser and sent to a flash drum by reducing the pressure to 1.7 atm through a pressure reduction valve. The gas stream obtained from the tank is used as fuel and the liquid stream is fed to first distillation column. The first column comprises of 15 stages with feed being fed in the 8^{th} stage. Benzene is obtained as distillate in the top which is recycled back to the reactor. The stream obtained as bottoms is fed to another distillation column. Second column has 20 stages and feed is sent in the 12^{th} stage. Cumene of higher purity is obtained as distillate and *p*-diisopropylbenzene is obtained in the bottoms.

Results

	Gas	C3	Fresh Benzene	p-DIB	Cumene
Temperature (K)	363.15	298.15	298.15	474.17212	424.87021
Pressure (atm)	2.3320687	24.673082	24.673082	0.98692327	0.98692327
Mass Flow (kg/h)	586.32736	4396.8948	15622.812	14.53898	11516.617
Molar Flow (kmol/h)	10.199988	104.24016	200.00016	0.089605975	95.833377
Volumetric Flow (m3/h)	125.63186	8.6662076	17.846664	0.020805009	15.480057
Mixture Density (kg/m3)	4.6670276	507.36089	875.39121	698.82114	743.96476
Mixture Molar Weight (kg/kmol)	57.483142	42.18043	78.114	162.25459	120.17334
Molar Fraction (Mixture) / Propane	0.466558	0.049933	0	0	1.99E-13
Mass Flow (Mixture) / Propane (kg/h)	209.8526	229.52594	0	0	8.42E-10
Molar Fraction (Mixture) / Propylene	0.164671	0.950067	0	1.33E-20	4.17E-14
Mass Flow (Mixture) / Propylene (kg/h)	70.678841	4167.3688	0	5.02E-20	1.68E-10
Molar Fraction (Mixture) / Benzene	0.340878	0	1	3.40E-14	0.000500468
Mass Flow (Mixture) / Benzene (kg/h)	271.59859	0	15622.812	2.38E-13	3.746464
Molar Fraction (Mixture) / Cumene	0.0278908	0	0	0.000390104	0.99949009
Mass Flow (Mixture) / Cumene (kg/h)	34.193489	0	0	0.0042014642	11512.723
Molar Fraction (Mixture) / P-diisopropylbenzene	2.32E-06	0	0	0.9996099	9.44E-06
Mass Flow (Mixture) / P-diisopropylbenzene (kg/h)	0.0038409795	0	0	14.534779	0.14681593

References

Luyben, William L. “Design and Control of the Cumene Process” *Industrial & Engineering Chemistry Research*, vol. 49, no. 2, 2010, pp. 719-734.

Flowsheet Source: http://www.chemsep.com/downloads/index.html