

### **3. VARIOUS PROCESSES OF MANUFACTURE AND PROCESS SELECTION**

#### **VARIOUS PROCESSES OF MANUFACTURE:**

Currently almost all cumene is produced commercially by two processes.

1. A fixed bed, Kieselguhr supported phosphoric acid catalyst system developed by UOP (Universal Oil Products Platforming Process).
2. A homogeneous  $\text{AlCl}_3$  and hydrogen chloride catalyst system developed by Monsanto.

#### **1. UOP Cumene Process:**

Propylene feed fresh benzene feed and recycle benzene are charged to the upflow reactor, which operates at 3-4 Mpa and at 200-260°C. The solid phosphoric acid catalyst provides an essentially complete conversion of propylene on a one-pass basis. The typical reactor effluent yield contains 94.8 Wt. % cumene and 3.1 Wt. % of diisopropylbenzene. The remaining 2.1 % is primarily heavy aromatics. This high yield of cumene is achieved without transalkylation of diisopropylbenzene and is unique to the solid phosphoric acid catalyst process.

The cumene product is 99.9 Wt. % pure and the heavy aromatics, which have an octane number of 109, can either be used as high octane gasoline blending components or combined with additional benzene and sent to a transalkylation section of the plant where diisopropylbenzene is converted to cumene. The overall yields of cumene for this process are typically 97-98 Wt. % with transalkylation and 94-96 Wt. % without transalkylation.

#### **2. Monsanto – Lummus Crest Cumene Process:**

Dry benzene, fresh and recycle and propylene are mixed in the alkylation reaction zone with  $\text{AlCl}_3$  and hydrogen chloride catalyst at a temperature of less than  $135^\circ\text{C}$  and a pressure of less than 0.4 Mpa. The effluent from the alkylation zone is combined with recycle polyisopropyl benzene and fed to the transalkylation zone, where polyisopropyl benzenes are transalkylated to cumene. The strongly acidic catalyst is separated from the organic phase by washing the reactor effluent with water and caustic.

The distillation system is designed to recover a high purity cumene product. The unconverted benzene and polyisopropyl benzene are separated and recycled to the reaction system. Propane in the propylene feed is recovered as liquid petroleum gas.

The overall yields of cumene for this process can be high as 99 Wt. % based on benzene and 98 Wt. % based on propylene. But these processes have been used more extensively for the production of ethylbenzene than for the production of cumene.

### **PRODUCTION OF CUMENE USING ZEOLITE CATALYSTS:**

There are two new processes using zeolite based catalyst systems, which were developed in the late 1980's.

#### **1. UNOCALS TECHNOLOGY IS BASED ON A CONVENTIONAL FIXED-BED SYSTEM:**

Unocal has introduced a fixed bed liquid phase reactor system based on a Y-type zeolite catalyst. The selectivity to cumene is generally between 70 and 90 Wt. %. The remaining components are primarily polypropyl benzenes, which are transalkylated to cumene in a separate reaction zone to give an overall yield to cumene of about 99 Wt. %. The distillation requirements involve the separation of propane for LPG use,

the recycle of excess benzene to polypropyl benzene for transalkylation to cumene and the production of purified cumene product.

2. The second zeolite process, which was developed by CR&L, is based on the concept of catalytic distillation, which is a combination of catalytic reaction, and distillation in a single column. The basic principle is to use the heat of reaction directly to supply heat for fractionation. This concept has been applied commercially for the production of MTBE but has not yet been applied commercially to cumene.

## **MANUFACTURE OF CUMENE BY PROPYLENE ALKYLATION OF BENZENE:**

### **A) FLOW SHEET:**

**B) CHEMICAL REACTIONS:**

a) Main Reaction:



Isopropyl benzene (Cumene)

b) Side Reaction:



Polyisopropyl benzene

**C) PROCESS DESCRIPTION:**

Propylene feed is mixed with benzene and pumped at 25 atms into the top of a reactor packed stage wise with  $\text{H}_3\text{PO}_4$  impregnated catalyst. The temperature is maintained at approximately  $250^\circ\text{C}$ . The reactor bottoms are separated into benzene, cumene and polycumenes in the remaining stills.