

# Ethylbenzene: Steady State

Consider the Ethylbenzene(EB) process shown in Figure 1. The process consists of two reactors and three columns along with two liquid recycle streams, as in Figure 1. The reaction chemistry consists of three reactions.



Fresh benzene and fresh ethylene (5% ethane) are the raw material fed to the plant. Complete ethylene conversion occurs in two CSTRs. The reaction section effluent is fractionated in the C1 column to purge fuel gas from the top of C1 and its bottom is sent to the C2 column to recover and recycle unreacted benzene back to the first CSTR. The bottoms are fractionated in the C3 column to recover 99.9 mol % pure ethyl benzene (EB) as the distillate. The diethyl benzene (DEB) drops down the bottom and is recycled to the second CSTR. The DEB is allowed to build in the recycle loop so that the DEB formation rate by the side reaction exactly matches the DEB trans alkylation rate for no net DEB formation. The DEB is thus recycled to extinction.

Table 1: **Reaction Kinetics and other Model Details<sup>a</sup>**

Reaction	Kinetics
$C_2H_4 + C_6H_6 \longrightarrow C_8H_{10}$	$r_1 = 1.528 \times 10^6 \exp \frac{-17000}{RT} C_B C_E$
$C_2H_4 + C_8H_{10} \longrightarrow C_{10}H_{14}$	$r_2 = 2.778 \times 10^7 \exp \frac{-20000}{RT} C_{EB} C_E$
$C_6H_6 + C_{10}H_{14} \longrightarrow 2C_8H_{10}$	$r_f = 1 \times 10^3 \exp \frac{-15000}{RT} C_B C_D$

<sup>a</sup> $C_B$ : Benzene Composition.  $C_E$ : Ethylene Composition.  $C_{EB}$ : Ethylbenzene Composition.  $C_D$ : DEB Composition. Composition units:  $kmol \cdot m^{-3}$ . Activation energy: cal/mol. Reaction rate units:  $kmol \cdot m^{-3} \cdot s^{-1}$ . R:  $8.316 kJ \cdot kmol^{-1}$ . Thermodynamic package: Chao-seader.

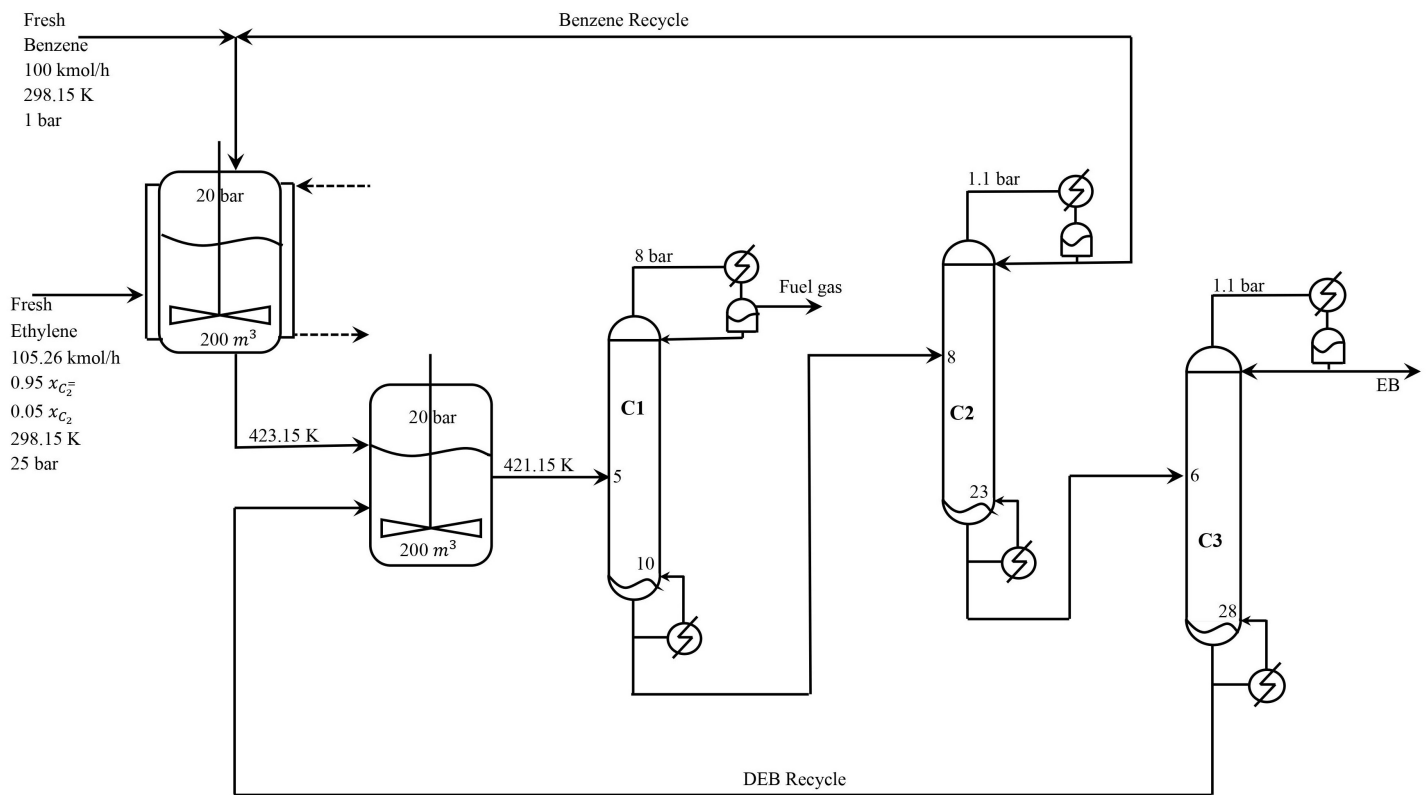


Figure 1: Ethyl Benzene Process

Converge the flowsheet in Aspen plus for a fresh ethylene flow rate of 105.26 kmol/h with an EB product purity of 99.9 mol% the main operating condition are shown in the figure above.