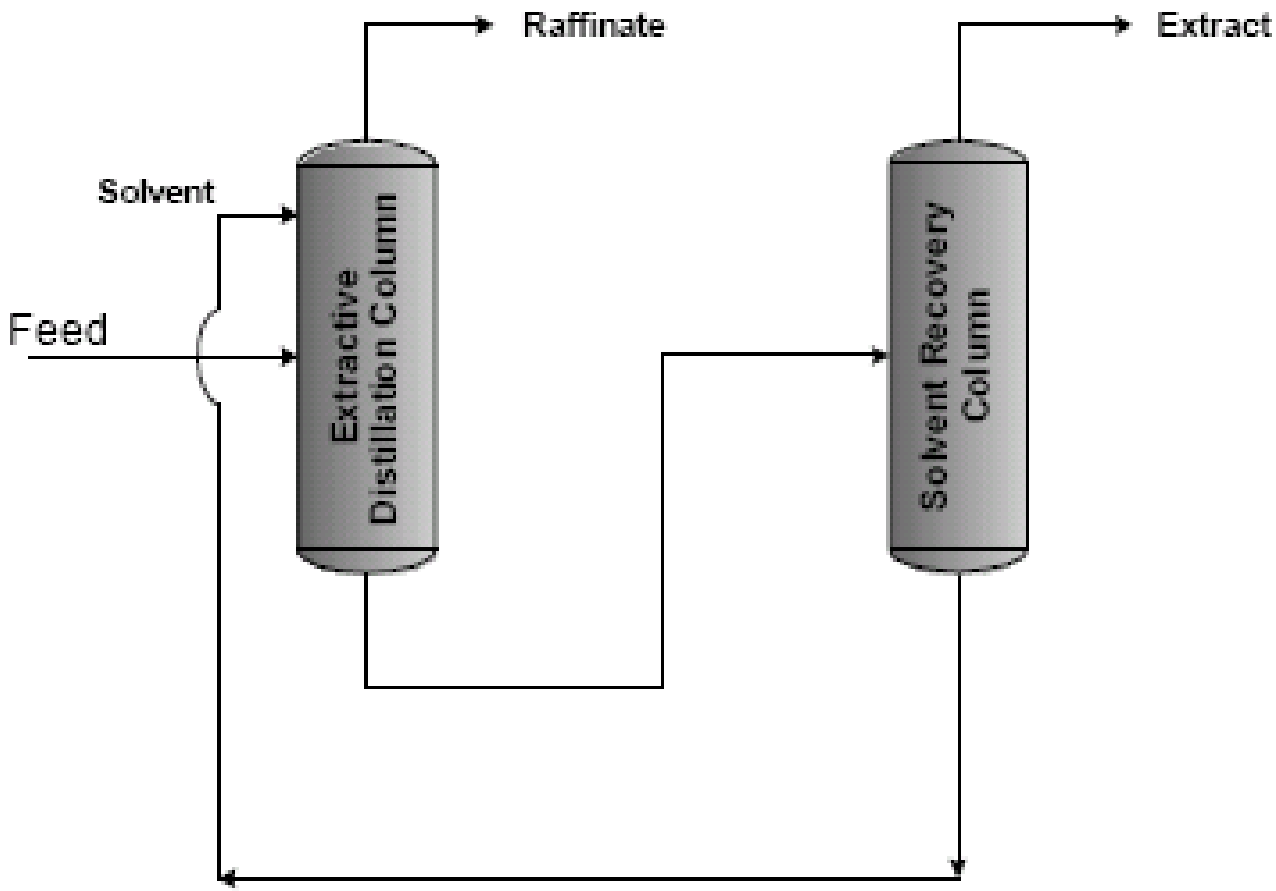
Extractive Distillation

What Is Extractive Distillation?

- Extractive distillation is a vapor-liquid process operation that uses a third component, or solvent, to effect a chemical separation
- The extractive agent creates or enhances the volatility difference between the components to be separated.
- The extractive agent and the less volatile component flow to the bottom of the distillation column, where the
- extracted component is recovered by a subsequent distillation
- The non-extracted species are distilled to the top of the extractive distillation tower.

Extractive Distillation Configuration

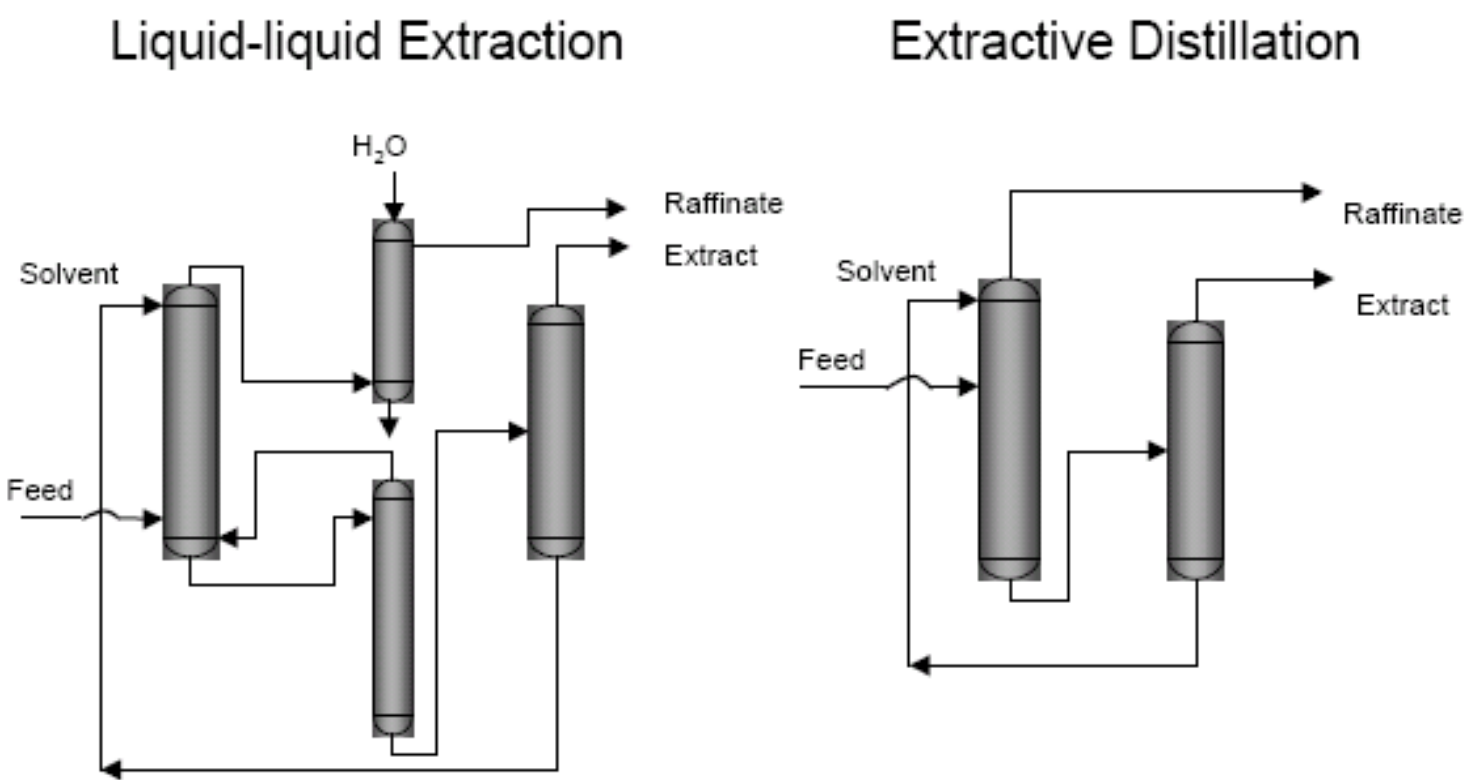


Choice of Solvent

- Should enhance significantly the natural relative volatility of the key component.
- Should not require an excessive ratio of solvent to nonsolvent (because of cost of handling in the column and auxiliary equipment.
- Should remain soluble in the feed components and should not lead to the formation of two phase.
- Should be easily separable from the bottom product.
- Should be inexpensive and readily available.
- Should be stable at the temperature of the distillation and solvent separation.
- Should be nonreactive with the components in the feed mixture.
- Should have a low latent heat.
- Should be noncorrosive and nontoxic

ED for Aromatics Recovery

- Liquid-liquid extraction (LLE) was for many years the primary choice for aromatics recovery due to narrow boiling feed fractions



LLE vs. ED

- The basic configuration for LLE requires four units, in contrast to the two required for ED
- ED systems now use better heat integration
- smaller and fewer pieces of equipment
- enhanced mass transfer devices
- they exhibit improved operability and controllability

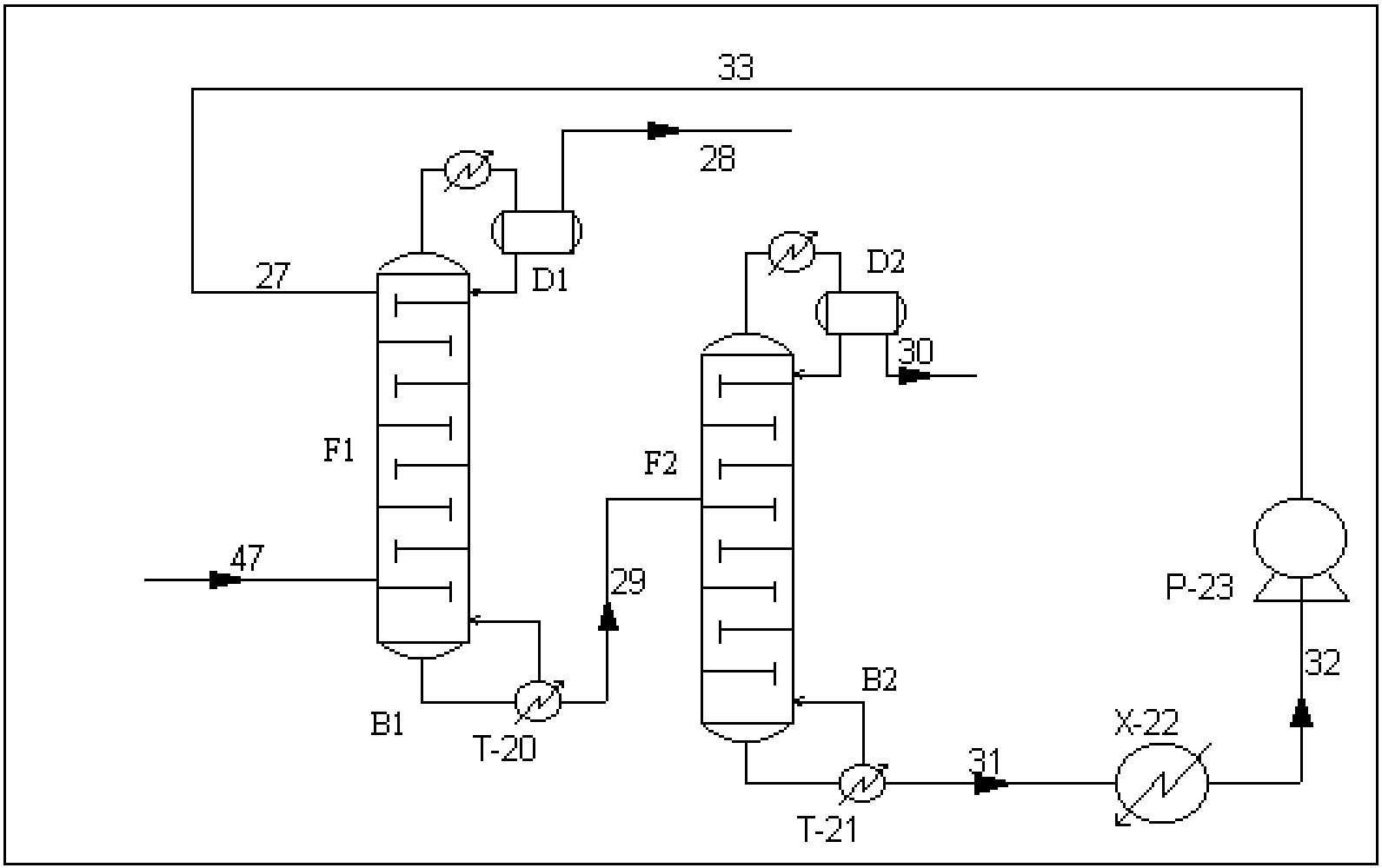
Case study

- deals with the azeotropic mixture formed between benzene and cyclohexane (91 C). At 150 kPa, cyclohexane and benzene will have boiling points of 94.34 C and 93.49 C respectively
- Recommended solvent for the benzene-cyclohaxane mixture from the literature is *propylene glycol*

Column operation

- The extractive distillation unit of this cyclohexane production plant consists of two distillation columns. The first column acts as an extractive column where the solvent is introduced at the second stage of the column, so that it will be present throughout the column and exits with the bottoms.
- The bottom product of the first column will then fed to the second column, i.e. the solvent recovery column, to undergo the normal distillation to separate both the components for further usage, i.e. benzene being recycled to the reactor for further conversion while solvent to the first column for reuse.

distillation unit for cyclohexane production plant (schematic)



distillation unit for cyclohexane production plant (tabular)

Unit Operation and Stream	Description	Operating parameter
Distillation Column		
1. T-20	First column (extractive column)	1.1 Operating pressure: 150 kPa 1.2 Number of tray: 45 1.3 Solvent (Stream 27)feed tray = 2 1.4 Feed (Stream 47)tray = 28
(i). T-21	Second column (Solvent recover column)	Operating pressure = 105 kPa 1.1.1 Number of tray: 20 1.1.2 Feed stream: 10
Heat exchanger		
1.0 X-22	Cool down the solvent for recycling	T_{out} = 80°C
Pump		
1.1.2 P-23	Pump the solvent for recycling	P_{out} = 150 kPa
Stream		
1. Stream 27	Solvent stream of 1,2-propanediol (ethylene glycol)	Molar flowrate = 3600 kgmol/hr
(i). Stream 47	Feed stream	Total molar flowrate = 355.43 kgmol/hr (refer to **Table 2**)
(ii). Stream 28	Product stream of Column T-20 distillate (cyclohexane)	Molar flowrate = 158.75 kgmol/hr with the purity of 99.3%.
(iii). Stream 29	Benzene-Solvent stream of bottom product from Column T-20, fed to solvent recovery column T-21.	Total molar flowrate = 3795.5 kgmol/hr with 94.8% of solvent
(iv). Stream 30	Product stream of Column T-21 distillate (Benzene) for recycle.	Total molar flowrate = 223.91 kgmol/hr with 84.96% of benzene
(v). Stream 31	Solvent stream of bottom product from Column T-21 (Solvent) for recycle.	Total molar flowrate = 3571.6 kgmol/hr with 99.87% of solvent