TRIPLE PRESSURE SWING COLUMN FOR SEPARATION OF TERNARY ACETONITRILE-METHANOL-BENZENE AZEOTROPIC SYSTEM

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Operational Relevance:

A complex and common ternary mixture of Acetonitrile-Methanol-Benzene mixture is encountered in Chemical and Pharmaceutical industries. Acetonitrile is used in Lithium ion batteries, Methanol with the recent implementations to blend in with petrol to mitigate pollution and Benzene in the polystyrene industries. The exposure to these chemical cause irritation of central nervous systems. Therefore , its attractive and necessary to separate and reuse these chemicals to protect environment and conserve resource. It is difficult to attain with conventional distillation due to presence of a ternary azeotrope with varied distillation boundaries.

Mixture System Info:

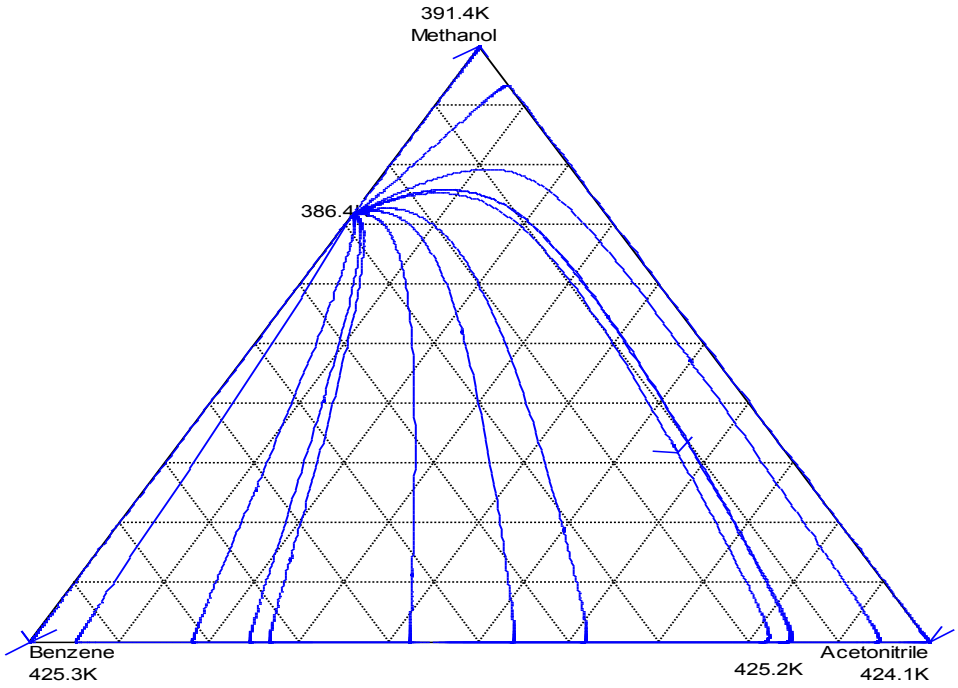
Component	Boiling Point K
Acetonitrile (A)	354.63
Methanol (M)	337.68
Benzene (B)	353.28

System	Temperature K	Azeotropic Composition (Wt %)
Methanol-Acetonitrile	336.55	76.49 (Methanol)
Methanol-Benzene	331.39	38.53 (Methanol)
Acetonitrile-Benzene	345.94	31.66(Acetonitrile)

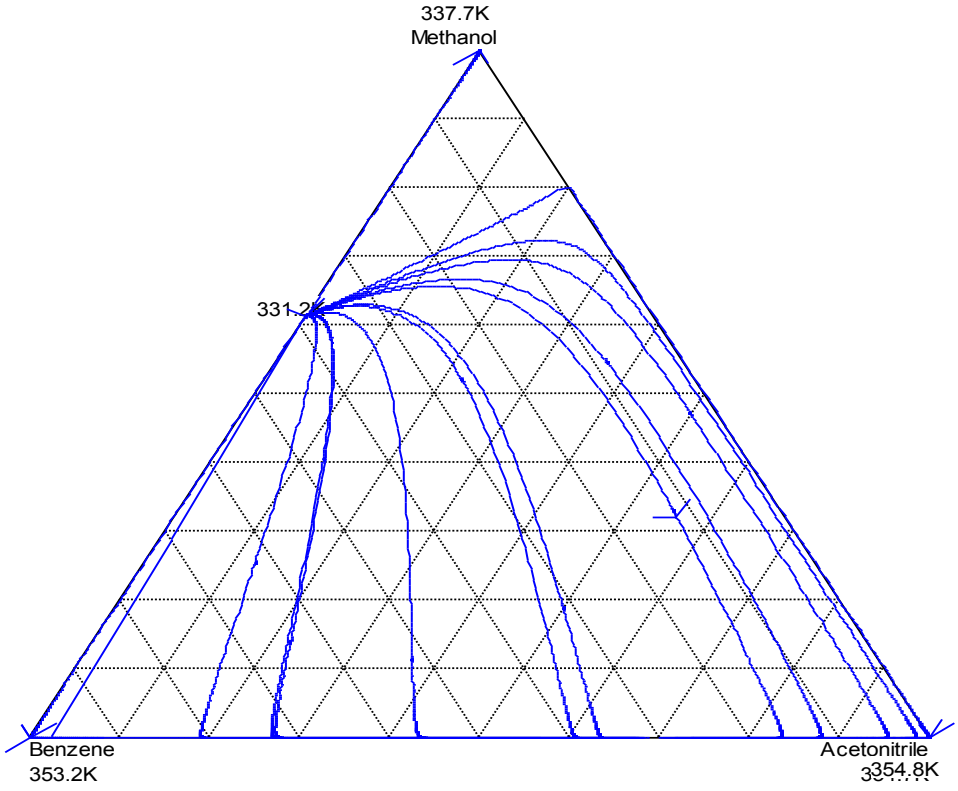
The influence of pressure on the azeotropic composition and temperature is a decisive factor and Residue Curve maps at different operating pressures are used to ascertain the optimization parameters for this multi-component separation. A pressure swing moves the distillation boundaries that lie between the corresponding purity values of desired products, thereby making the separation feasible.

Process Flowsheet:

The process consists of 3 Pressure swing columns (referred C1,C2,C3) operating at 608-101.326-608 KPa pressures respectively. 1000 kg/hr of feed (0.7 M - 0.2 A- 0.1B) is fed to the 37th stage of a 47 staged distillation column (C1) along with the recycle stream of the C3 fed to 28th stage. The bottoms has pure Acetonitrile while the distillate (D1) is sent to C2 where it is faced with a reduced pressure. D1 is fed to the 18th stage of a 50 staged Column with the bottoms yielding pure methanol and overhead (D2) fed to C3. D2 is fed to the fourth of 14 staged column where the bottoms is pure benzene and the overhead is recycled back to C1. The Residue Curve Map for the compositions at the given pressure is shown below.



RCM 608 KPa



RCM at 101.325 KPa

Results:

The thermodynamic models employed while simulating are:

a. The vapour phase is assumed to be ideal

b. The liquid phase activity coefficients are modelled by Wilson Parameters.

c. Extended Antoine for enthalpies calculation.

	RECYCLE	METHANOL	FEED	D3	D2	D1	BENZENE	ACETONITRILE	
Temp.	388.19	337.662	323	388	332	387.83	424.786	424.195	K
Pressure	6.00049	0.996792	6.00 049	6.00	0.99	6.0004	6.00049	6.00049	atm
Mass Flow	1351.9	701.291	1000	1351	1452	2152.8	99.652	198.952	kg/h
Mass Frac.(A)	0.07664 15	0.00128083	0.2	0.07	0.07	0.0487	0.00528044	0.999207	
Mass Frac.(M)	0.45649	0.998719	0.7	0.45	0.42	0.611	4.87786E-10	0.000772222	
Mass Frac.(B)	0.46686	2.7839E-17	0.1	0.46	0.50	0.3392	0.99472	2.06336E-05	

Conclusions & Recommendations:

1. Any configuration can be used for separation A-M-B, A-B-M, M-A-B . Design variables include specifying product purities, feed location, the number of trays on each column, reflux ration and boiler load. Higher reflux increases yield at the expense of reboiler duty. The optimisation is so complex that PSDOS (Pressure Swing Distillation Optimised Software) has to be used and A-M-B sequence was reported to have minimum TAC.

2. In many Pressure swing operations, the different temperatures and pressures give an option for heat integration. The condenser duty of the third column could be used in the reboiler in second column(which operates at 6 times lesser pressure) which could result in lower energy costs and the optimum sequence pressure.

References:

1. Zhu et al Pressure swing Distillation of A-M-B system.

2. Distillation Design by William L.Luyben