




LIQUID-LIQUID EXTRACTION

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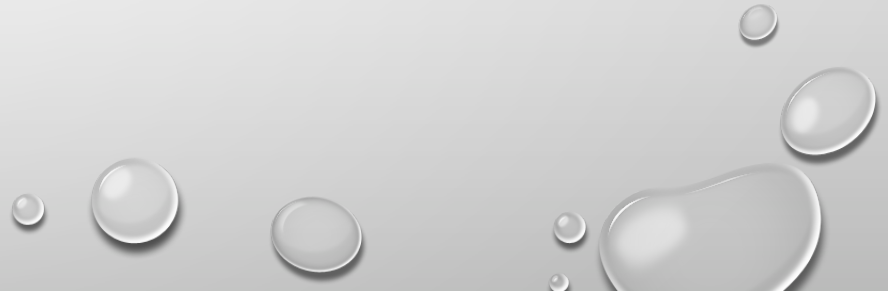
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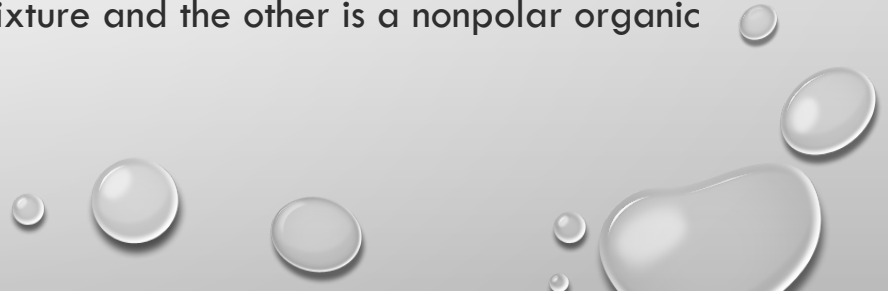


PRESENTATION OUTLINE

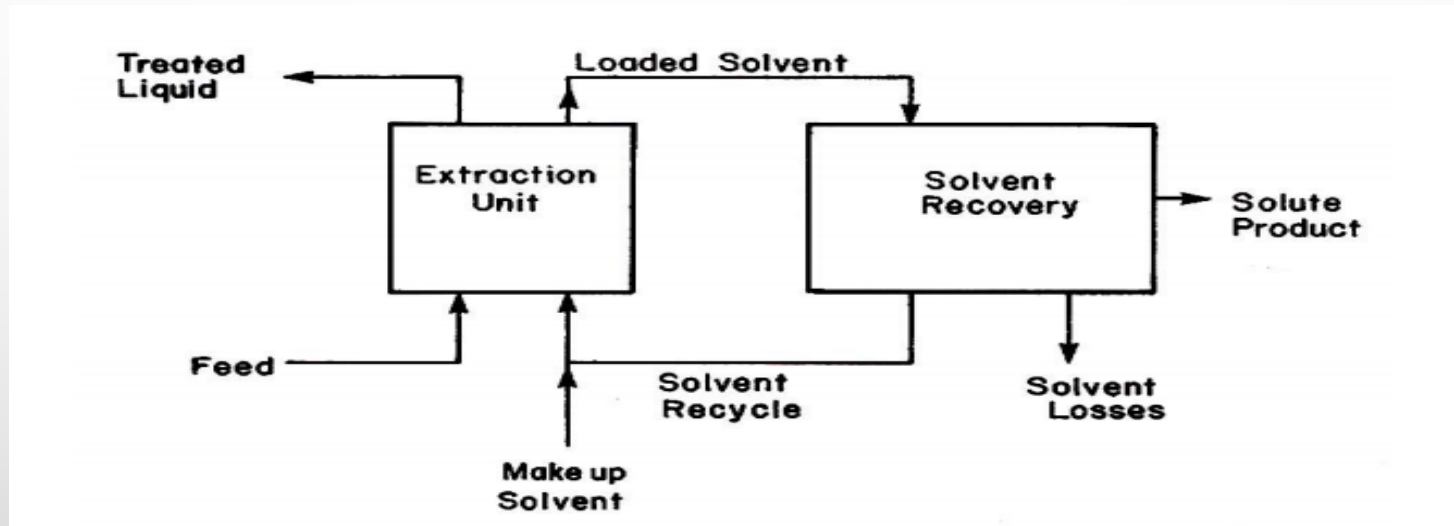
- Description of liquid-liquid extraction
 - Basic mass and energy balance equations
 - Basic design and operating principles
 - Uses of liquid-liquid extraction
 - Limitations of liquid-liquid extraction
 - Applications of liquid-liquid extraction in industries
 - Differences with other unit operations
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PROCESS DESCRIPTION

- Extraction is a process where one or more solute(s) are removed from one liquid phase (diluent) by transferring that/those the solute(s) to another liquid phase (or a solvent)
 - Accordingly, extraction is suitable for separating materials that may decompose or denature at elevated temperature
 - Normally, the diluent + the remaining solute is called the raffinate phase, while the second solvent + the solute is called the extract phase
 - Frequently, one of the solvents is water or an aqueous mixture and the other is a nonpolar organic liquid
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PROCESS DESCRIPTION (CONT'D)

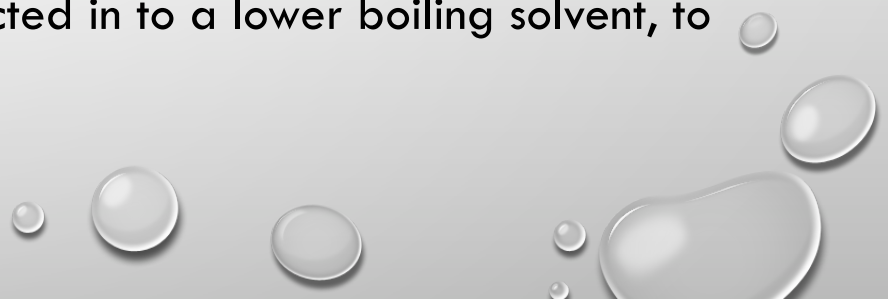


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<<http://prodpran.Che.Engr.Tu.Ac.Th/AE335/09%20liquid-liquid%20extraction.Pdf>> [accessed 1 april 2021].



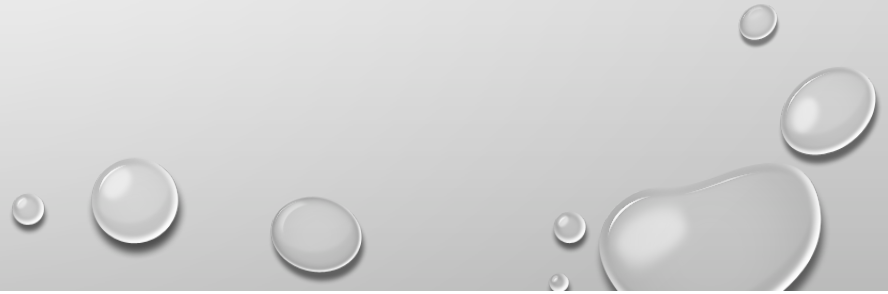
WHEN IS IT USED?

An alternative to distillation:

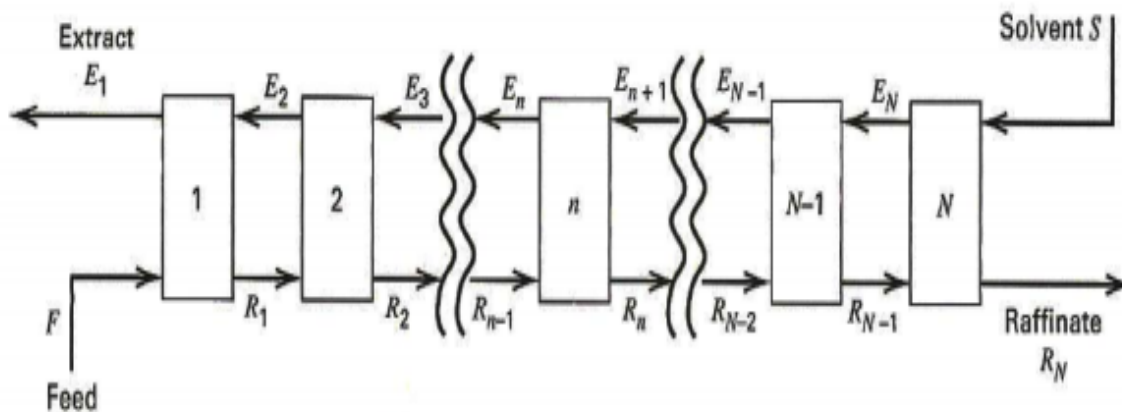
- Where the components in the feed have close boiling points.
 - Extraction in a suitable solvent may be more economic if the relative volatility is below 1.2.
 - If the feed components form an azeotrope.
 - If the solute is heat sensitive, and can be extracted in to a lower boiling solvent, to reduce the heat history during recovery
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CHOOSING A SUITABLE SOLVENT

- Affinity for solute
 - Density: the greater the density difference between the feed and extraction solvents, the easier it will be to separate the solvents.
 - Miscibility
 - Safety
 - Cost
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MASS BALANCE



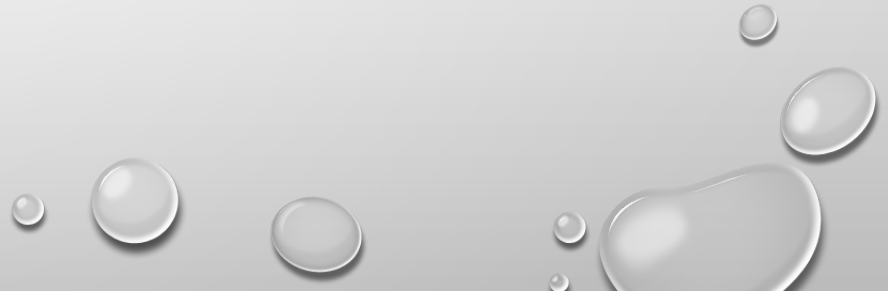
Performing the overall mass balance from stage 1 to stage **N** results in:

$$F + S = E_1 + R_N$$

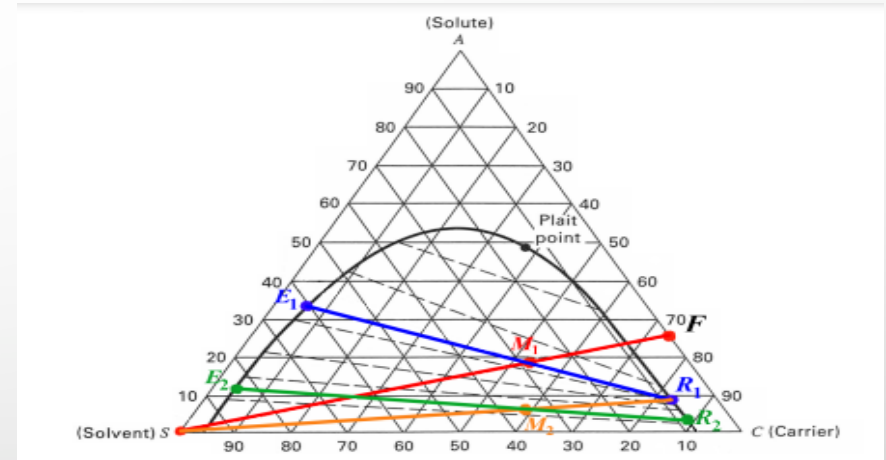
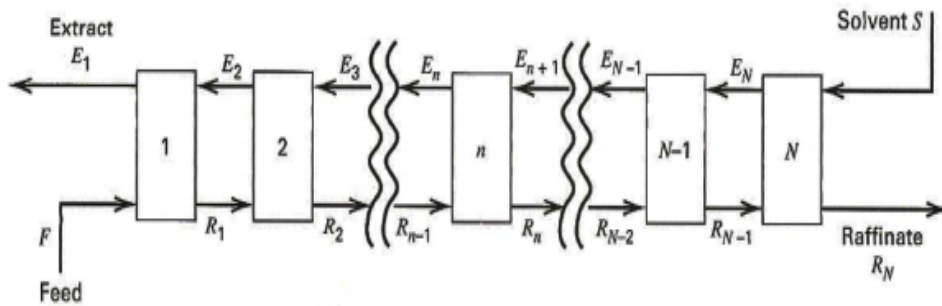
mazzotti, m., gabrielli, p., gazzani, m. and milella, f., 2016. *MEMBRANE SEPARATIONS RATE CONTROLLED SEPARATION PROCESSES*. 1st ed. [ebook] zurich. Available at: <https://ethz.ch/content/dam/ethz/special-interest/mavt/process-engineering/separation-processes-laboratory-dam/documents/education/RCS/Membrane_course.pdf> [Accessed 10 March 2021].



BASIC DESIGN OF AN EXTRACTOR

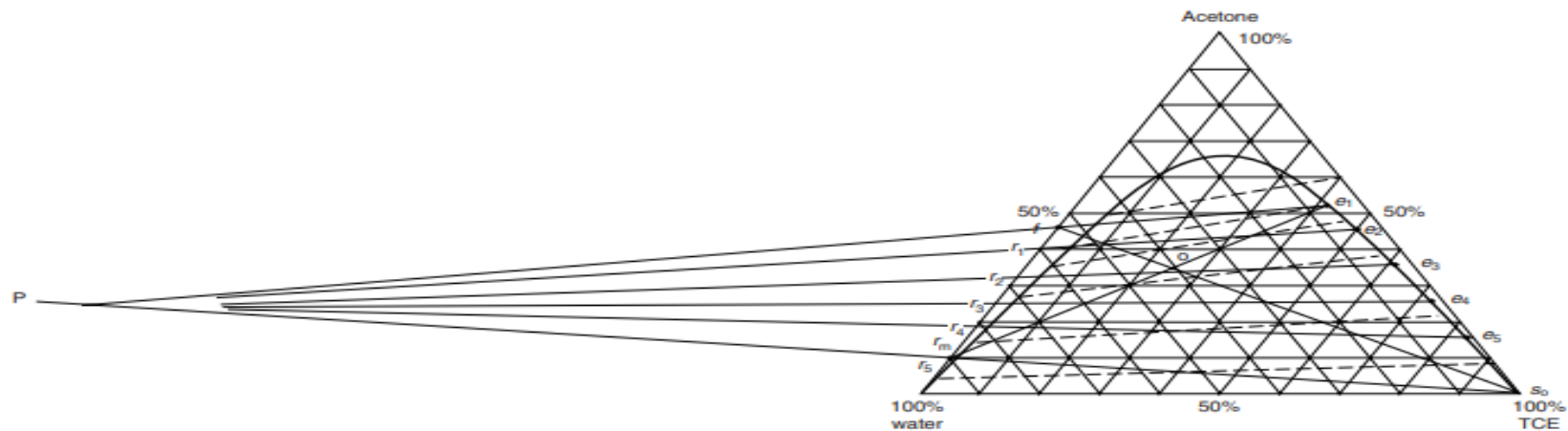
- The number of stages required
 - Column height
 - Relative density of the solvents to be used
 - Operating conditions
 - Feed, solvent & raffinate compositions
 - Distribution coefficient
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LOCATING THE OPERATING POINT (HUNTER NASH'S APPROACH)



Youtube.Com. 2021. *Before you continue to youtube.* [Online] available at:
<<https://www.Youtube.Com/watch?V=zosilkkjd1u>> [accessed 8 april 2021].

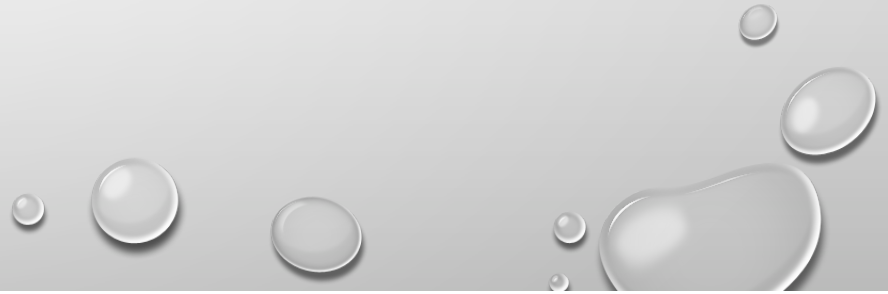
LOCATING THE OPERATING POINT (USING HUNTER NASH'S APPROACH)



Google docs. 2021. Coulson richardson s chemical engineering. Vol. 6 chemical engineering design 4th ed.Pdf. [Online] available at: <<https://drive.Google.Com/file/d/0b2xntfjlgslwqxlmawvrtmxzyve/view>> [accessed 30 march 2021].

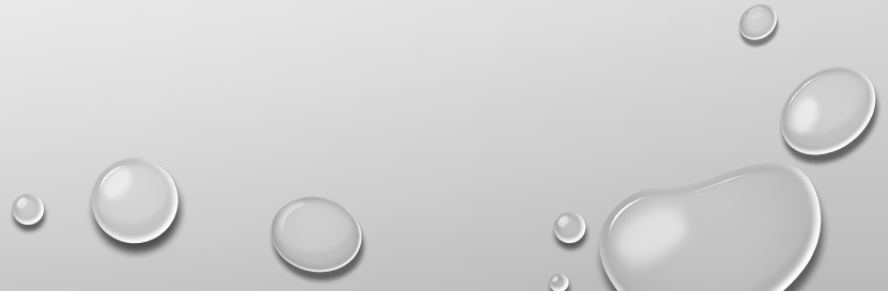


USES OF LIQUID-LIQUID EXTRACTION

- Extraction of valuable products from fermentation broth
 - Removal of high boiling organics from waste water such as phenol, aniline, etc.
 - Purification of heat sensitive materials such as pharmaceuticals, flavor, fragrances
 - Recovery of products from reactions such as agricultural chemicals.
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MOST COMMON INDUSTRIAL APPLICATIONS OF LLE

- Chemical industries: recovery of products from reactions, recovery of high boiling organics from wastewater, washing of acids/ bases from organic streams.
 - Pharmaceuticals- separation of penicillin from fermentation liquors.
 - Waste water treatment
 - Petroleum refining- separating high purity products such as toluene, olefins.
 - Food processing-refining of vegetable oils.
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LESS COMMON INDUSTRIAL APPLICATION LIQUID-LIQUID EXTRACTION

- Purification of base metals
- Refining of precious metals
- Ore extraction



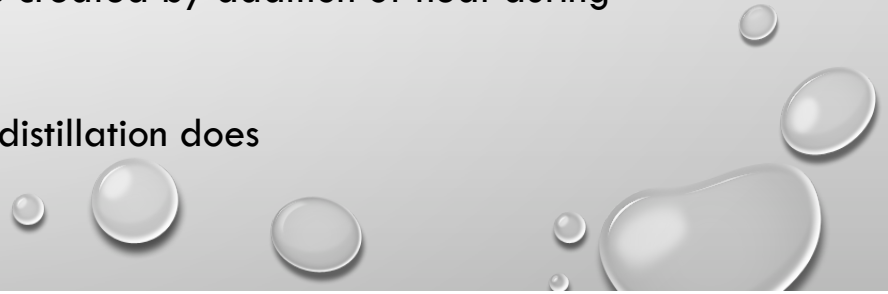


LIMITATIONS

- It involves a great deal of time with laborious shaking
 - Can result in formation of emulsions that are hard to break
 - Consumes large amount of organic solvent
 - Glassware must be cleaned after each use
 - Generates considerable wastes
 - Low selectivity
 - Need to use high volumes of solvent which can lead to environmental pollution
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DIFFERENCES BETWEEN LIQUID-LIQUID EXTRACTION (LLE) AND DISTILLATION

- LLE uses differences in solubilities of solutes in two solvents while distillation uses differences of boiling points of components in a mixture
 - LLE uses selective solubility as a degree of separation while distillation uses relative volatility as a degree of separation
 - LLE doesn't produce pure products while distillation produces almost pure products
 - LLE uses a separating funnel while a distillation apparatus is used for distillation
 - No new phases created during LLE while new phases are created by addition of heat during distillation
 - LLE doesn't require heating and cooling provisions while distillation does
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