

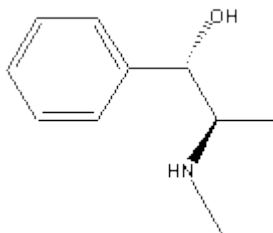
EPHEDRINE

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LIFE CYCLE INVENTORY SUMMARY

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CHEMISTRY



Ephedrine

PROCESS SUMMARY:

Ephedrine occurs in certain plants of the genus *Ephedra*, which includes a large number of species. These are distributed throughout the temperate and subtropical regions of Europe, Asia and America.

Ephedrine, having the solubility reactions of a typical alkaloid is easily separated from an extract of the plant.

The plants are powdered and then extracted with methanol, the remainder of the plants are filtered off and the extract is concentrated and treated with sodium carbonate. The methanol from the concentration step is sent back for the extraction of the plants.

The alkaloid is then extracted with ether from the concentrated extract. Upon removal and recycle of the solvent, ephedrine is crystallized from ethanol and the final product separated from ethanol by filtration.

All solvents have been recycled with an efficiency of 90%. Distillation energy was added in the cradle to gate roll up data.

Summary of LCI information

Product: Ephedrine
CAS RN: 299-42-3
Basis: 1 kg Ephedrine
References: Ullmann's Encyclopedia of industrial chemistry, VCH Publishers, 1985
Hurlbut, R.A. and Carr., J. R., J. of AOAC Intl., 81(6),1121-1127, 1998
Yamasaki. K., et al. Chem. Pharm. Bulletin. 22(12), 2898-2902, 1974
Yamasaki. K., Fujita, K, Chem. Pharm. Bulletin. 27(1), 43-47, 1979
Chen, K., Ephedrine and related substances, Williams & Wilkins, 193

Plant Location:

Comments: 1) The product is sold as 99% pure
2) Data were calculated through process design

Materials

Inputs

Material	Amount	Units	Comments
Ephedra plants	215.700	kg	
Methanol	194.000	kg	
Sodium Carbonate	0.100	kg	
Ether	37.000	kg	
Ethanol	3.990	kg	
Water	10.000	kg	
Total	460.790	kg	

Outputs

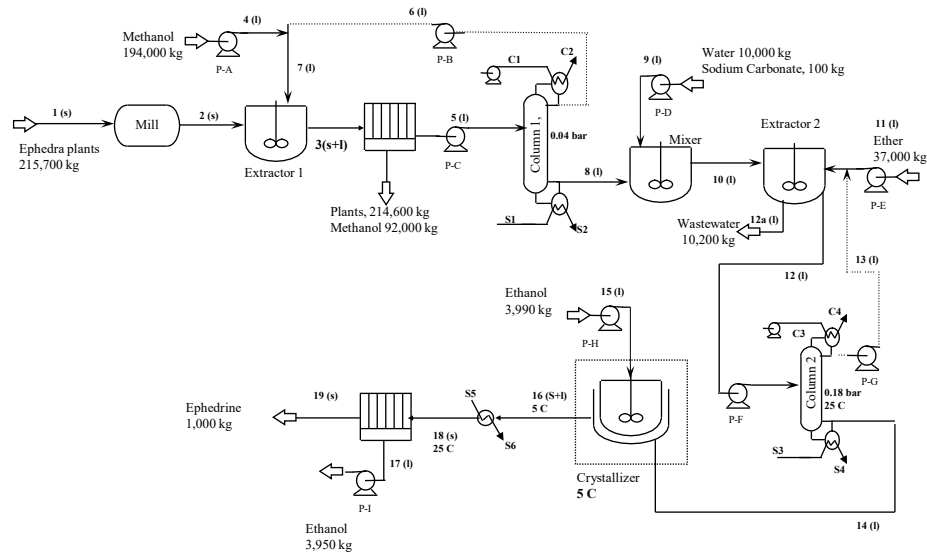
Material	Amount	Units	Comments
Ephedrine	1.000	kg	Product (solid)
Plant Residue	306.600	kg	
<i>Plants</i>	214.600	kg	
<i>Methanol</i>	92.000	kg	
Wastewater	10.200	kg	
<i>Methanol</i>	0.055	kg	
<i>Sodium Carbonate</i>	0.090	kg	
<i>Water</i>	10.000	kg	
<i>Ephedrine</i>	0.055	kg	
Ethanol	3.950	kg	
Fugitive Emissions	139.040	kg	
<i>Ethanol</i>	0.040	kg	
<i>Ether</i>	37.000	kg	
<i>Methanol</i>	102.000	kg	
Total	460.790	kg	

Plant Residue	306.600	kg				
<i>Plants</i>	214.600	kg				
<i>Methanol</i>	92.000	kg				
Wastewater	10.200	kg				
<i>Methanol</i>	0.055	kg				
<i>Sodium Carbonate</i>	0.090	kg				
<i>Water</i>	10.000	kg				
<i>Ephedrine</i>	0.055	kg				
Ethanol	3.950	kg				
Fugitive Emissions	139.040	kg				
<i>Ethanol</i>	0.040	kg				
<i>Ether</i>	37.000	kg				
<i>Methanol</i>	102.000	kg				
Total	460.790	kg				
Energy Requirements						
Concept	Amount	Units	Comments			
Electricity	39,868	kJ				
Heating--Steam	3.36E+07	kJ				
Heating--Fuel	na	na				
Cooling--Water	-3.36E+07	kJ				
Cooling--Refrigerant	-298.82	kJ				
Cooling-- other fluid	na	na				
Potential Heat Recovery	0.00	kJ				
Net Energy	3.36E+07	kJ	Σ (Heat, Electricity, Potential Heat Recovery)			
Process Emissions						
Chemical	Amount			Units	Comments	
	Air	Liquid	Solid	Solvent		
Ephedrine		0.055			kg	
Ethanol	0.004		0.40	3.950	kg	
Ether	0.074		3.63		kg	
Methanol	0.194	0.055	19.15		kg	
Plants			214.600		kg	
Sodium Carbonate		0.090			kg	
<i>Water</i>		10.000			kg	
Total Contaminated Water	10.00	kg				
Total Chemical Emissions	242.19	kg				

PROCESS DIAGRAM INTERPRETATION SHEET

- 1) As much as possible, standard symbols are used for all unit processes.
- 2) Only overall input and output chemicals are labeled on these diagrams. All intermediate information is given on the attached Process Mass Balance sheet
- 3) The physical state of most streams is shown (gas, g; liquid, l; solid, s)
- 4) The process numbering is as follows,
 - generally numbers progress from the start to the end of the process
 - numbers are used for process streams
 - C i , i = 1,..n are used for all cooling non-contact streams
 - S j , j = 1,..n are used for all steam heating non-contact streams
- 5) Recycle streams are shown with dotted lines
- 6) For most streams, the temperature and pressure are shown, or indicated in general with a note at the end of the page.

Ephedrine [299-42-3] Last modified: 25-Apr-99



Notes:

- 1) Unless otherwise noted, all the units are operated at room temperature
- 2) Unless otherwise noted, all the units are operated at atmospheric pressure

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Mass Balance Sheet

Product: Ephedrine [299-42-3]

Physical State of Chemical Losses:

Gas	Liquid	Solid
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Negative amounts indicate that the stream is an output

Stream #	Total Flow	Ephedra plants	Methanol	Ephedrine	Sodium Carbonate	Water	Ether	Ethanol
	kg	kg	kg	kg	kg	kg	kg	kg
1	215,700	215,700	0	0	0	0	0	0
2	215,700	215,700	0	0	0	0	0	0
3	10,452,700	215,700	10,237,000	0	0	0	0	0
4	194,000	0	194,000	0	0	0	0	0
5	10,238,100	0	10,237,055	1,045	0	0	0	0
5a	-306600	-214,600	-92,000	0	0	0	0	0
6	10,043,000	0	10,043,000	0	0	0	0	0
7	10,237,000	0	10,237,000	0	0	0	0	0
8	1,100	0	55	1,045	0	0	0	0
9	10,100	0	0	0	100	10,000	0	0
10	11,200	0	55	1,045	100	10,000	0	0
11	37,000	0	0	0	0	0	37,000	0
12	1,811,000	0	0	990	10	0	1,810,000	0
12a	-10200	0	-55	-55	-90	-10,000	0	0
13	1,810,000	0	0	0	0	0	1,810,000	0
14	1,000	0	0	990	10	0	0	0
15	3,990	0	0	0	0	0	0	3,990
16	4,990	0	0	990	10	0	0	3,990
17	-3950	0	0	0	0	0	0	-3,950
18	1,000	0	0	990	10	0	0	0
19	-1,000	0	0	-990	-10	0	0	0
Fugitive Em	-139040	0	-102,000	0	0	0	-37,000	-40

Energy

A) Heating Requirements

<u>Unit Process</u>	<u>kJ/kg Product</u>	<u>Comments</u>
Reboiler for Column 1	31,767,058.82	
Reboiler for Column 2	1,785,882.35	
Heater	298.82	
TOTAL	33,552,941.18	

B) Cooling Requirements

<u>Unit Process</u>	<u>kJ/kg Product</u>	<u>Comments</u>
Crystalizer	-298.82	Refrigeration
Condenser for Column 1	-31,767,058.82	
Condenser for Column 2	-1,785,882.35	
TOTAL	-33,553,240.00	

C) Electricity

<u>Unit Process</u>	<u>kJ/kg Product</u>	<u>Comments</u>
Agitators	27,868	
Filters	10,780	
Mill	1,149	
Pumping	71	Estimated with 0.003 kJ/kg pumped
Total	39,868	

* For cooling and heating requirements, an 85% of heat transfer efficiency is assumed and included in these calculations.

** For distillation, a reflux ratio of 1.3 was assumed

Physical Properties Table

Substance	MW	Cp (J/mol-K)	ΔH_f (kJ/mol)	ΔH_v (kJ/mol)	Tb (C)
Ephedrine	165.23	345*	----	----	39 (f) 200(v)
Ethanol	46.07	112.68 (l)	-277 (l)	46.42	78.5
Ether	74.12	179.1	-271.2 (l)	27.37	34.6
Methanol	32.04	81.32	-238.9 (l)	37.4	64.7
Sodium Carbonate	105.99	111	-1130.77	----	----
Water	18	75.37	-285 (l)	43.99	100

NOTES

* Calculated

(sub) Sublimation

(f) Fusion

(v) Vaporization

