

A Novel Commercial Method for Extracting Artemisinin:

Extracting *Artemisia Annu* with Ethanol and Purifying Ethanolic Extracts



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Properties of ethanol

- **1. General advantages:**
 - Local availability and lower price of the solvent
 - Better occupational and environmental safety (spiking needed to avoid abuse for recreational purposes)
 - More flexibility for the production of other phytopharmaceutical and nutraceutical products
- **2. High efficiency:**

quantitative extraction with ethanol possible – with hexane efficiency is only 75%
- **3. Good stability:**

no losses of artemisinin content of liquid extracts up to six months. Some losses under heat > 40°C.
- **4. Poorer selectivity:**

co-extracts a larger amount of polar impurities – mainly sugars
(crude extract is therefore more viscous and crystallisation impeded)
- **5. Forms an azeotrope with water – rectification needed.**

Choice of type of extractor

- Counter-current continuous (too expensive)
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- Batch: Percolation (not efficient enough) + Scale up expensive
- Batch: high velocity mixer with customised stirrer paddles (optimal)

Optimal extraction conditions on a customised SPT mixer-settler extractor

- Ethanol: 95% - 100%
- Temp: room temperature
- Total process time on extractor : with a high velocity mixer-settler **3-4 hrs** (extract, drain, wash, drain).
- Leaves/solvent: simple extraction (1 hr) : 1 kg to 7.5 L – quantitative recovery of artemisinin,
 - but 1.5 ltr extract (20%) remain on leaves after draining: therefore washing required or washing+ pressing,
- After pressing: 0.5 ltr of extract remain on leaves.
- Serial extraction possible: extract of batch 1 can be used as solvent for batch 2

Estimated solvent requirements for different extraction protocols

- Simple extraction and washing only : 12.5 ltr per kg leaves
- Simple extraction, washing, pressing: 9 ltr per kg leaves
- Serial extraction and washing only : 6 – 7 ltr per kg of leaves
- **Serial extraction and pressing : 4 - 5 ltr per kg of leaves**

Rectification

(calculations of costs based on a 6 ton per 24 hrs facility)

- Dilution of solvent by plant liquid is only about 1-2% per batch.
- Rectification can be done simply by linking the rectification column to the evaporator and stripping off the excess plant fluid continuously.
- Additional costs of capital equipment: 8%
- Additional evaporation costs: 25%

Economic considerations (comparison with conventional hexane plants)

- Extraction rate is 20% higher with ethanol
- Capital expenditure is less :
 - due to more rapid extraction (with high speed extractor SPT extractor 3 - 4 hrs instead of 16 hrs) less extractor capacity is needed.
 - but equipment for rectification (stripping) is needed.
- Overall expenditure for evaporation is much less even if rectification is included:
Up to 16 - 20 L hexane per ton of leaves, vs 4 – 5 L ethanol per ton of leaves.

Extraction with ethanol is much more economical

Purification protocol

Steps

- Concentration of extract
- Coating with diatomite + drying
- Eluting with ethyl-acetate/hexane (15/85)
- Filtration with silica gel (small quantity: $\frac{1}{2}$ of weight of solid)
- Evaporation – crystallisation
- Hot filtration with AC + Re-crystallisation

Recovery of artemisinin present in extract : ~ 80%

Estimated Cost of purification per metric ton of leaves: ~ 60 USD (without capital+labour)

More expensive than conventional purification of hexane extracts but less expensive than silica gel chromatography

- Publication pending.
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Thank you