Evonik’s CO$_2$ extracts: making your products “naturally” better!
Supercritical fluid extracts...
“the perfect portrait of nature’s bounty”
Evonik’s timeline of supercritical fluid extraction

1982

Industrial scale development of CO$_2$ extraction of hops flavor and bitter compounds for the beer industry
Evonik’s timeline of supercritical fluid extraction

Industrial scale development of CO₂ extraction for the decaffeination of tea and coffee

1982 1986
Evonik’s timeline of supercritical fluid extraction

- 1982: Production plant including tolling and creation capabilities focused on flavor and fragrance applications.
- 1986: Expansion.
- 1990: Further development.
Evonik...

a continual self-renewal
Multifunctional equipment for testing & production

1 Lab plant
- pressure: max 420 bar
- liquid/solid
- 4 l autoclave / 2 m-column
- CO₂ / Propane

2 Production plants
- pressure: max 280 / 420 bar
- liquid / solid
- 4 x 200 l autoclaves
- CO₂

1 Propane plant
- pressure: max 80 bar
- liquid
- 7,5 m column
Carbon Dioxide’s path to solvent capabilities

To achieve solvent properties CO$_2$ needs to be “liquefied” or “supercritical”

In its “Supercritical” phase, carbon dioxide...

- retains the high solvent potency of its liquid state, and
- benefits from the lower viscosity and much higher diffusion of its gaseous form.
Supercritical fluid extraction: process flow diagram

SFE process – exposing starting material & CO₂ to very precise pressure & temperature settings

**Step 1: Extraction**
- Botanical raw material is loaded in vessel.
- Pressure increased to a min. threshold of 74 bars (1070 psi)
- Temperature brought to a minimum of 31°C.
- CO₂ now reaches supercritical stage.
- Supercritical CO₂ flows freely through raw material capturing soluble aroma molecules.
Supercritical fluid extraction: process flow diagram

SFE process – exposing starting material & CO₂ to very precise pressure & temperature settings

Step 2: Separation
• The flow moves on to a separator where pressure is released, temperature is lowered.
• Supercritical CO₂ reverts back to its gaseous state, thereby separating from the extracted liquid.
Supercritical fluid extraction: process flow diagram

SFE process – exposing starting material & CO₂ to very precise pressure & temperature settings

**Step 3: CO₂ recovery**
- The spent CO₂ gas is recovered and stored in a condenser.
- CO₂ temperature is lowered further to its liquefaction point for storage.
- Recovered CO₂ can then be used in future batches.

---

August 2016 | Evonik’s CO₂ extracts: making your products “naturally” better!
Supercritical fluid extraction: flexibility in starting raw materials

Extraction of aqueous & fatty liquids expands possibilities for new botanical ingredients

- **Oils**: hazelnut, peanut, sesame, sunflower
- **Dried leaves**: tea
- **Ground solids**: coffee beans
- **Roots**: ginger
- **Wood**: oakwood, cinnamon
- **Seeds**: celery
- **Liquids**: fruit juice distillates
Supercritical fluid extraction: completely natural advantages

- 100% FTNS extracts; clean labeling
- No regulatory limitations; GRAS
- Organic-compliant, Kosher, Halal
- Free of artifacts or solvent residues
- Gentle, low temperature extraction allows for the capture of finer aromas molecules
- Tailor-made profiles; highly flexible & selective extraction technology
- 36+ month shelf life under proper storage conditions
- Shelf stable; inert production environment protects from oxidation & off-flavors
- Highly-concentrated extracts; competitive cost-in-use
Superior capabilities are backed by strict external certification

- Food Safety System Certification / FSSC 22000 (including HACCP)
- ISO 9001 Quality
- ISO 14001 Environment
- ISO 50001 Energy
- Kosher / Orthodox Union OU
- Certified Organic / Lacon
- Halal (selected products) / Halal Control
- AEO-F / (“reliable partner”; simplified custom procedures“)
- Compliance with EU-cosmetics directive:
  Coffee, Espresso*, Espresso HR*, Peanut*, Hazelnut*, Oak*, Black Tea, Jasmin Tea, China White Tea, Green Tea*, Rooibus, Honeybush
  *: IFRA Certificates available
## Flavor & fragrance extracts: standard portfolio

### Nuts
- Hazelnut
- Peanut
- Sesame
- Sunflower

### Teas
- Black
- China White, Pai Mu Tan
- Green
- Green, organic
- Honeybush
- Jasmine
- Keemun
- Rooibos

### Coffees
- Arabica
- Arabica, water-soluble
- Espresso
- Espresso, water-soluble
- Espresso Heavy Roast
- Espresso Heavy Roast, water-soluble

### Aromatics
- Celery
- Cinnamon
- Ginger
- Oakwood
Natural CO$_2$ extracts bring your flavors to life!
Supplementary company & product portfolio information
2015: Evonik in figures

Employees
December 31, 2014
33,576

18.2 %
Profitability (adjusted EBITDA margin)

€2.465 billion
Adjusted EBITDA

€13.5 billion
Return on capital employed (ROCE)
**Supercritical fluid extraction: portfolio of activities**

**EVONIK’s CO₂ Extraction portfolio**

<table>
<thead>
<tr>
<th>Natural Flavor &amp; Fragrance Extracts</th>
<th>“Tailored” FTNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defatted foodstuff</td>
<td>oilseeds, fat-free cocoa, oats</td>
</tr>
<tr>
<td>(Sterilization) aseptic botanicals</td>
<td>High value plants &amp; nuts</td>
</tr>
<tr>
<td>(Phyto extraction) nutritional ingredients</td>
<td>fatty oils (PUFA) sterols carotenoids, phospholipids</td>
</tr>
<tr>
<td>(Decontamination) Purified botanicals</td>
<td>pesticide or off-flavor removal</td>
</tr>
</tbody>
</table>
Supercritical fluid extraction: strength in technology

- **Capacities:**
  Campaigns can vary from “5 kg to 50 tons”

- **Liquid/liquid extraction:**
  Improved process technology allows better yields, through put and tailoring of the extraction process

- **Use of Co-Solvents:**
  Ex-proof equipment allows the use of even flammable co-solvents like Ethanol

- **Propane extraction:**
  Only commercial plant worldwide for Propane extraction

- **Solid Extraction:**
  Experience and equipment available for raw material preparation, e.g. kryo-grinding

- **“Soft Factors”:**
  Skilled and experienced crew. Experts with up to 30 years of SFE-experience. Huge data base of already extracted material
CO₂ Nut extracts: true to the natural profile

- Complete flavor profile of roasted and creamy notes
- Rounds off overall aroma or enhances low-fat foods and beverages
- Highly concentrated for minimal dosing
- Available in oil- or water-soluble versions
- Low-caloric, trans-fatty acid-free
- Enriched 4X tocopherole content
CO$_2$ Nut extracts: smooth & creamy nut flavors

Perfect as a building block for compounded flavors or as top note to round off flavor profile in:

- **Beverages**: alcoholic, flavored syrups
- **Dairy**: ice cream, puddings, yogurts, milk shakes
- **Bakery**: energy/nutrition bars, pastries, coatings, fillings
- **Confectionary**: chocolates, pralines, fillings, creams
- **Marinades**
- **Recommended dosage range**: 100 - 500 ppm

**Sensorial delivery:**

- **Peanut**: very roasted, smooth, creamy, full-bodied, red skin notes
- **Hazelnut**: creamy, delicate roasted scent
- **Sesame**: roasted, brown, savory
- **Sunflower**: peanut notes without the peanut allergens
CO$_2$ Tea extracts: elevating the tea experience

- Rich, floral notes provide premium aroma without astringency
- Range of fermentation available as non- and fully-fermented.
- Two herbal varieties: Honeybush & Rooibos.
- Flexibility in carrier solvents: MCT, MPG, ethyl alcohol
CO₂ Tea extracts: a variety for every taste & mood

- **Green** — Chinese tea, unfermented, floral, hay, honey, slightly buttery, unripe, very pleasant, well-rounded
- **China White, Pai Mu Tan** — White tea, delicate, almost sweet, smooth, velvety
- **Jasmine** — Chinese green tea with Jasmine flowers, delicate, floral, perfume
- **Black** — tea blend (Malawi, Argentina, Indonesia, Kenya), fermented, maté notes, hay-like, rich brown notes, tobacco
- **Keemun** — Chinese black tea, fruity sweet with toasted touch
- **Rooibos** — South African herbal tea, fermented, vanilla, butterscotch, creamy, full-bodied
- **Honeybush** — South African herbal tea, fermented, floral, rose, fresh, straw, similar but sweeter than Rooibos, distinct honey scent
Perfect as a building block for compounded flavors or as tea note enhancement in:

- **Beverages**: Ready-To-Drink sector, flavored waters
- **Flavored syrups**
- **Dairy**: ice cream, puddings, yogurts
- **Bakery**: pastries, coatings, fillings
- **Confectionary**: alcoholic fillings, fruit preps, creams, jellies
- **Recommended dosage range**: 100 ppm (as a top note)
CO₂ Coffee extracts: satisfying coffee cravings

• Complete flavor profile of coffee bean, fully-balanced for premium sensory sensation
• Roasted top notes
• Three degrees of roasting: regular, espresso, espresso heavy roast
• Variety of bean origins: pure arabica, blend of arabica/robusta
• Low caffeine contribution
• Available in oil- or water-soluble versions
CO₂ Coffee extracts: from mild to robust

- **Coffee Arabica** – premium blend, dark, chocolate notes, full-bodied, caramel, toffee, butterscotch, slight pyrazine-nut notes
- **Coffee Arabica water-soluble**
- **Coffee Espresso** – roasted, ashy, earthy, tobacco, variety of coffee peaks
- **Coffee Espresso water-soluble**
- **Coffee Espresso Heavy Roast** – very roasted without the burnt character, rich, aromatic, very well-balanced
- **Coffee Espresso Heavy Roast water-soluble**
CO\textsubscript{2} Coffee extracts: flavor beyond the coffee cup

Perfect as a building block for compounded flavors or as top note to round off flavor profile in:

- **Beverages**: Ready-To-Drink sector, iced coffees
- **Liqueurs, flavored syrups**
- **Dairy**: ice cream, yogurt, milk shakes, puddings
- **Bakery**: pastries, fillings, coatings
- **Confectionary**: alcoholic fillings, fruit preps, creams, jellies

- **Recommended dosage range**: 200 – 300 ppm
**Oakwood:**
- Rich, smoky, woody, oak barrel character with a medium toast quality, aromatic, very well balanced.
- Flavor enhancer; particularly for Vanillin
- Flexibility in carrier solvents: MCT, MPG, ethyl alcohol
- Recommended dosage range: 10 - 20 ppm

**Ginger:**
- Pronounced spiciness
- Enhanced citrus-like top notes
- Two versions: essential oil or oleoresin
- Recommended dosage range: 20 - 100 ppm

**Celery CO₂ Extract**

**Cinnamon CO₂ Extract**
CO$_2$ Aromatic extracts: elevating exotic flavors

Perfect as a building block for compounded flavors or as top note to round off flavor profile in:

- **Beverages**: Ready-To-Drink sector
- **Dairy**: ice cream, yogurt
- **Bakery**: pastries, fillings, coatings
- **Confectionary**: alcoholic fillings, fruit preps, creams, jellies
- **Wine**
- **Tobacco**
- **Vanillin enhancement**
- **Marinades**