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Super Critical Fluid Extraction

Skill Course



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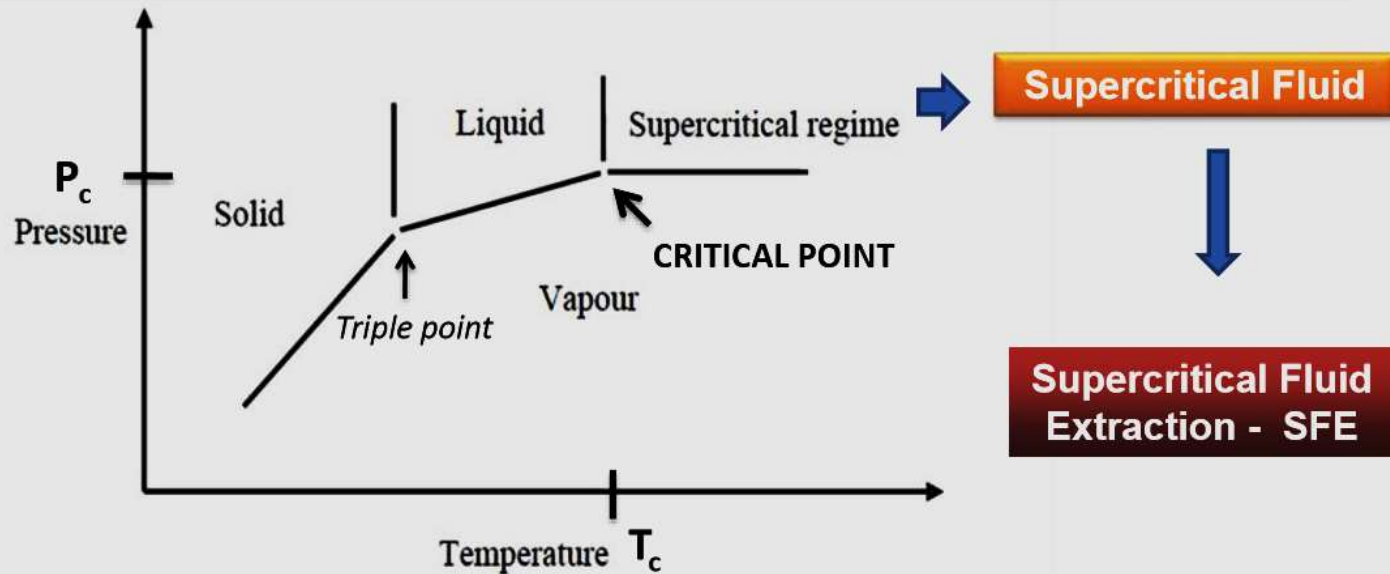
1. What is supercritical fluid



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Typical Pressure-Temperature of a substance



When a fluid is subjected to a pressure and a temperature higher than its critical point, the fluid is said to be " **supercritical** " .

The fluid is said "supercritical" when it is heated above its critical temperature and compressed above its critical pressure.

In the supercritical region, the fluid exhibits particular properties and has an intermediate behavior between that of a liquid and a gas.

Supercritical CO₂



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Carbon dioxide (CO₂) is the most widely used supercritical fluid.

Because :

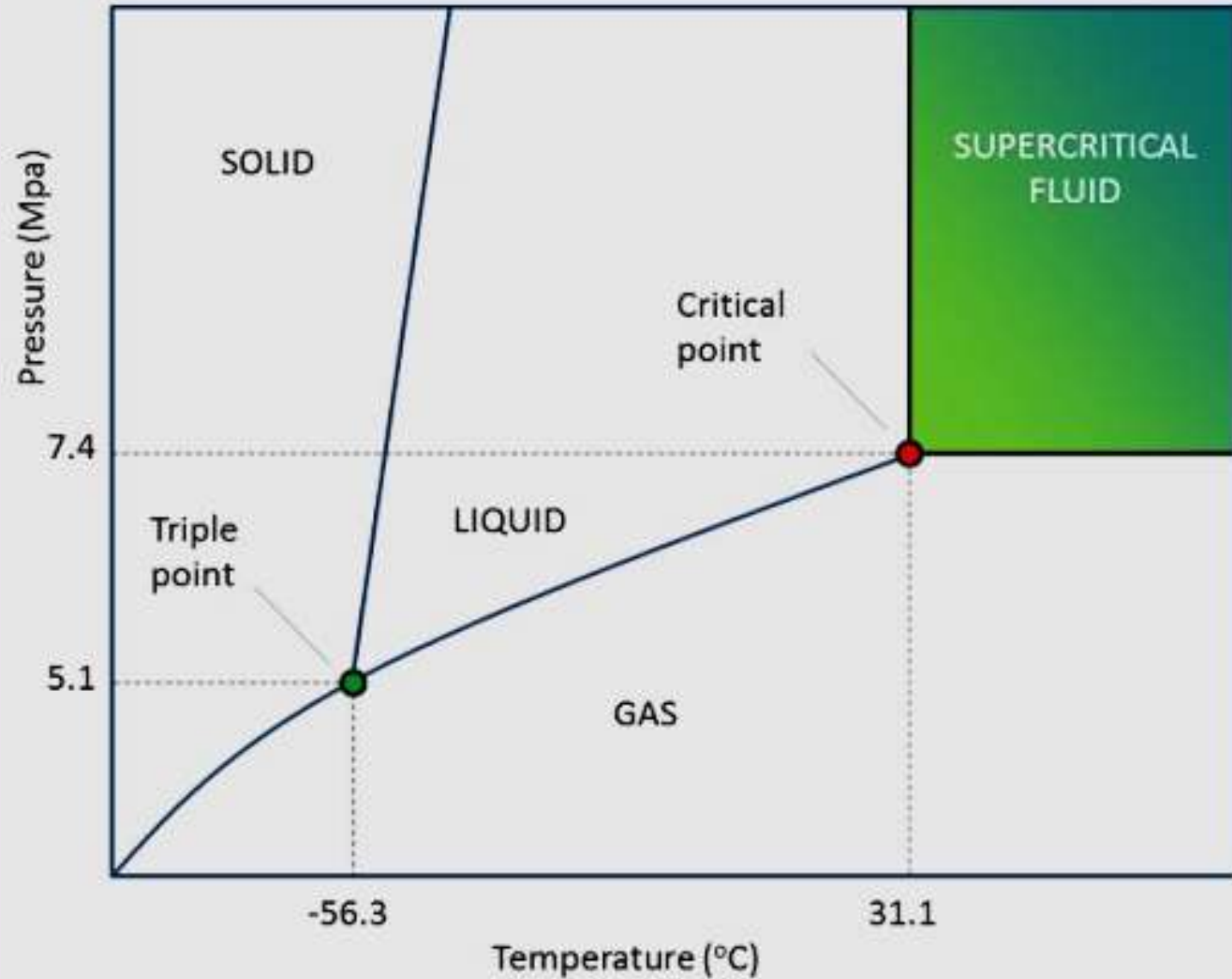
- CO₂ is cheap. Readily available at high purities and at low costs
- chemically inert
- non-toxic
- non-flammable
- The critical point of CO₂ is easily accessible (critical temperature 31°C and critical pressure 74 bar)
- This allows the fluid to be used at mild conditions of temperatures (40-60°C).
- Due to its interesting properties **Supercritical CO₂** can be described as a "**green**" solvent.



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Phase diagram of CO₂





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Critical properties of some solvents

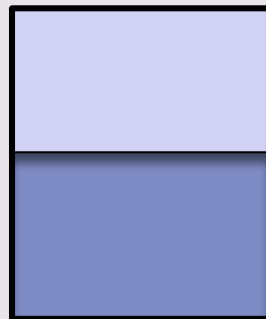
Solvent	Molecular weight	Critical temperature	Critical pressure	Critical density
	g/mol	K	MPa (atm)	g/cm ³
Carbon dioxide (CO ₂)	44.01	304.1	7.38 (72.8)	0.469
Water (H ₂ O) (acc. IAPWS)	18.015	647.096	22.064 (217.755)	0.322
Methane (CH ₄)	16.04	190.4	4.60 (45.4)	0.162
Ethane (C ₂ H ₆)	30.07	305.3	4.87 (48.1)	0.203
Propane (C ₃ H ₈)	44.09	369.8	4.25 (41.9)	0.217
Ethylene (C ₂ H ₄)	28.05	282.4	5.04 (49.7)	0.215
Propylene (C ₃ H ₆)	42.08	364.9	4.60 (45.4)	0.232
Methanol (CH ₃ OH)	32.04	512.6	8.09 (79.8)	0.272
Ethanol (C ₂ H ₅ OH)	46.07	513.9	6.14 (60.6)	0.276
Acetone (C ₃ H ₆ O)	58.08	508.1	4.70 (46.4)	0.278



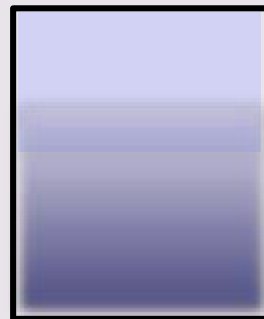
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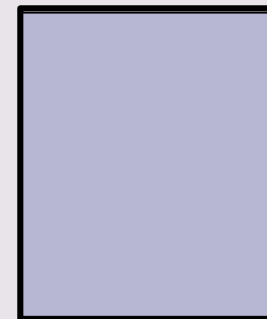
- There is no liquid to gas phase boundary in a supercritical fluid. Hence there is no surface tension.
- By changing the pressure and temperature of the fluid, the properties can be adjusted to be more liquid- or gas-like.
- One of the most important properties of supercritical fluids is their ability to act as solvents.
- **Solubility in a supercritical fluid increases with the density** of the fluid (at constant temperature).
- Since density increases with pressure, **solubility tends to increase with pressure.**



Two distinct phases



Subcritical



Supercritical



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Critical point

- All supercritical fluids are completely miscible with each other
- A single phase for a mixture can be obtained if the critical point is exceeded.
- The critical point of a binary mixture can be calculated as the arithmetic mean of the critical temperatures and pressures of the two components

$$T_{c(mix)} = (\text{mole fraction of } A) \times T_{c(A)} + (\text{mole fraction of } B) \times T_{c(B)}$$



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Supercritical carbon dioxide formation

- A pressure vessel made of aluminum and acrylic is filled with pieces of dry ice.
- The dry ice melts under high pressure, and forms a liquid and gas phase.
- When the vessel is heated, the CO_2 becomes supercritical — the liquid and gas phases merge together into a new phase that has properties of a gas, but the density of a liquid.

- Supercritical CO_2 is a good solvent.
- It is used for decaffeinating coffee, dry cleaning clothes, and other situations where avoiding a hydrocarbon solvent is desirable for environmental or health reasons.