

Introduction and Physical Properties of Supercritical Fluid

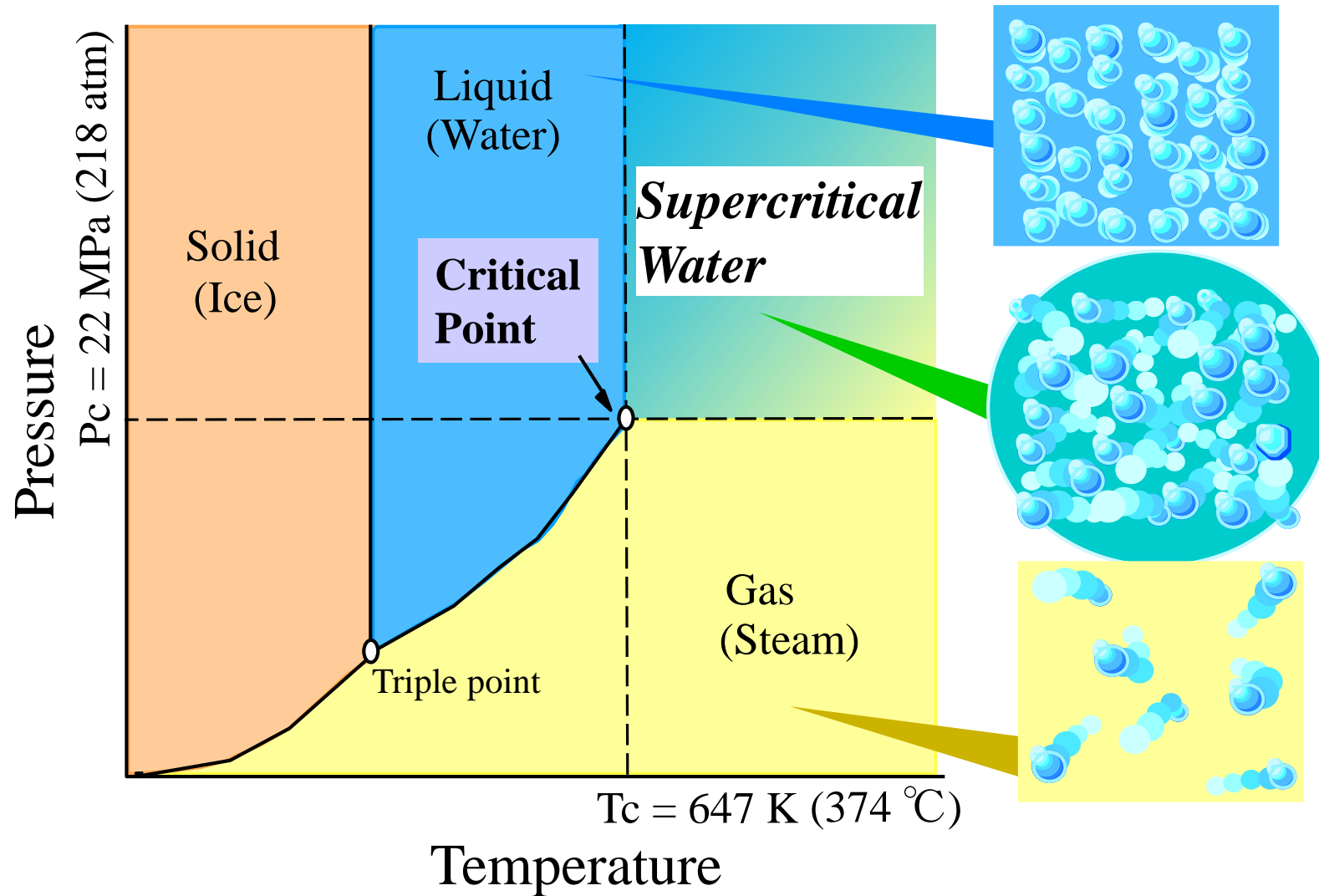
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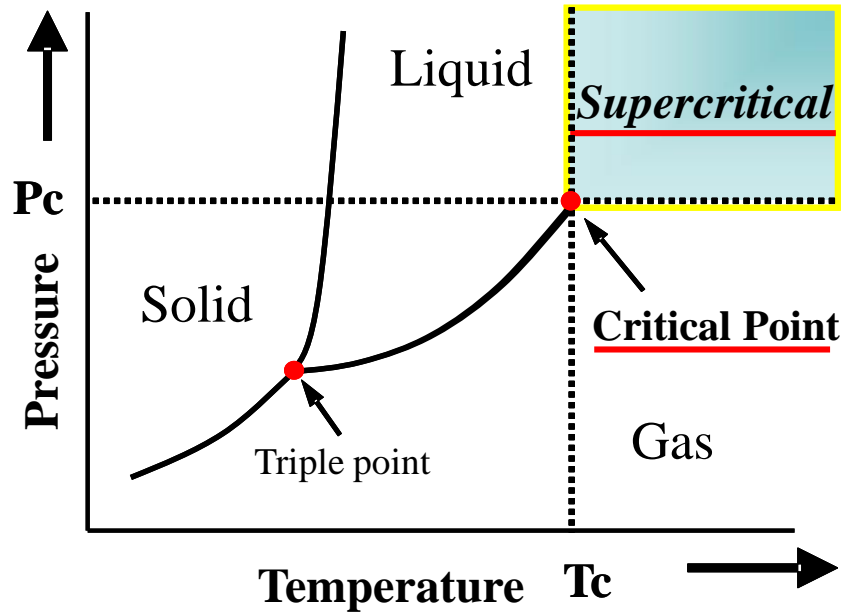
Phase Diagram of Water



Carbon dioxide: $T_c = 304\text{K}$ (31°C), $P_c = 7\text{MPa}$ (73atm)

What is Supercritical Fluid

Supercritical Fluid A phase of substance above critical point



High adaptability

- ✓ Solubility of fluid and diffusibility of gas
 - ▶ It can extract from complicated matrix.
- ✓ Continuous change of density
 - ▶ Adjustable application on various extraction target

Supercritical CO₂ extraction...**Safe and Harmless**

***An alternative way
for organic solvent extraction.***

Characteristics of supercritical fluid

	Gas	Supercritical fluid	Liquid
Density (kg/m ³)	1	100 ~ 1000	1000
Viscosity (mPa · s)	0.01	0.1	1
Diffusion factor (m ² /s)	10 ⁻⁵	10 ⁻⁷ ~ 10 ⁻⁸	10 ⁻¹⁰

Properties of supercritical carbon dioxide

1) The critical temperature and pressure are relatively low

	Critical temperature [$^{\circ}\text{C}$]	Critical pressure [MPa]
Carbon dioxide	31.2	7.4
Water	374.2	22.1
Methanol	239.6	8.1
Ethanol	243.4	6.38

- Advantage in designing device of industrial usage
- Reduce running cost

2) Safe and less impact to environmental

- Not combustible, not combustion assistant
- No toxicity
- Inactive in normal temperature and pressure

3) No solvent remained after extraction

- CO_2 is in gas phase under normal temperature and pressure, which diffuse immediately

4) Handling is easy

- Low price, high purity
- Can be released to atmosphere directly
- Easy for storage

Definition of words

- High-temperature High-pressure Fluid (高温高压流体)
Pressured hot water (加圧熱水), High pressure fluid (高压流体),
High-temperature high-pressure water (高温高压水)
- Supercritical fluid (超臨界流体)
Supercritical water (超臨界水), Supercritical carbon dioxide
(超臨界二酸化炭素)
- Liquidized carbon dioxide gas (液体の炭酸ガス)
- Hot water (熱水) (Hydrothermal reaction) (水熱反応)

Topics

High-temperature, High-pressure (Supercritical Water, Subcritical Water)

- Suntory: Malt processing (Energy 1/2, waste amount 1/3)
- National: dish washing machine
(the first water saving, highly-concentrated mist dishwashing detergent in the world – 4.13.2004)
- Sharp: oven (removes excessive oil and salt, prevents vitamins degradation)
- Osaka Prefecture University: Waste recycling plant
(The first commercial plant, 1 billion yen, 70 ton/day, 200-250°C, 20-50 atm; Kogyo Shinbun, August 15 edition)
- Compost, fuel, new functional material, low temperature steam cooking (no lye)

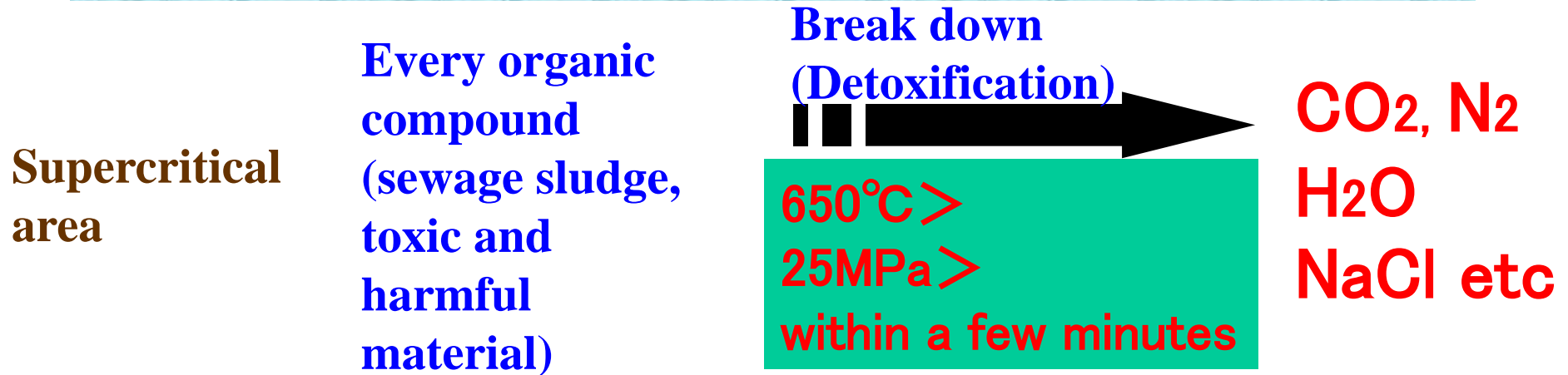
Teijin fiber: Wastewater treatment

Supercritical carbon dioxide

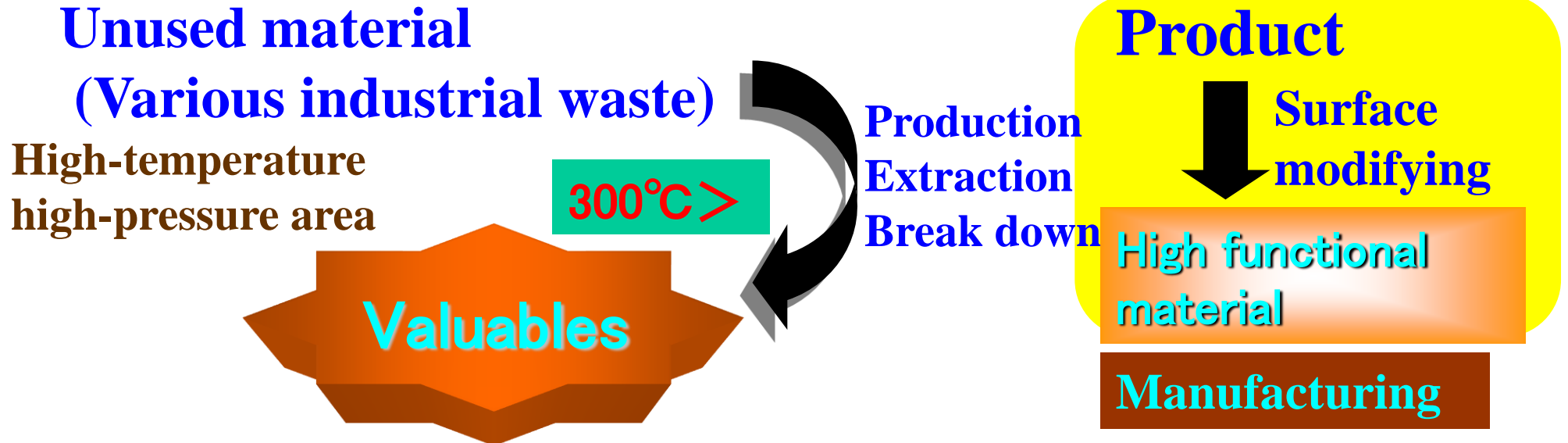
- Takemoto oil & fat co., ltd: pomace sesame oil >>> sesamin
- Hop >>> hop effective component
- Coffee beans >>> caffeine
- Environmental analysis, extraction and separation of useful component from biomass

About High-Temperature High-Pressure Water

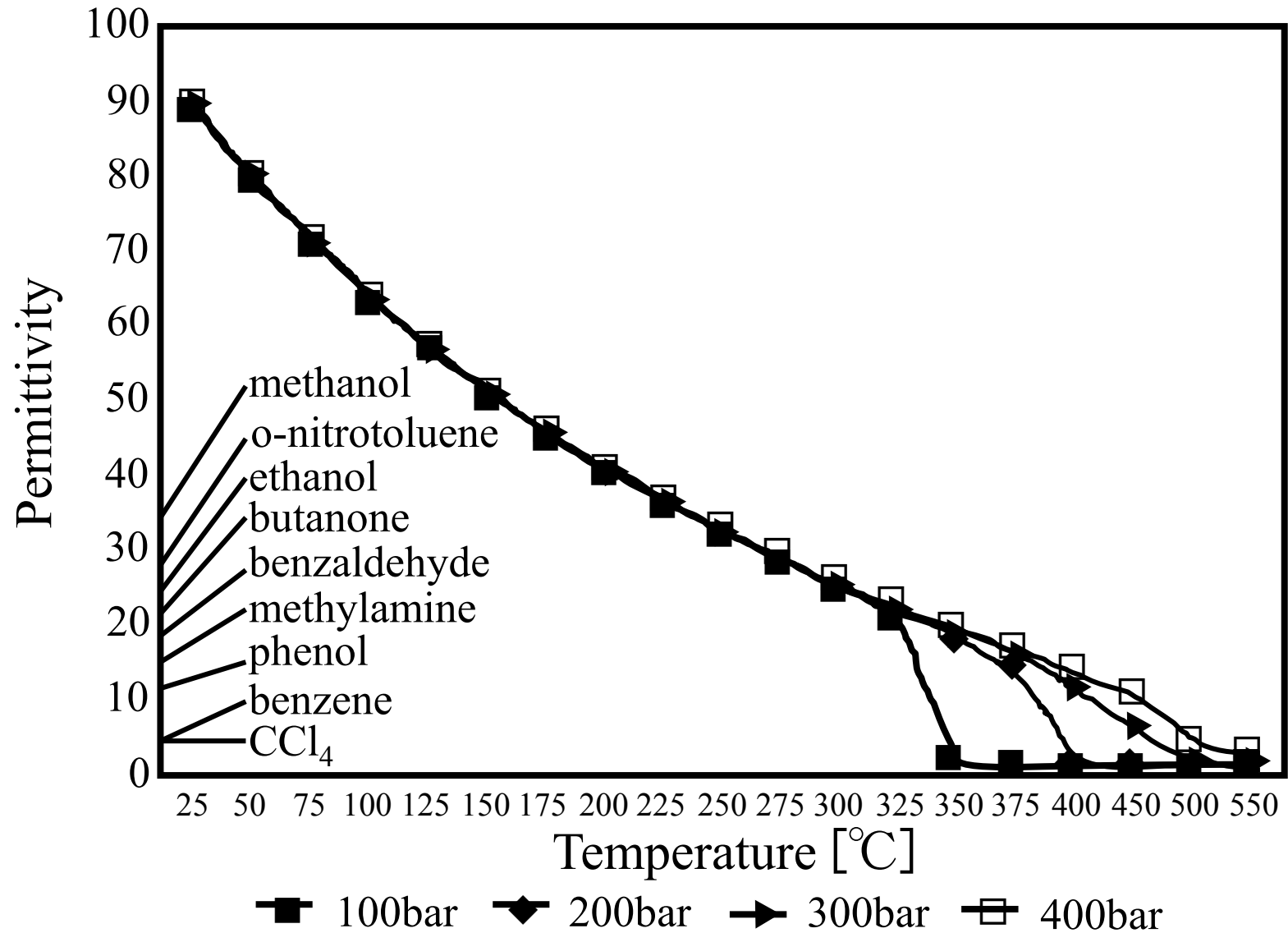
Keywords: hydrolysis, ionic product, polarity, radical reaction



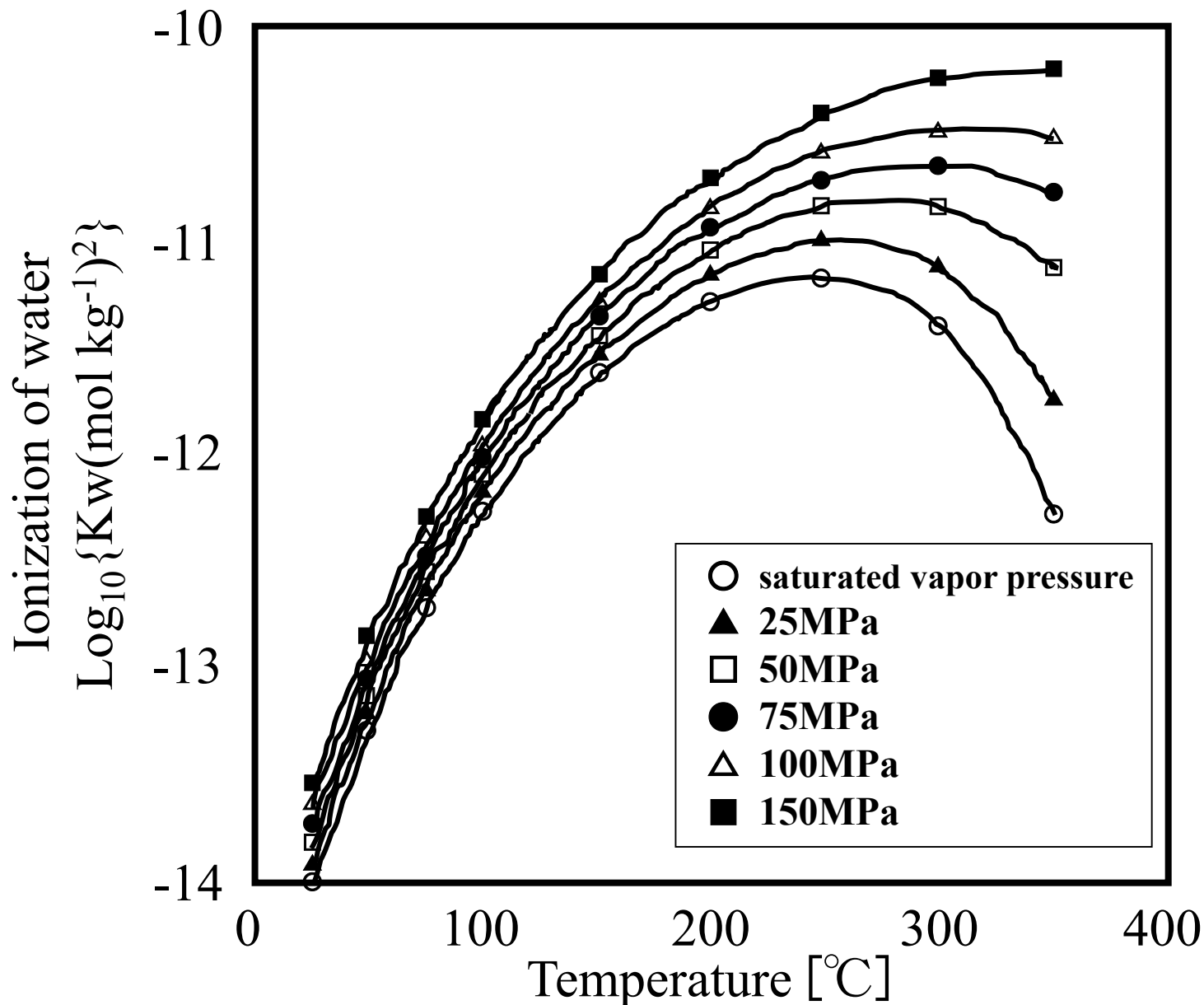
The critical point of water: 374°C, 22.1MPa



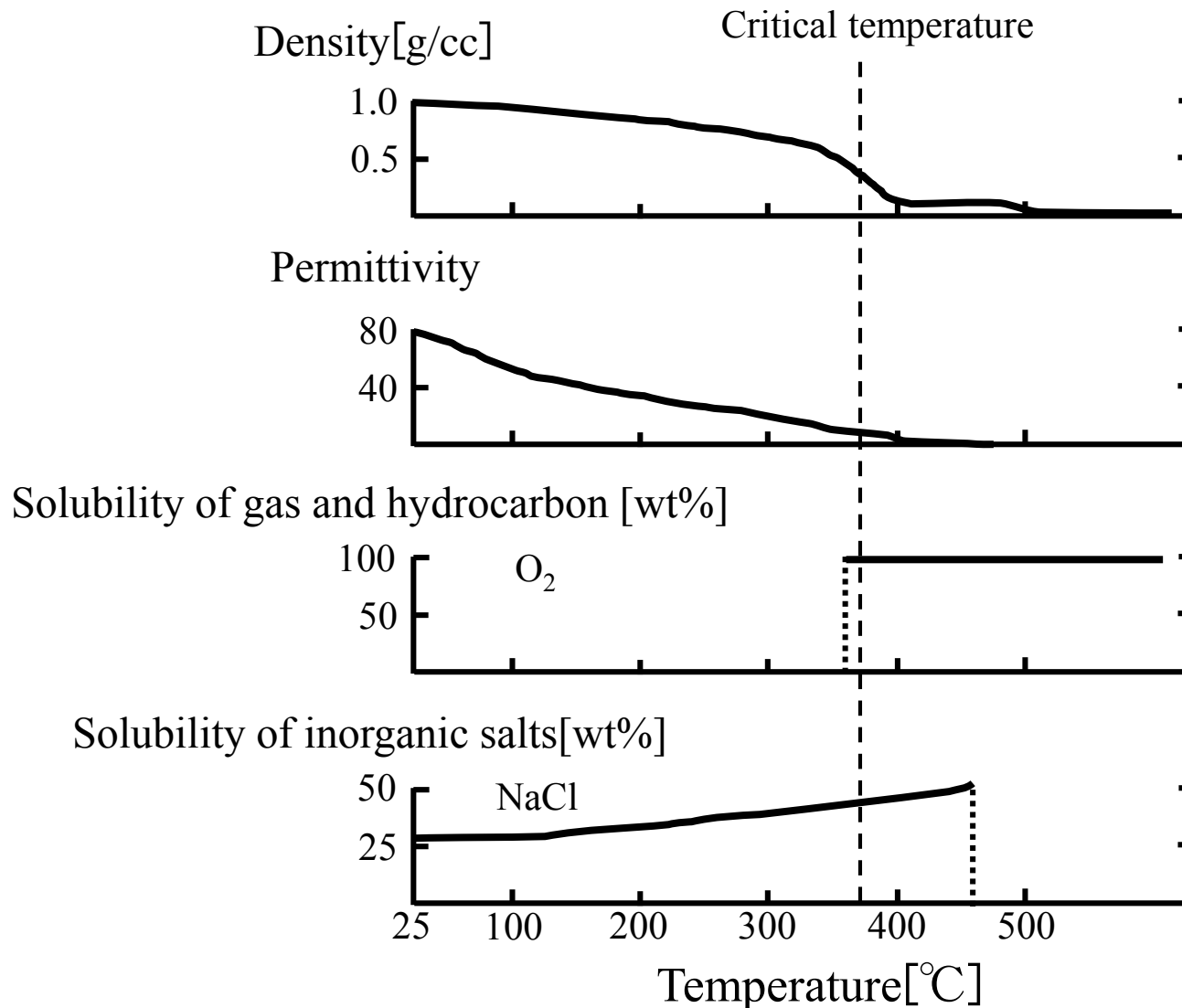
Effect of Permittivity of water on temperature and pressure



Ionization of water by temperature



Water characteristics around 250atm



Comparison between water and carbon dioxide

Fluid	Water		Carbon dioxide
Critical temperature	374.4 °C		31.0 °C
Critical pressure	22.1 MPa		7.39 MPa
Permittivity (polarity)	Normal temperature and normal pressure	About 78 (high polarity)	(Low polarity)
	Supercritical area	Under 10 (low polarity)	
Ionic product	Normal temperature and normal pressure	10⁻¹⁴ (pH7)	Not dissociated
	Subcritical area	10⁻¹¹ (pH5.5)	
Characteristics	It becomes the place for ion reaction (hydrolysis, dehydration) and radical reaction without requiring an additive.		It is suitable for extraction and the separation of thermally unstable component, and widespread solvent strength.
Common points	Low cost, non-toxic, stability, enable to be released directly to atmosphere		