A transparent micro-device to study mass transfer and thermodynamics in two-phase flows at high pressure

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Microreactor Features

- Operating range: up to **30 MPa** – up to **400 K** and minimal flowrate: 0.01 µL min^{-1}
- Geometry: Inner diam. 100 to 1000 µm – Cylindrical section
- **Axisymmetry – up to 8 m long**
- Coaxial injection for 2-phase flow
- Optically **transparent** (fused silica capillary [1])
- Cost: **inexpensive** – doesn't require any specific milling tool
- 3D configuration to minimize the curvature
- **Low Bond number**

Fabrication

- A PMMA block (270 x 140 x 20 mm^3) is machined with a digital milling machine.
- Fused-silica capillary tubing is inserted into the chassis with the help of sleeves **[Region B]** and the plastic coating is removed from the capillary (for the optical access **[Region A]**).
- A glass window (40 x 40 mm^3) is inserted in the chassis.
- OSTEMER resin (chosen because of its transparency and low shrinkage properties **[2]**) is poured over the top of the capillary system into the PMMA support. The ensemble is then exposed to UV light.
- Stainless-steel connectors are used to connect the capillary reactor to the external network pipes (pumps etc.).
- The microreactor is put into a transparent box and immerged in a circulating heat transfer fluid **[Region C]** in order to maintain a constant temperature in the reactor.

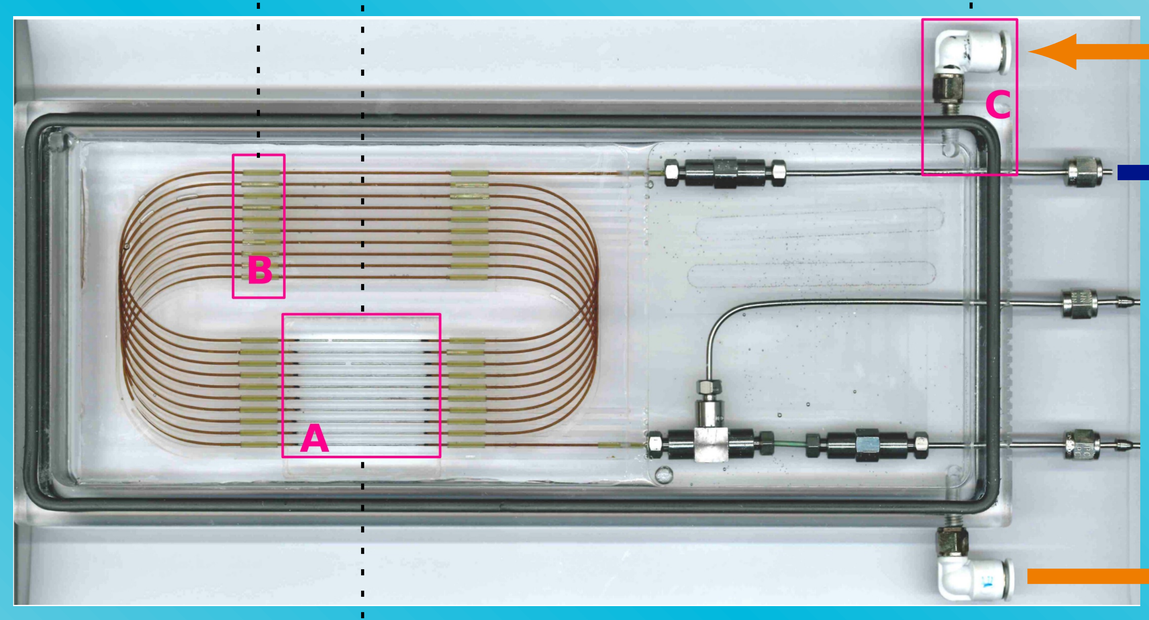


Figure – The transparent high pressure microreactor.

High Pressure Fluid Properties

Viscosity, density and surface tension (with water) of CO_2 change with pressure: ≠ fluid properties ≠ mass transfer

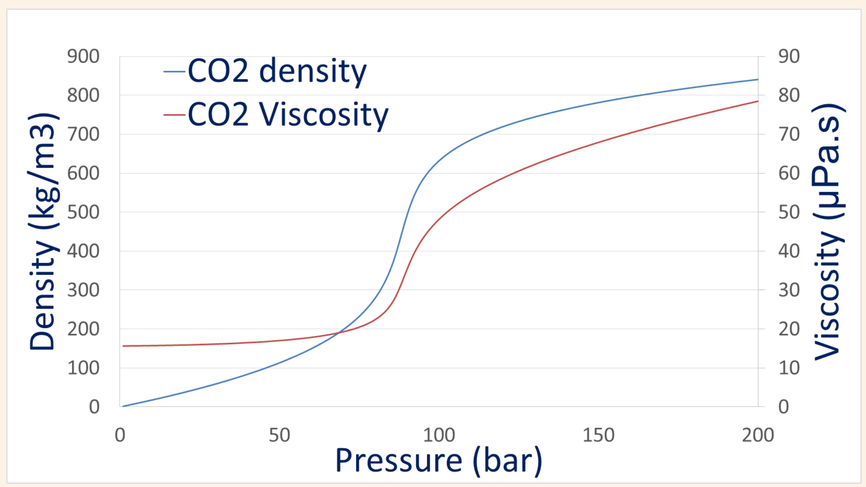
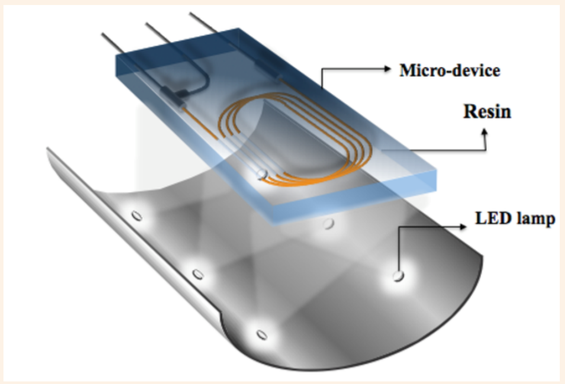


Figure – Fluid properties of CO_2 changing with pressure at 313 K **[3]**

Camera Set Up



- **CCD camera:** 1280×1024 pixels up to 2000 fps
- **Optical assembly:** FOV 8×6 mm^2 WD 120 mm
- **Image Resolution:** 6 μm/pixel
- **Light intensity:** 2200 lm

Optical access to the flow makes it possible to quantify the volume change of bubbles (due mass transfer between the gas and the liquid phases).

Figure – $P = 20$ MPa; $T = 308$ K; $V_{CO_2} = 0.02$ mL/min; $V_{H_2O} = 0.02$ mL/min in a 530 µm capillary. **[Region A]** **[1]**

References

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