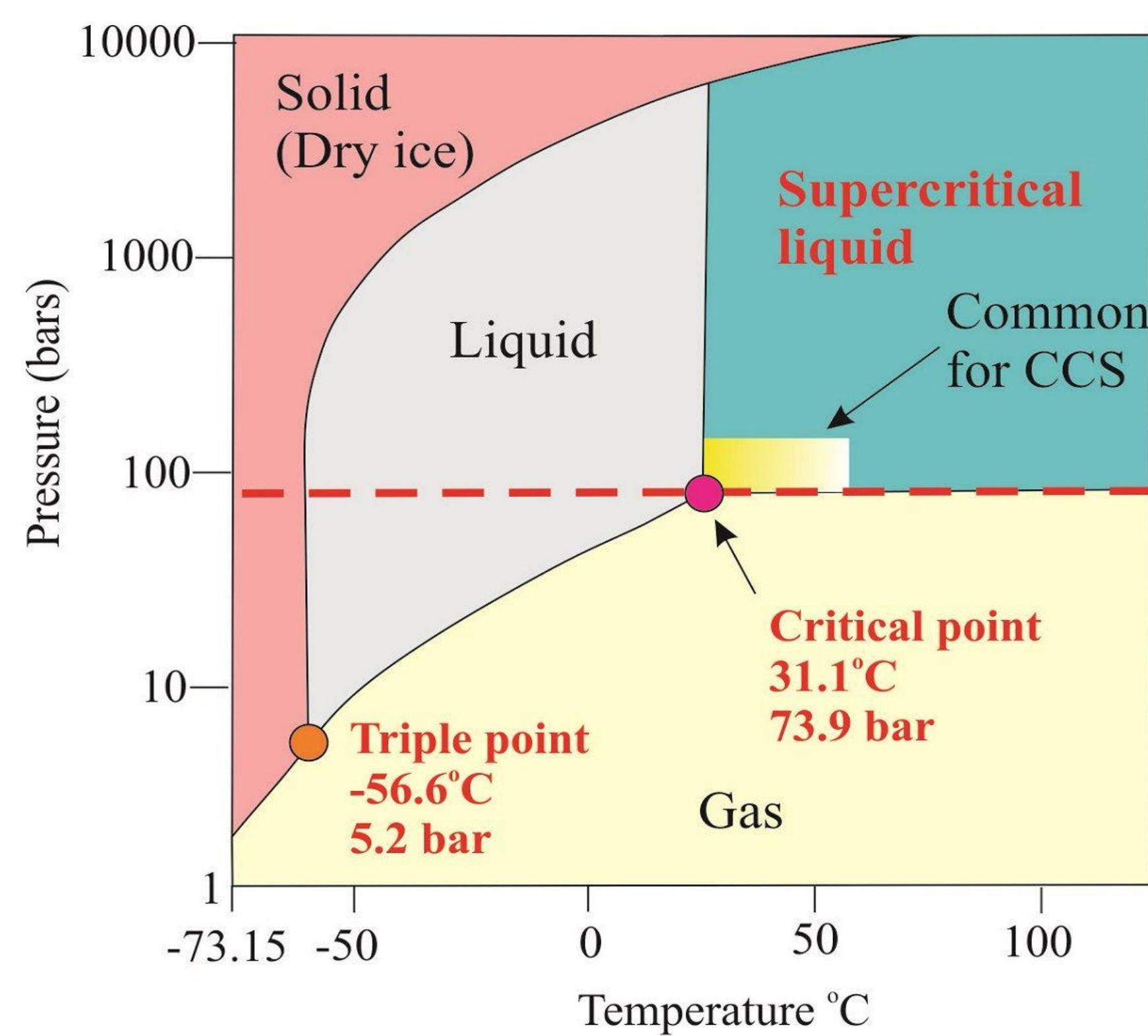


Using Novel Production Methods for Dense Phase CO₂ Reference Materials

From Representative Sampling to Traceable Reference Values

1. Context & Motivation

- Accurate CO₂ sampling and measurement are critical for pipeline operation, storage, and custody transfer. Reliable measurements require truly **representative** sampling; calibration alone using standard gas mixtures is insufficient.
- Assessing sampling representativeness requires **dense-phase CO₂ reference materials** and suitable sample vessels capable of **preserving phase and composition** from extraction to laboratory analysis.
- This study aims to evaluate piston cylinders and a novel collapsible liquid vessel (CLV) for dense-phase CO₂ **sampling and reference material production.**



2. The Challenge

- Compositional instability due to surface reactions
- Phase changes and partitioning across pistons or membranes
- Non-representative sampling during depressurisation
- Material compatibility with reactive impurities
- Long-term stability and homogeneity

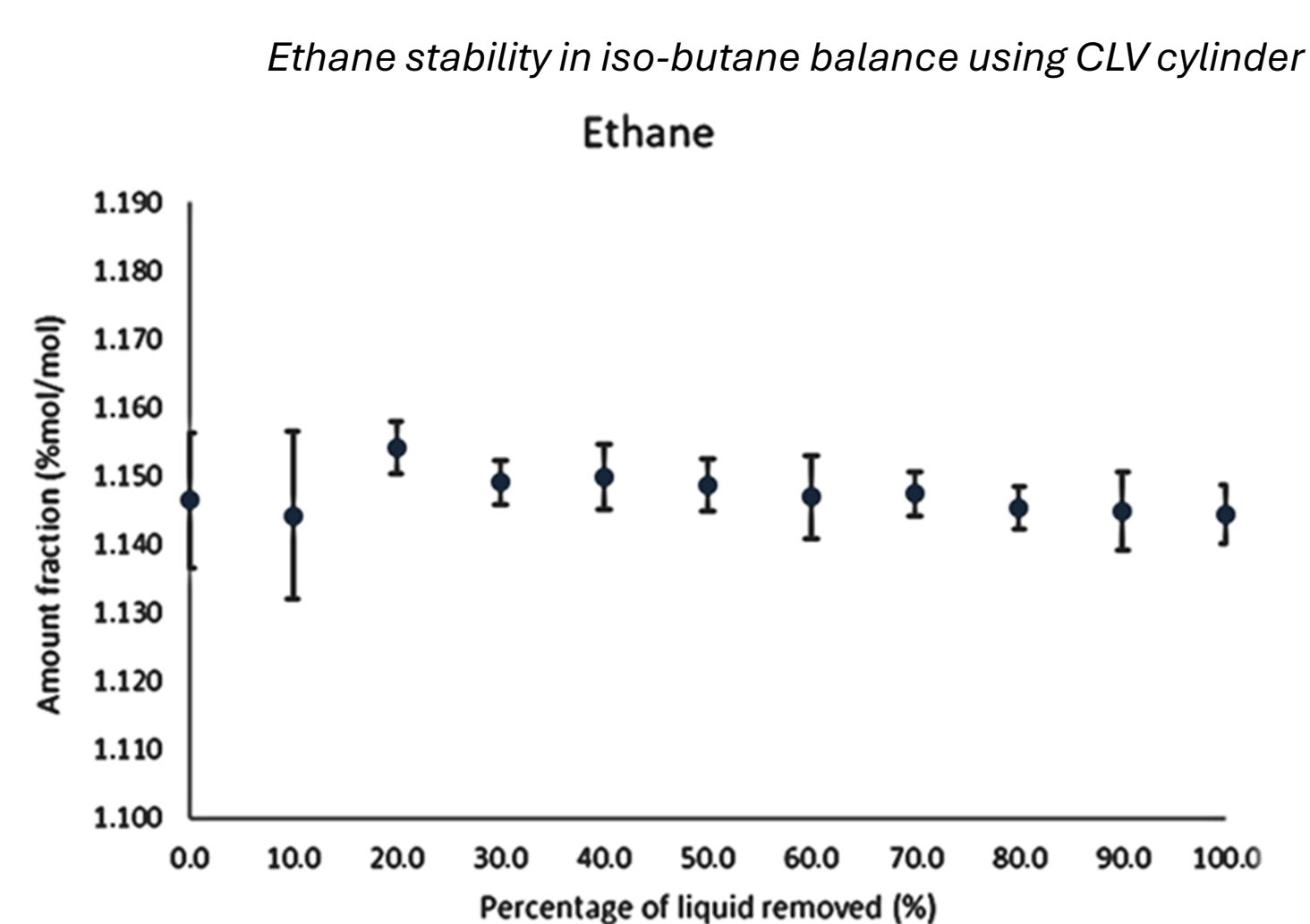
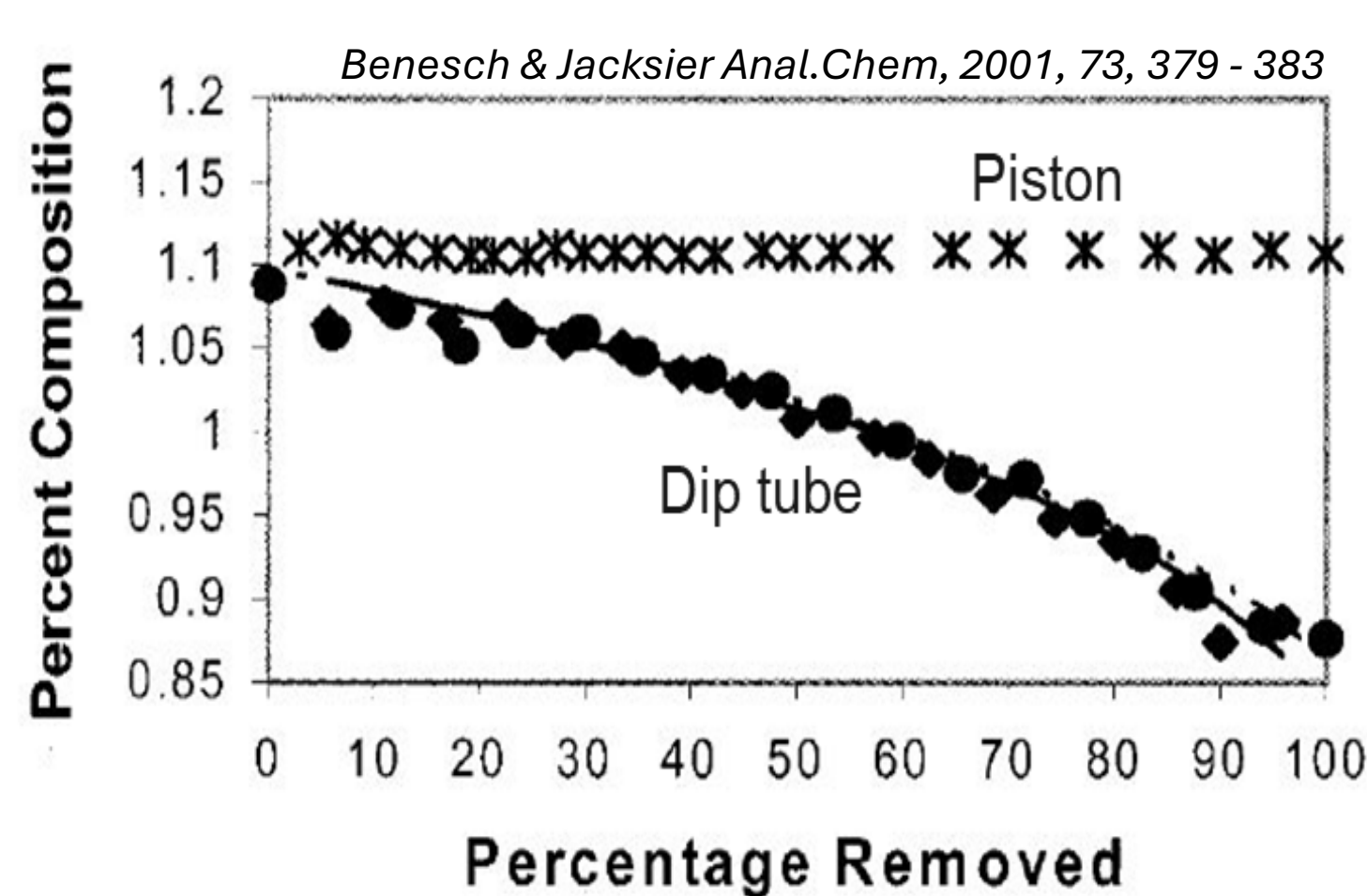


3. Proposed Solution: Collapsible Liquid Vessel (CLV)

- Single Phase:** Maintains the sample in a single dense/liquid phase throughout storage and use, eliminating gas-liquid equilibrium effects.
- Chemically Inert:** Uses a collapsible internal bladder to ensure complete separation between the sample and the pressurising gas.
- Zero Diffusion:** Eliminates membrane-driven diffusion (e.g., of He or Ar) common in piston cylinders.
- Proven stability** for volatile components in liquid hydrocarbon mixtures

4. Proof of Stability for Ethane in Liquid Hydrocarbon Mixtures

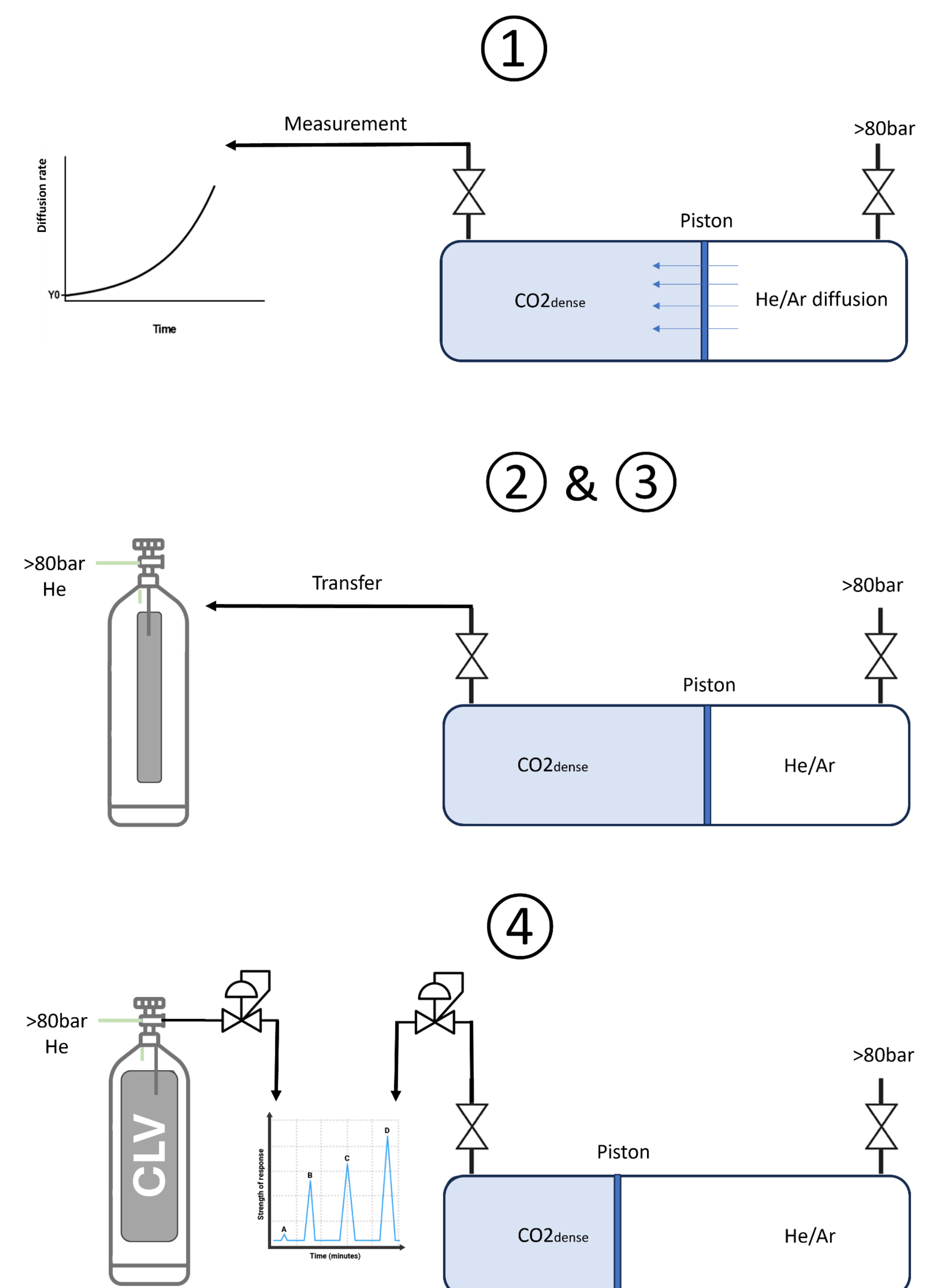
The stability of ethane in liquid hydrocarbon mixtures using CLV has been demonstrated to be equivalent to a piston cylinder. A comparison of CLV, piston cylinder, and dip tube is shown below. The same concept will be applied to evaluate stability in dense-phase (liquid) CO₂, forming the basis of this study.



5. Investigation Plan

Objective: Evaluate compositional integrity during dense-phase CO₂ transfer from a piston-cylinder pipeline analogue into collapsible liquid vessels, to assess CLV applicability as receiving cylinders for CCS sampling.

- Stage 1 – Diffusion Baseline**
Quantify He/Ar permeation across piston membranes under dense-phase CO₂.
- Stage 2 – Mixture Preparation**
Gravimetric preparation of dense-phase CO₂ mixtures in piston cylinders.
- Stage 3 – Phase-Preserving Transfer**
Immediate transfer to CLVs to avoid phase transition.
- Stage 4 – Stability Assessment**
Time-series comparison of piston vs CLV composition.



6. Expected Impact

- Demonstrated suitability:** CLV technology shown to maintain compositional integrity for dense-phase CO₂ mixtures.
- Traceability pathway:** Enables certified, traceable reference materials for dense-phase CCS applications.
- Representative sampling:** Confirms dense-phase pipeline conditions can be preserved during collection and transfer.

