HSLU Hochschule Luzern

**Technik & Architektur**

**Master Thesis Energy and Environment**

# Liquid Solvents for Direct Air Capture and Utilization

## Experimental Characterization, Optimization and Stability Testing

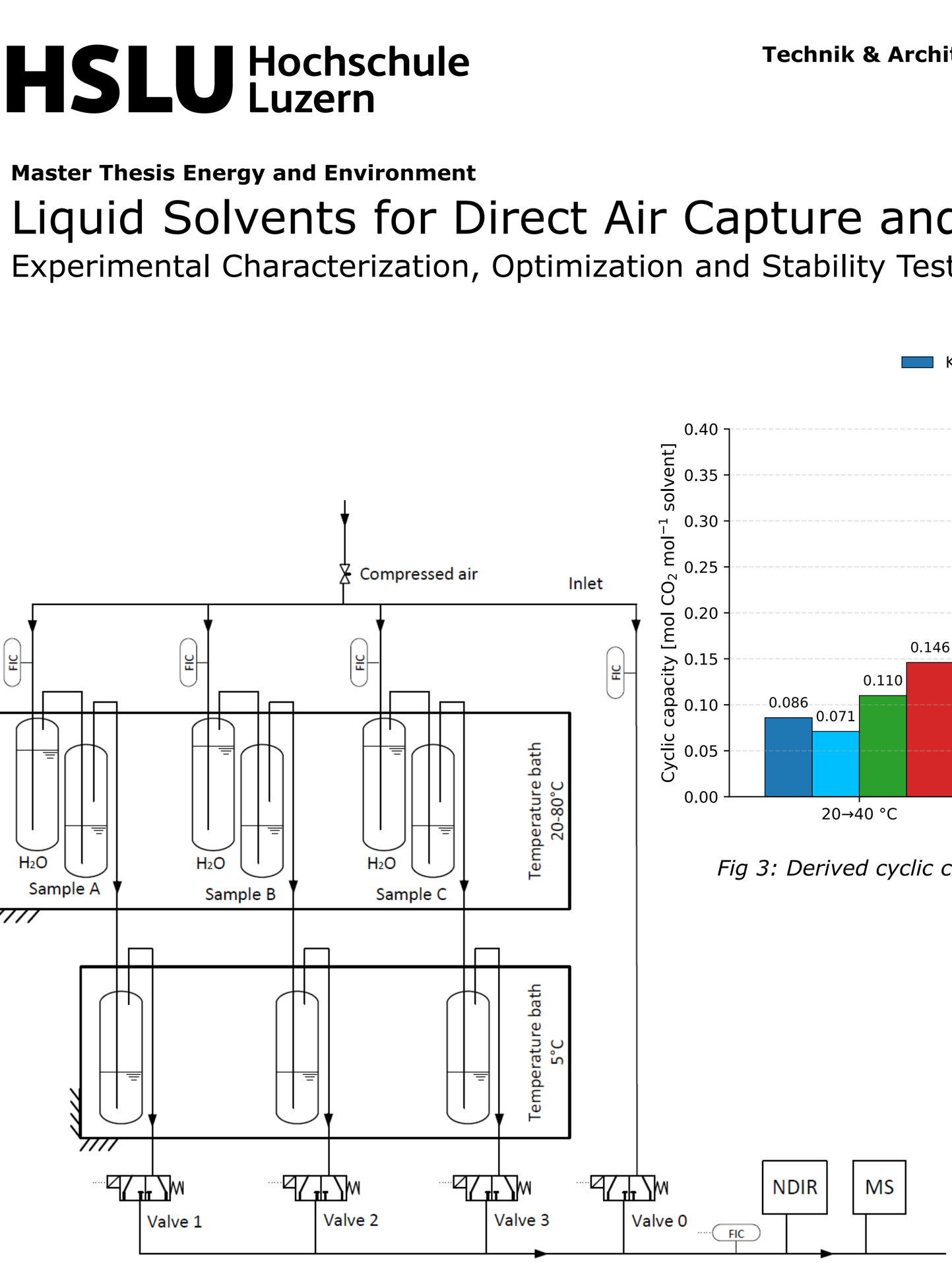


*Fig 1: Schematic of experimental setup for parallel absorption and desorption experiments*

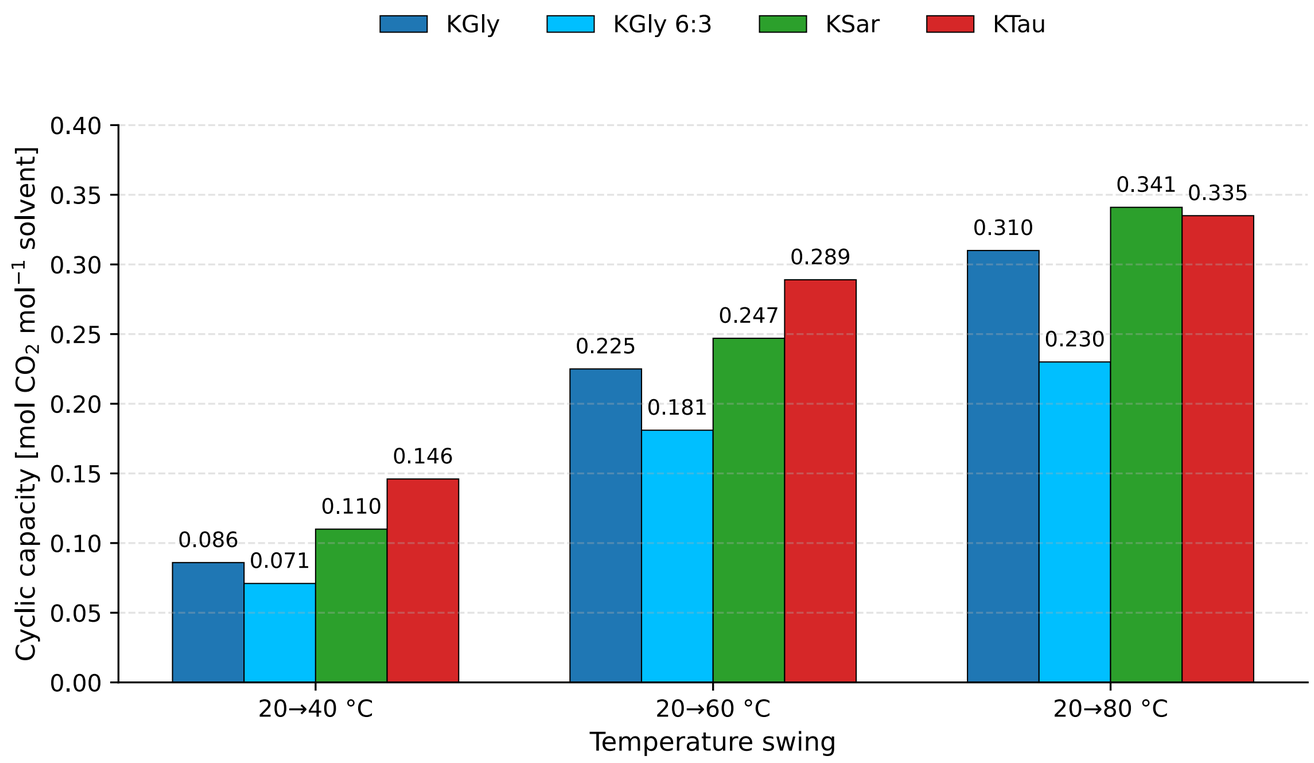


*Fig 3: Derived cyclic capacities for tested solvents and temperature swings*

*Fig 2: Solvent samples after $CO_2$ absorption: thermally cycled >200 times left, <10 times right*

### Motivation

Direct air capture (DAC) can remove $CO_2$ from ambient air and provide a renewable $CO_2$ source, for example for greenhouse enrichment.

Because air contains only about 400 ppm $CO_2$, efficient solvents are needed. Amino acid salt solutions are promising because they chemically bind $CO_2$ and have low volatility.

### Procedure

Three 3 mol/L aqueous amino acid salt solvents were tested:

- Potassium Glycinate (KGly)
- Potassium Sarcosinate (KSar)
- Potassium Taurinate (KTau)

The solvents were investigated in a parallel absorption–desorption setup using ambient air *(Fig 1)*. $CO_2$ uptake and release were measured with an NDIR gas analyzer during temperature swings from 20 to 80 °C.

Additional tests evaluated solvent enhancement strategies using $TiO_2$ addition and excess KOH, as well as thermal stability by cycling loaded solvents 200 times between 20 and 90 °C.

### Key Findings

Cyclic capacity is more relevant than absolute $CO_2$ loading for temperature-swing DAC operation, because it describes how much $CO_2$ can be repeatedly absorbed and released.

KSar showed the highest cyclic capacity for the 20 → 80 °C temperature swing, while thermal cycling over 200 cycles caused no measurable performance loss.

KTau showed the strongest response at moderate temperature swings *(Fig 3)*, reaching 0.289 mol $CO_2$/mol solvent for 20 → 60 °C.

For the larger 20 → 80 °C swing, KSar reached the highest cyclic capacity with 0.341 mol $CO_2$/mol solvent, followed closely by KTau and KGly.

Excess KOH increased absolute $CO_2$ loading but did not improve cyclic capacity *(KGly 6:3 in Fig 3)*.

$TiO_2$ addition showed no systematic performance improvement under the tested conditions.

Thermal cycling *(Fig 2)* caused no measurable loss in absorption/desorption performance, although further chemical analysis is needed to assess degradation

**Céline Winkelhausen**

Supervisor: Dr. Benjamin Fumey

Advisor: Prof. Dr. Mirko Kleingries

Expert: Dr. Andreas Borgschulte

**FH Zentralschweiz**

MSE | MASTER OF SCIENCE IN ENGINEERING