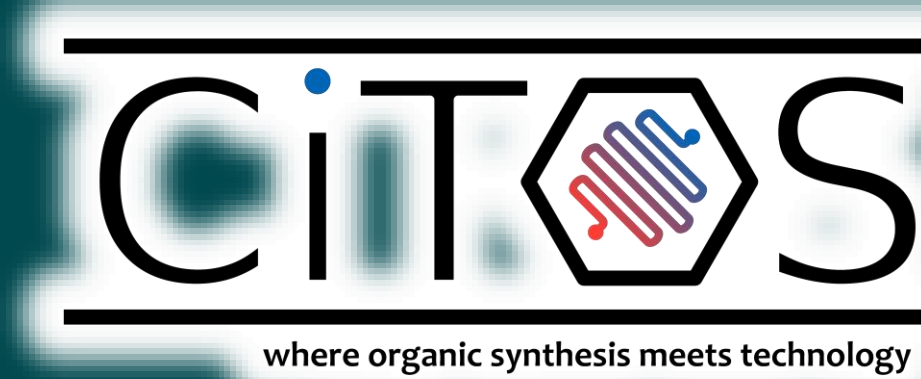


# An Automated Flow Platform for the Nitration of Furfural



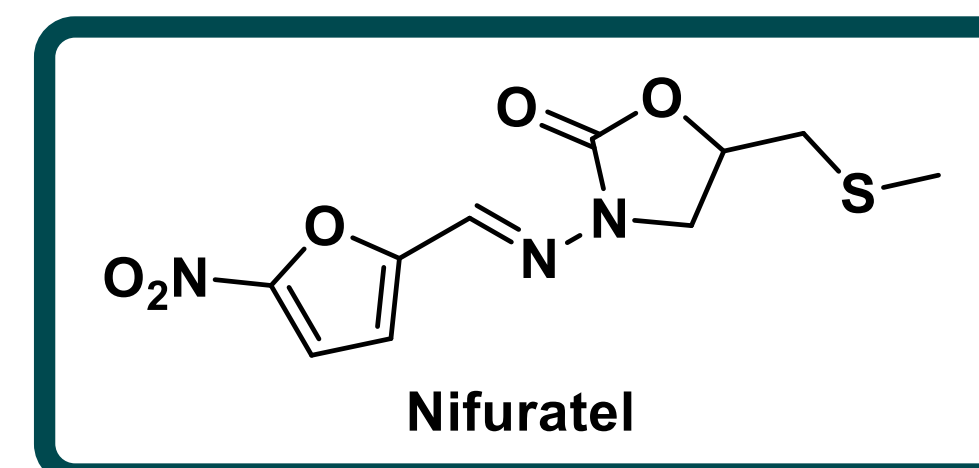
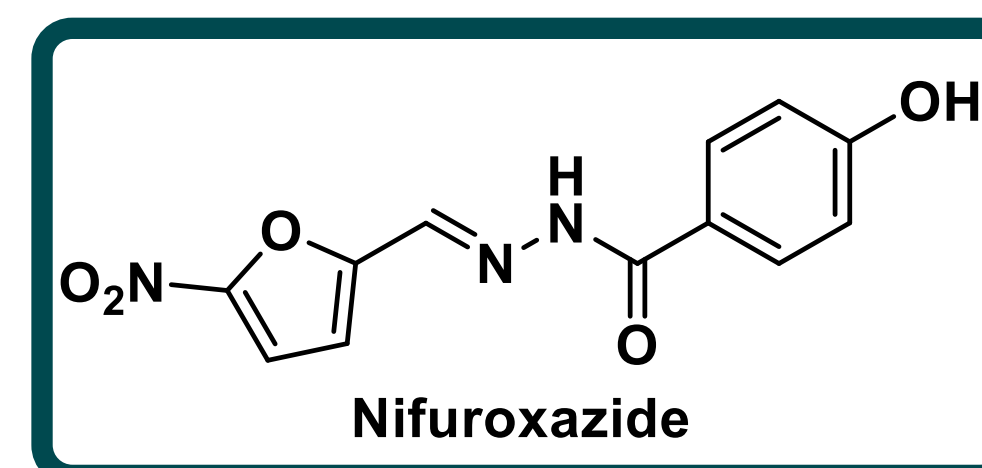
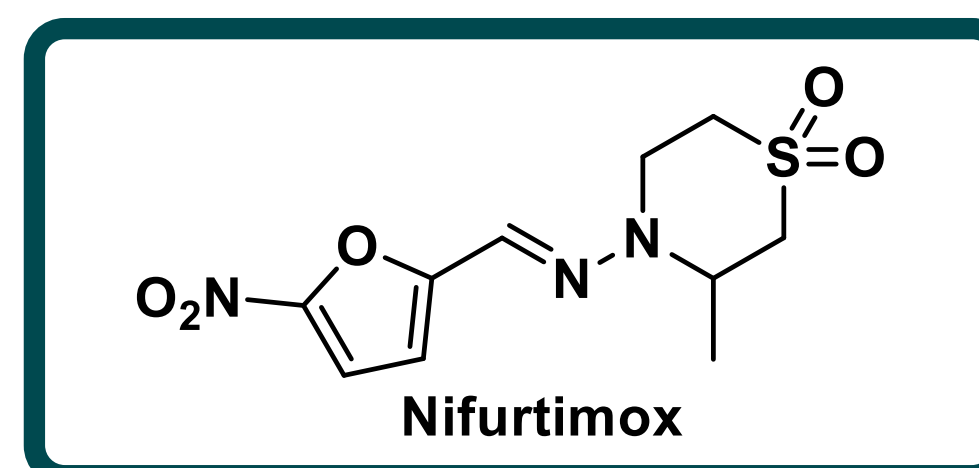
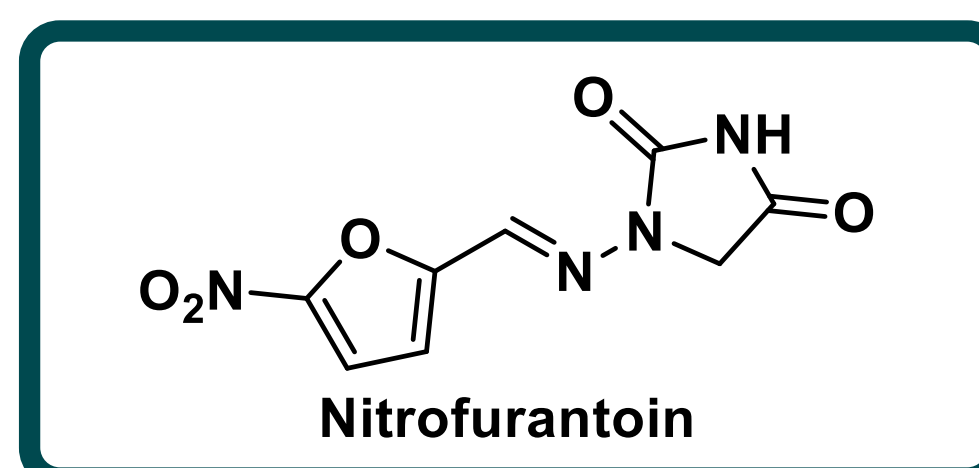
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- ❑ Nitrofurfural (**NI**) – a precursor towards important antimicrobial APIs: Nitrofurantoin, Nifurtimox, Nifuroxazide, Nifuratel and others
- ❑ Furfural (**FUR**) – bio-based building block
- ❑ Safety hazards during nitration processes
- ❑ Cumbersome nitration of furfural



## Goal – development of a system for continuous flow synthesis of nitrofurfural

### Difficulties

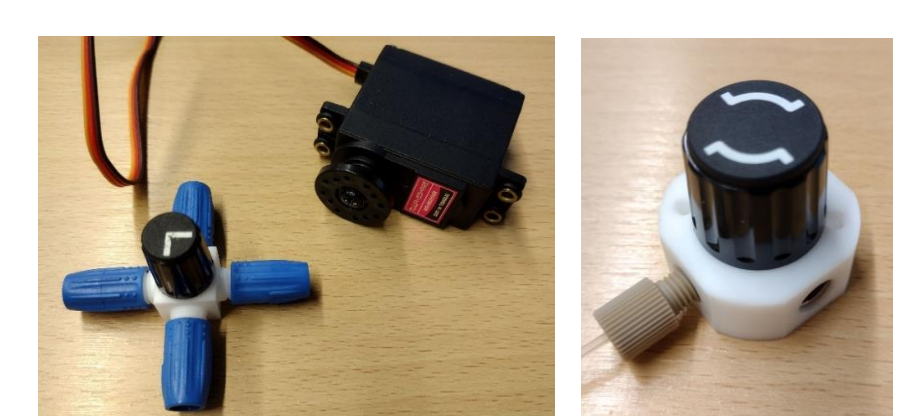
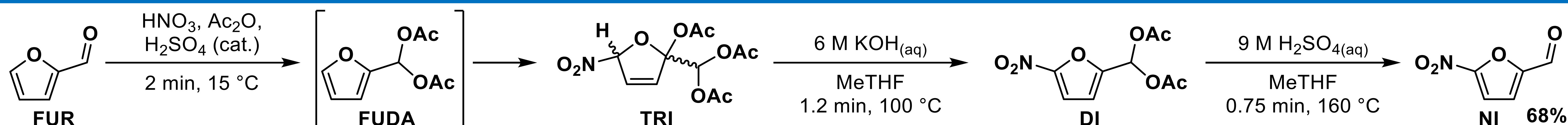
- ❑ Nitrating mixture: 90% HNO<sub>3</sub> in Ac<sub>2</sub>O - not suitable for storage, unstable
- ❑ Corrosiveness of 90% HNO<sub>3</sub>
- ❑ Standard PEEK connectors not suitable
- ❑ Special pump needed
- ❑ Reproducibility issues

### Solutions

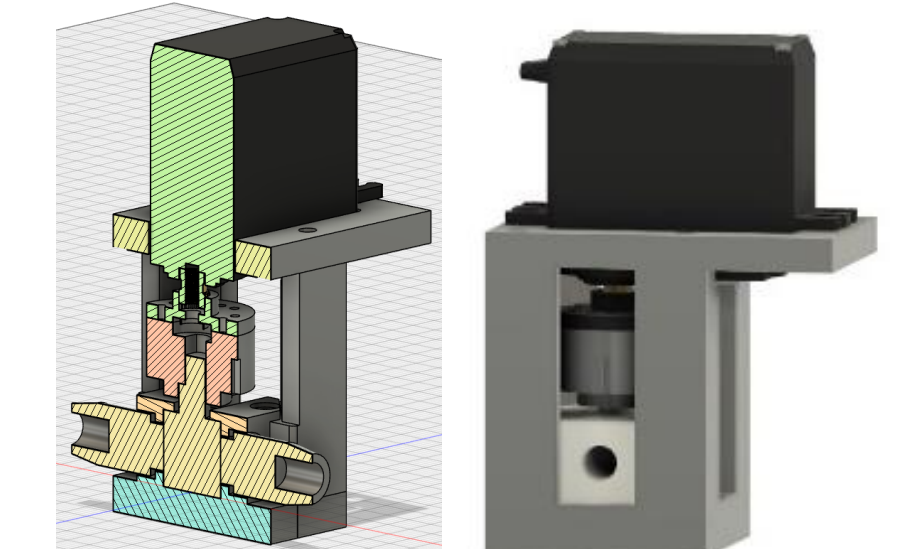
- ❑ PCTFE connectors (VICI), PFA tubing
- ❑ Pumps: FLOM UI-22-110 PCTFE (HNO<sub>3</sub>); Syrris Asia; Knauer Azura P4.1S
- ❑ Measurement of process parameters
- ❑ *In situ* formation of nitrating mixture
- ❑ Process automation

### Advantages

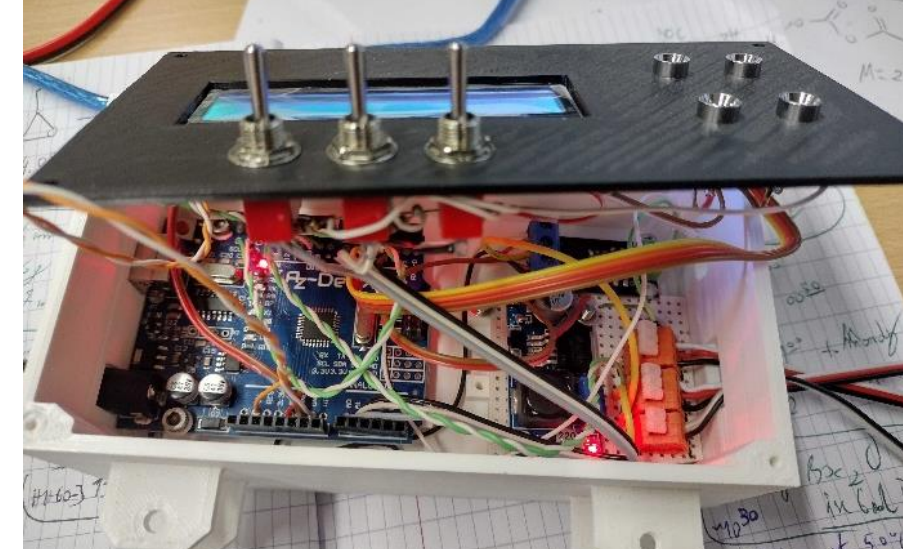
- ❑ Precise control of stoichiometry
- ❑ Improved heat transfer, precise control of temperature
- ❑ Inherent safety and process repeatability
- ❑ Reduced human error possibility
- ❑ Reproducibility and quality assurance



Diba Omnifit LP PTFE/PCTFE valves for HNO<sub>3</sub> and servo-motor for actuation



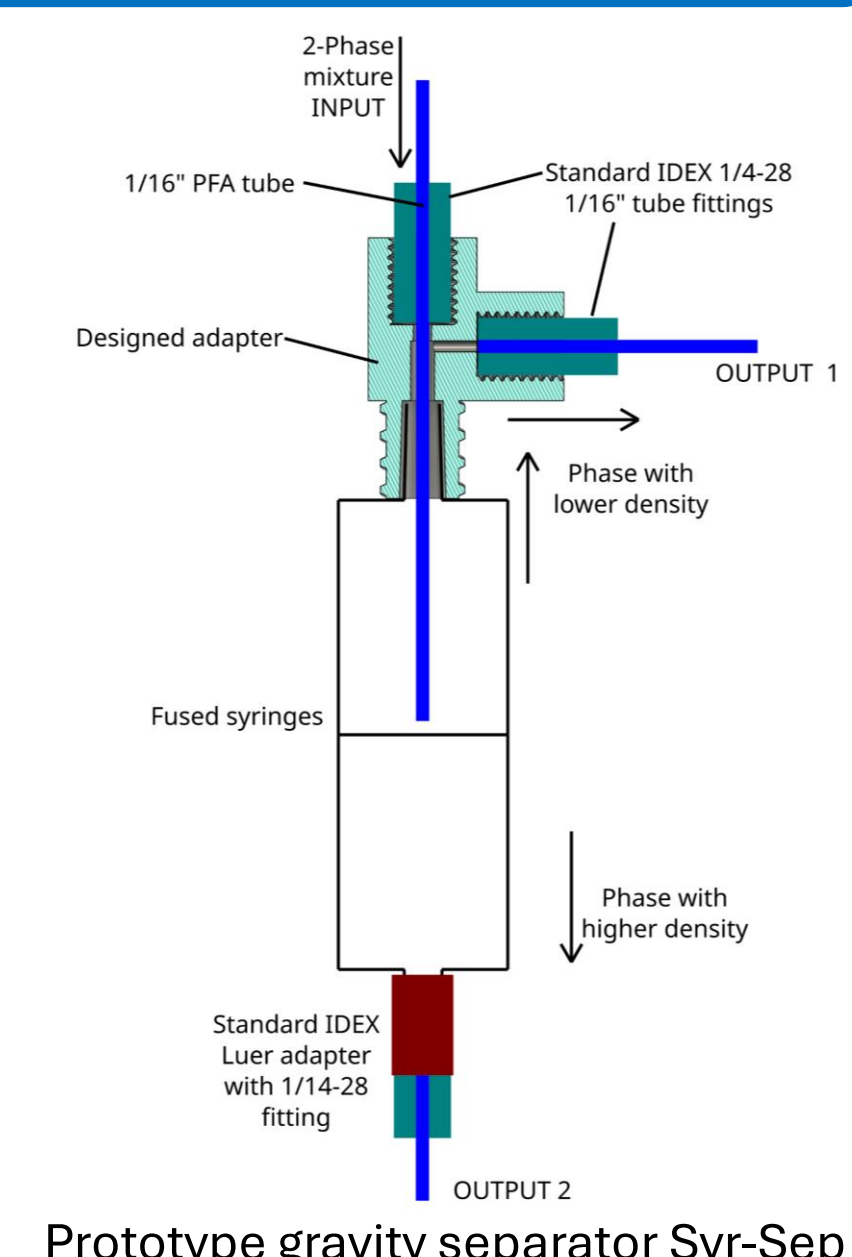
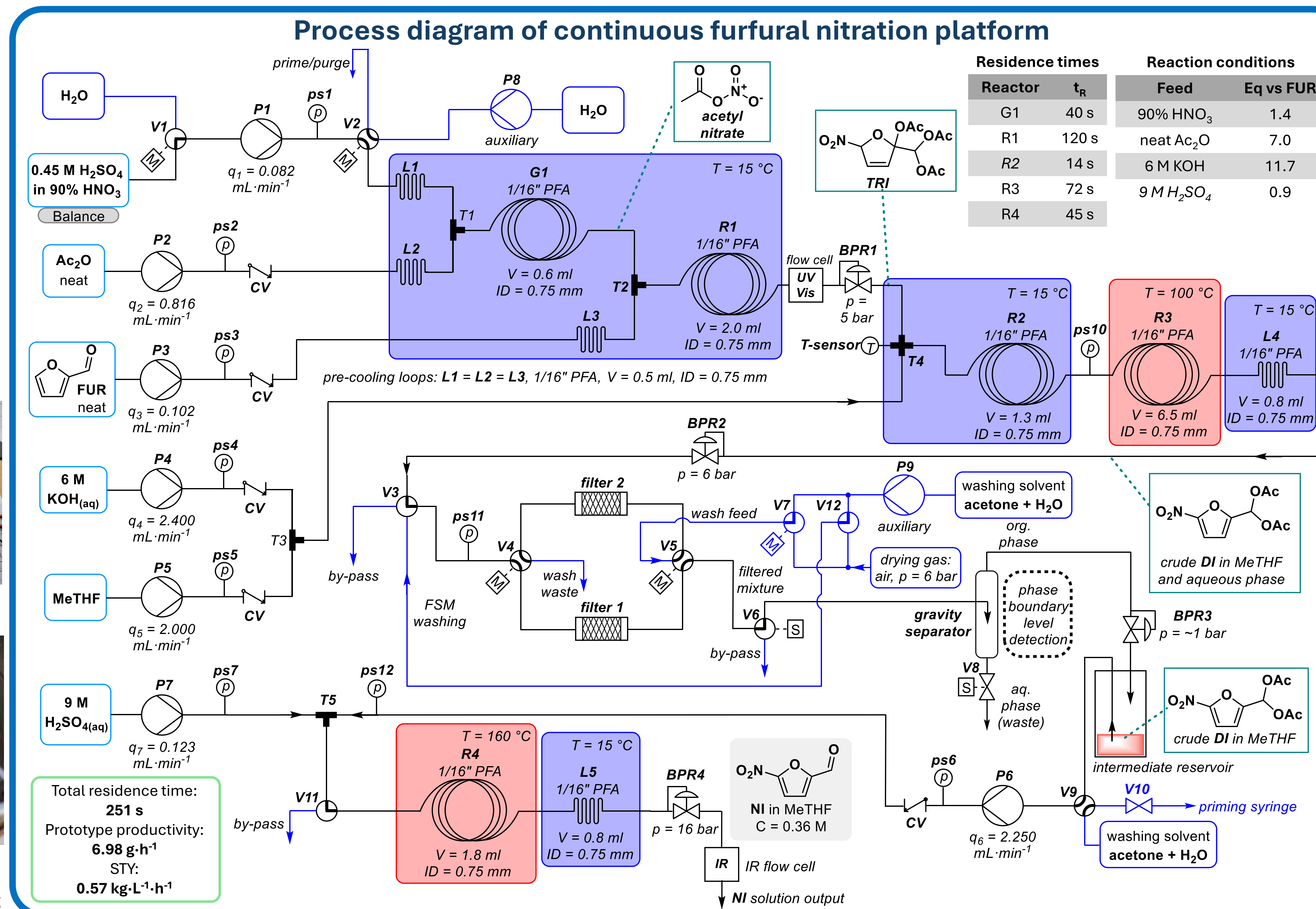
3D design of actuated valves; cross-section, overview



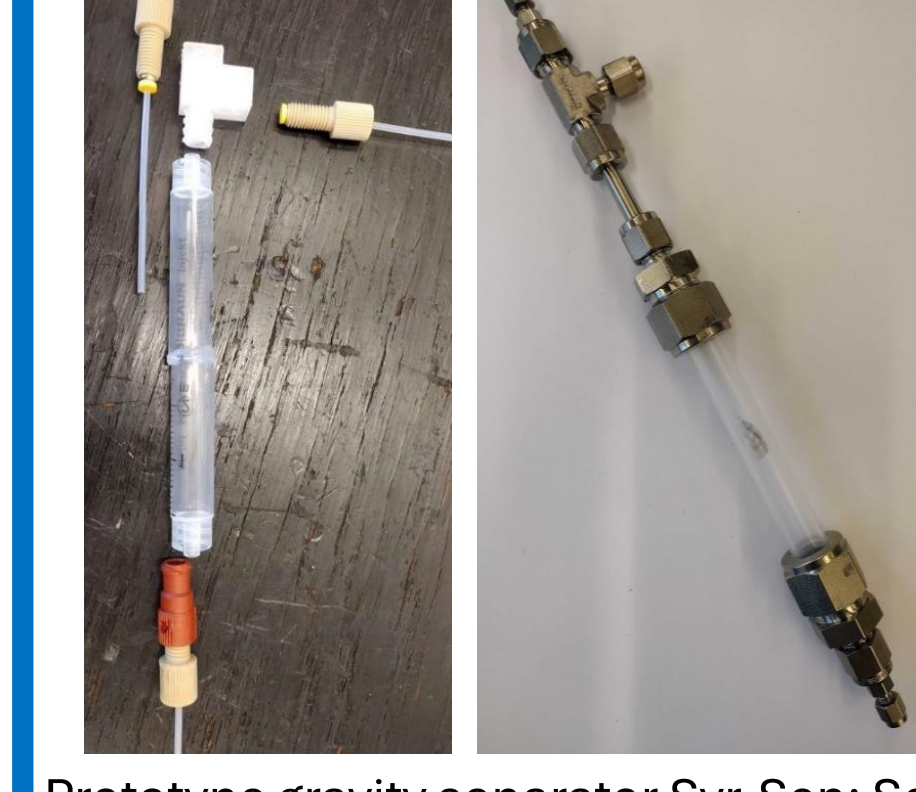
HNO<sub>3</sub> dosing controller during assembly



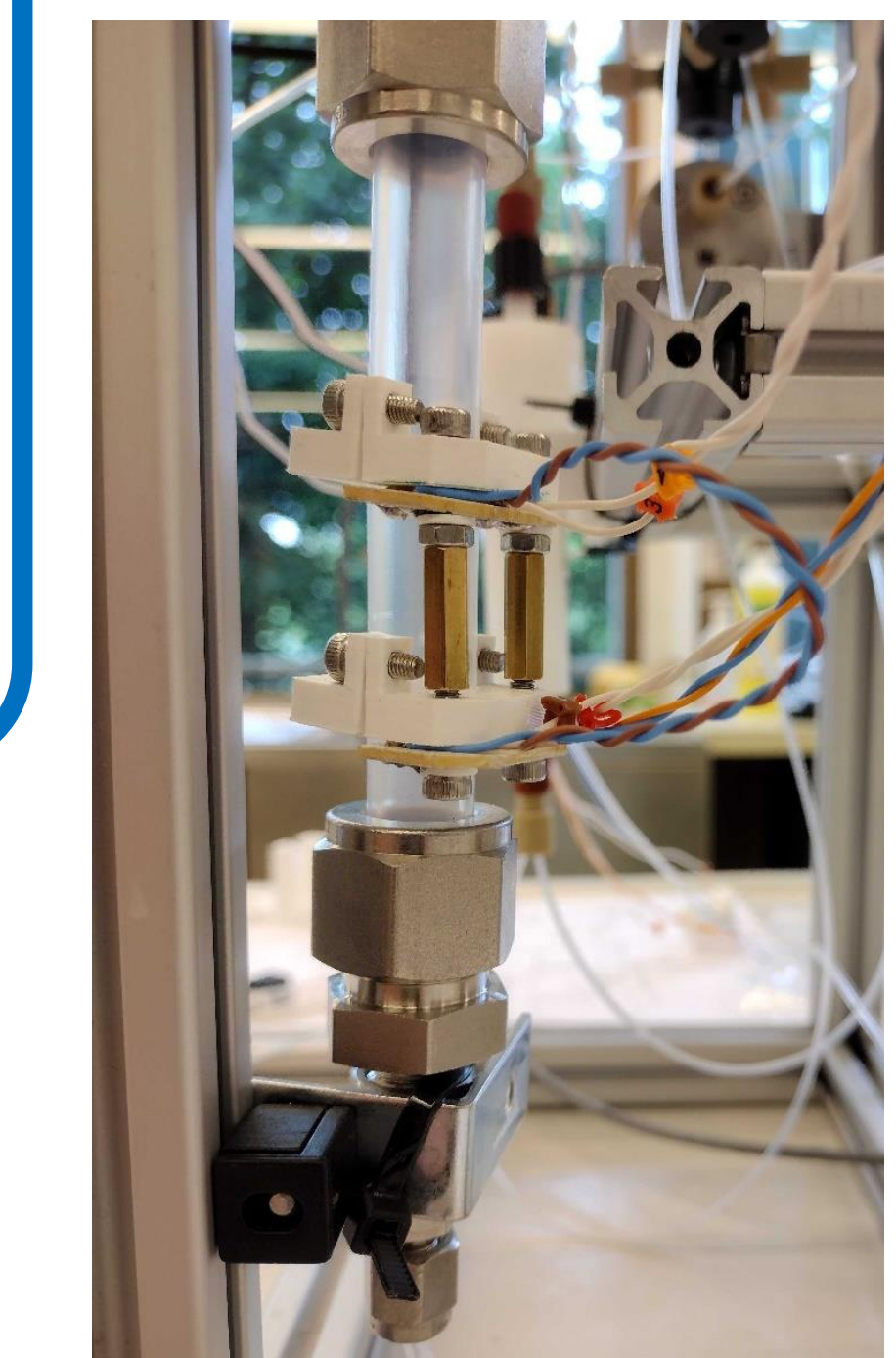
Cooling bath (jacketed beaker) with 3D printed holder for reactors G1, R1, R2 and L1-L5; efficient mechanical mixing



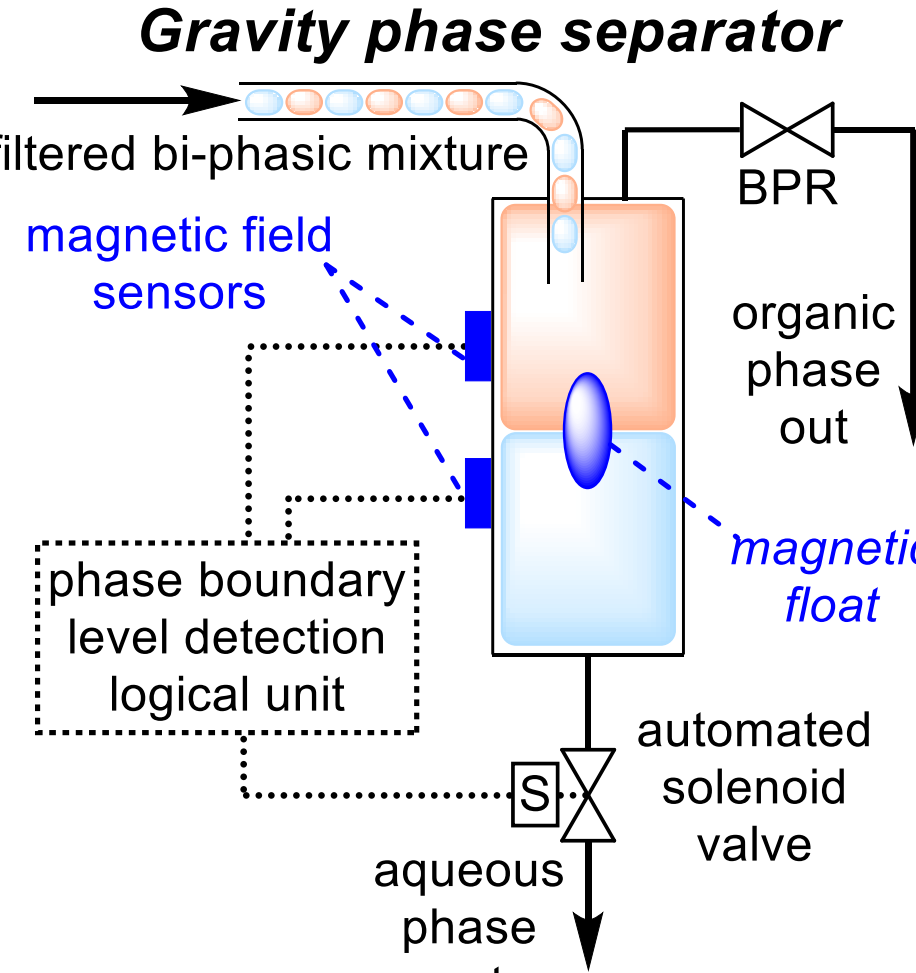
Prototype gravity separator Syr-Sep



Prototype gravity separator Syr-Sep V2.0 made out of Swagelok parts



Phase-boundary tracking and valve control for continuous separator using Hall-sensors



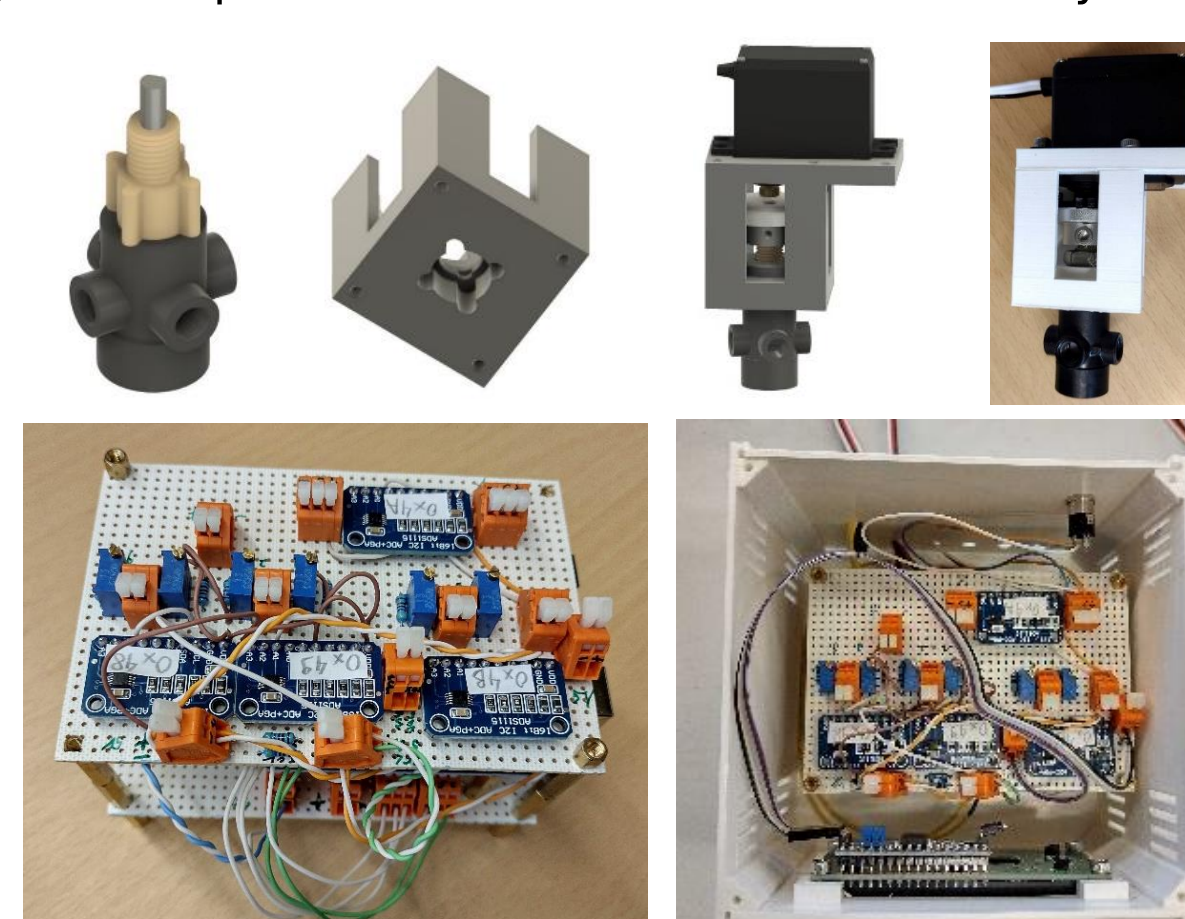
Overview of the continuous flow nitration setup: pumps, automated valves, metal jacketed beaker (cooling of reactors G1, R1, R2), p/T readers visible; FSM is on the left side



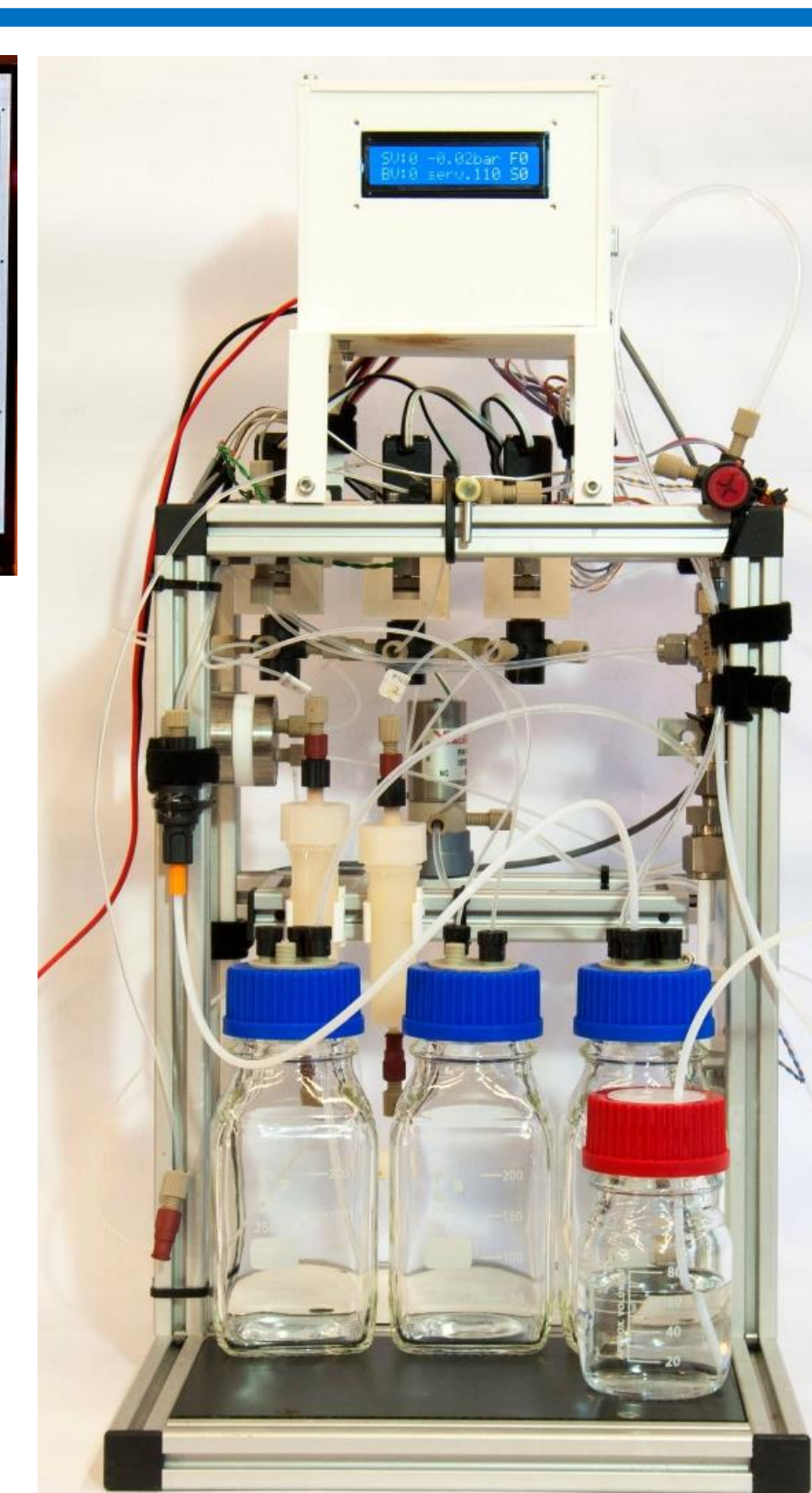
Screens for plotting real-time process parameters, e.g. pressure, temperature, HNO<sub>3</sub> pumping, state of the FSM; Data acquisition custom software created in Python



Balance for monitoring the 90% HNO<sub>3</sub> pumping



Actuated IDEX valves and filtration and separation module control unit (FSMCU) during assembly



Filtration and separation module (FSM)