Electronic Supplementary Information

A modular 3D printed isothermal heat flow calorimeter for reaction calorimetry in continuous flow

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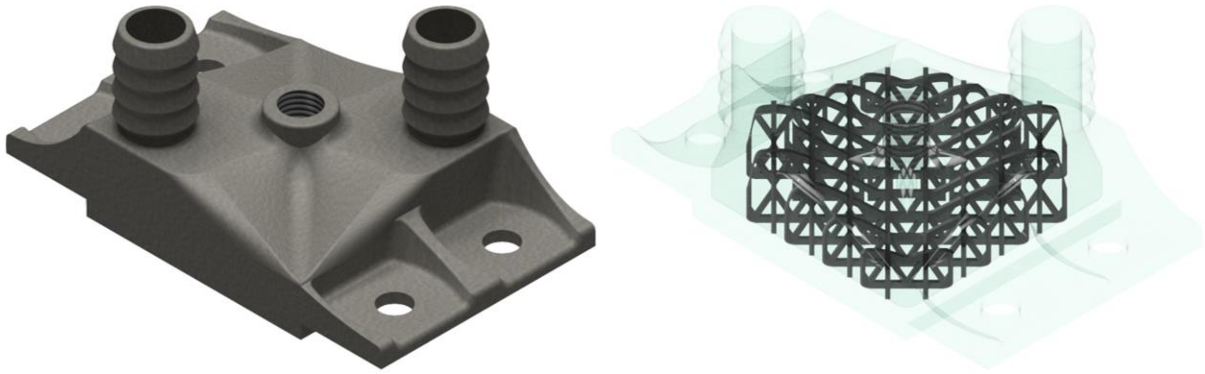


Figure S1 CAD image of a cooling block with its internal support structure. This support provides necessary connection between layers during fabrication and increases the internal contact area for heat transfer of the coolant to the metal.

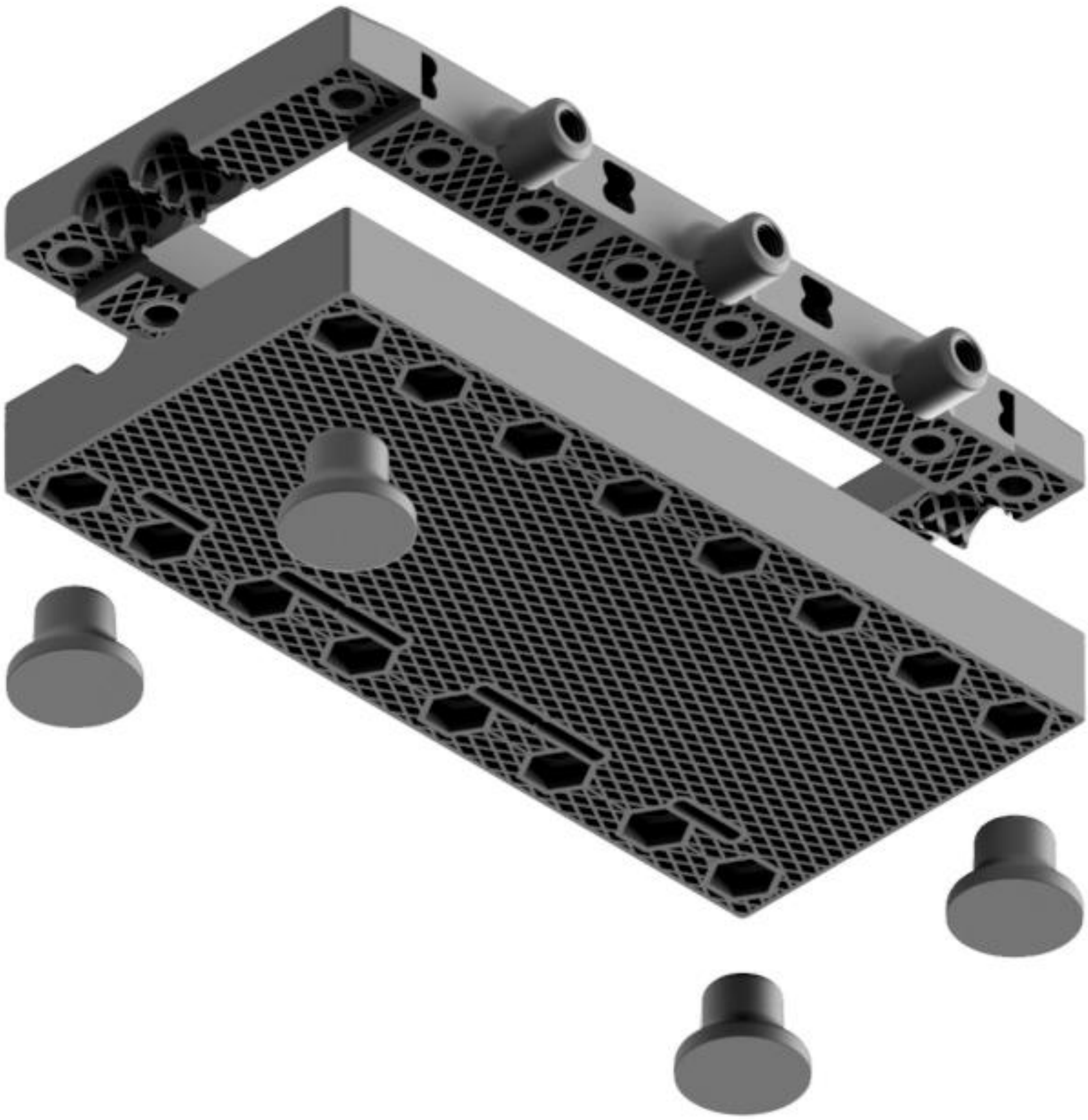


Figure S2 CAD image of casing elements, base plate, and feet. All parts were manufactured with a UV-curable resin printed by a DLP printer without additional printing support. Prism like internal structure was added to increase mechanical strength and provide a layer wise connection.

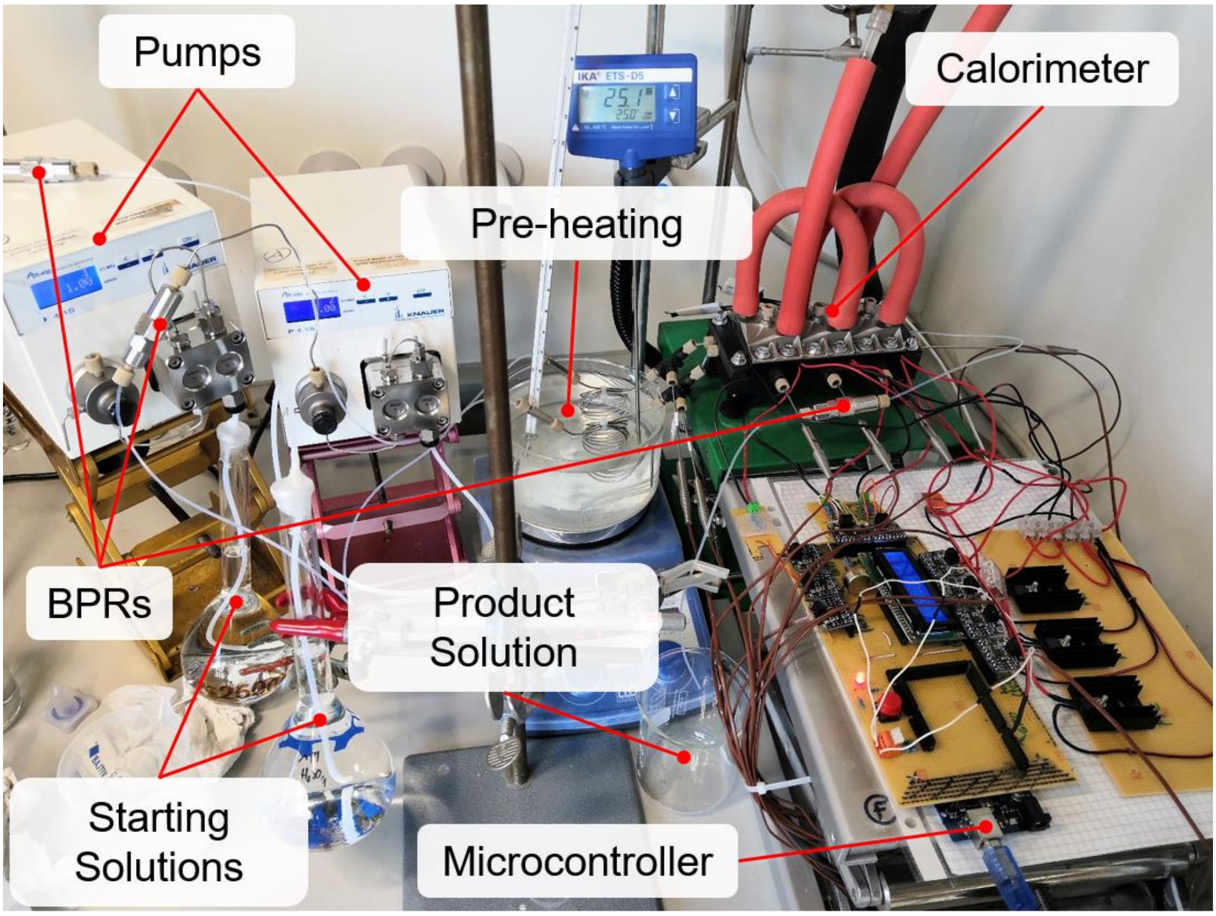
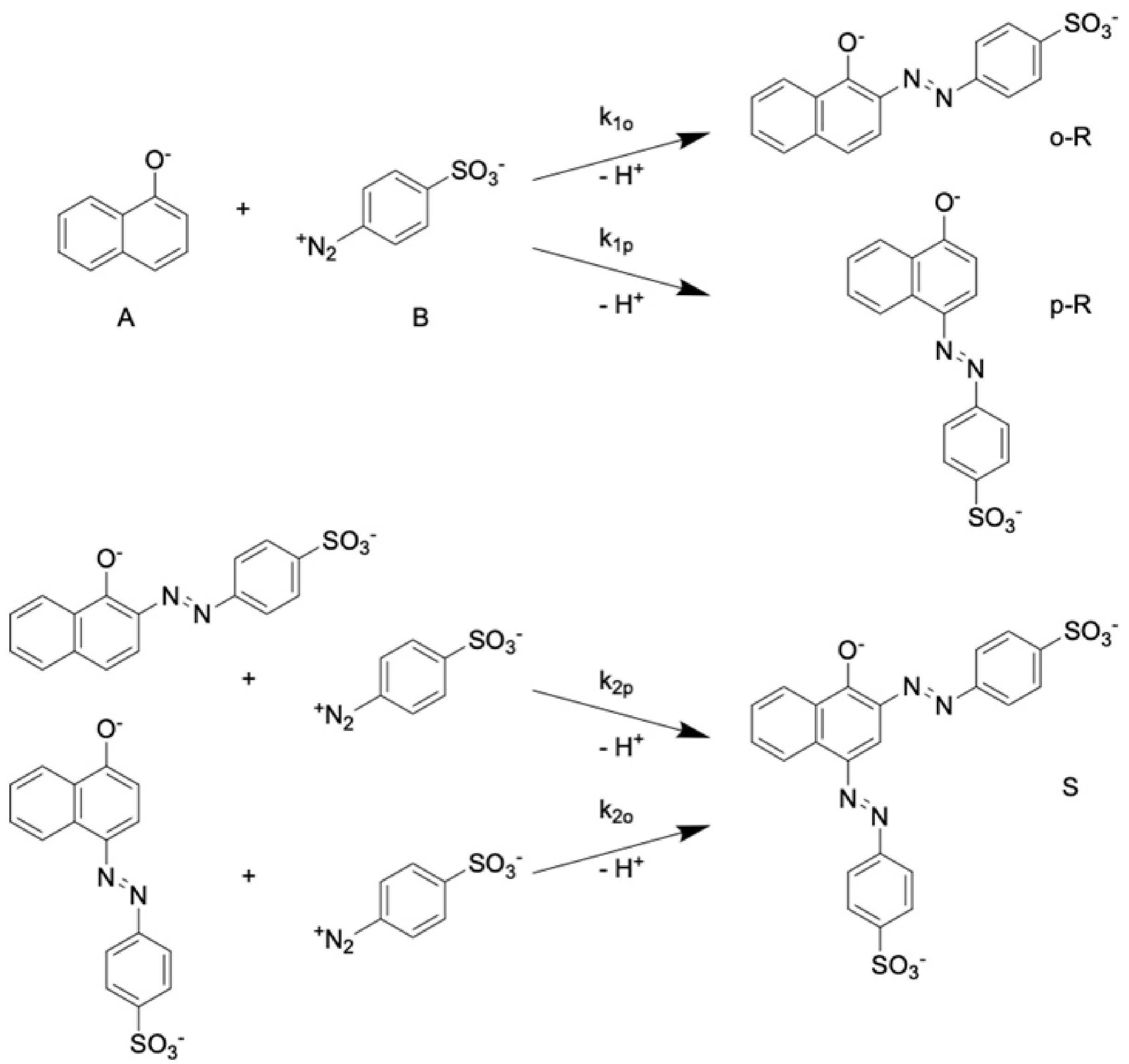


Figure S3 Picture of the experimental setup used for the neutralization experiments. The designed calorimeter can be seen in the right corner of the fume hood. In front of it is the control circuit connected to a PC.



Scheme S1 Mechanism of the Bourne reaction, as described by J. R. Bourne, O. M. Kut, J. Lenzner and H. Maire, Ind. Eng. Chem. Res., 1990, 29, 1761–1765.

In the next figures, the following temperatures are shown: Set temperature of the regulation, T_set; Temperature of the pre-cooling segment, T_pre; Temperature of the reactor segment r1, T_r1; Temperature of the reactor segment r2, T_r2; Temperature measured at inlet A (used for AcOH during neutralizations), T_A; Temperature measured at inlet B (used for NaOH during neutralizations), T_B; Outlet temperature, T_out. Arrows in the figures indicate total flow rates unless stated otherwise.

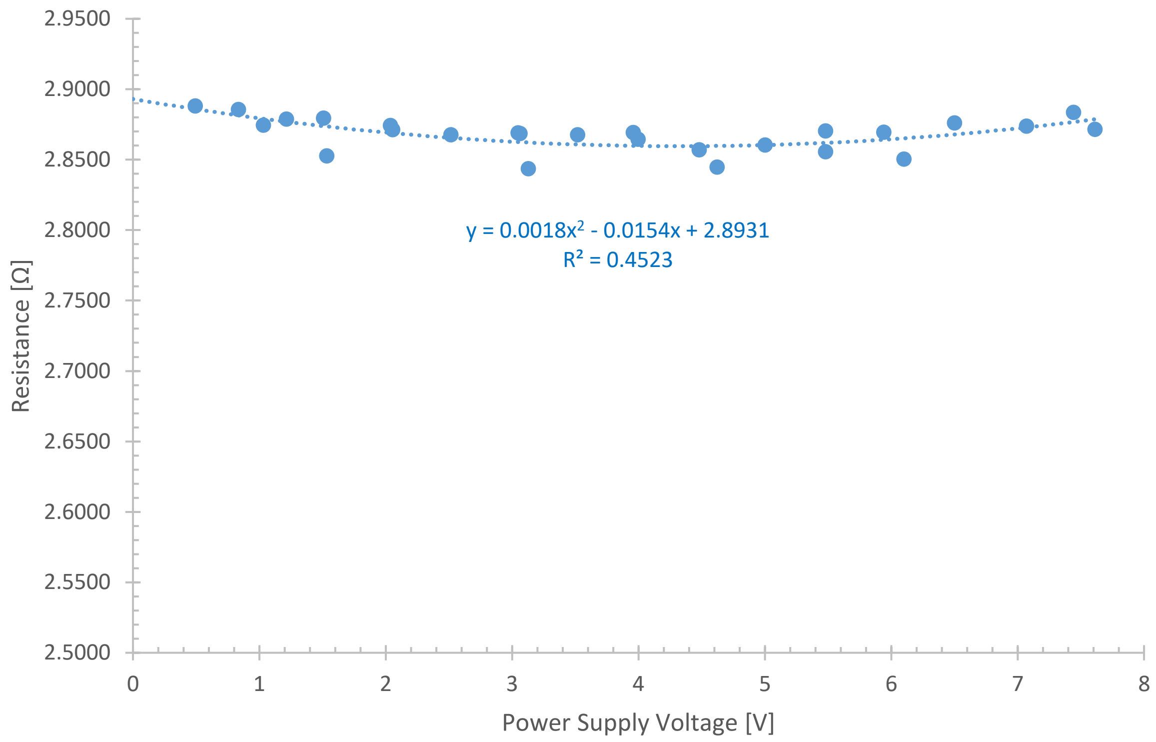


Figure S4 Change of heating foil resistance during calibration. This change was accounted within the calibration.

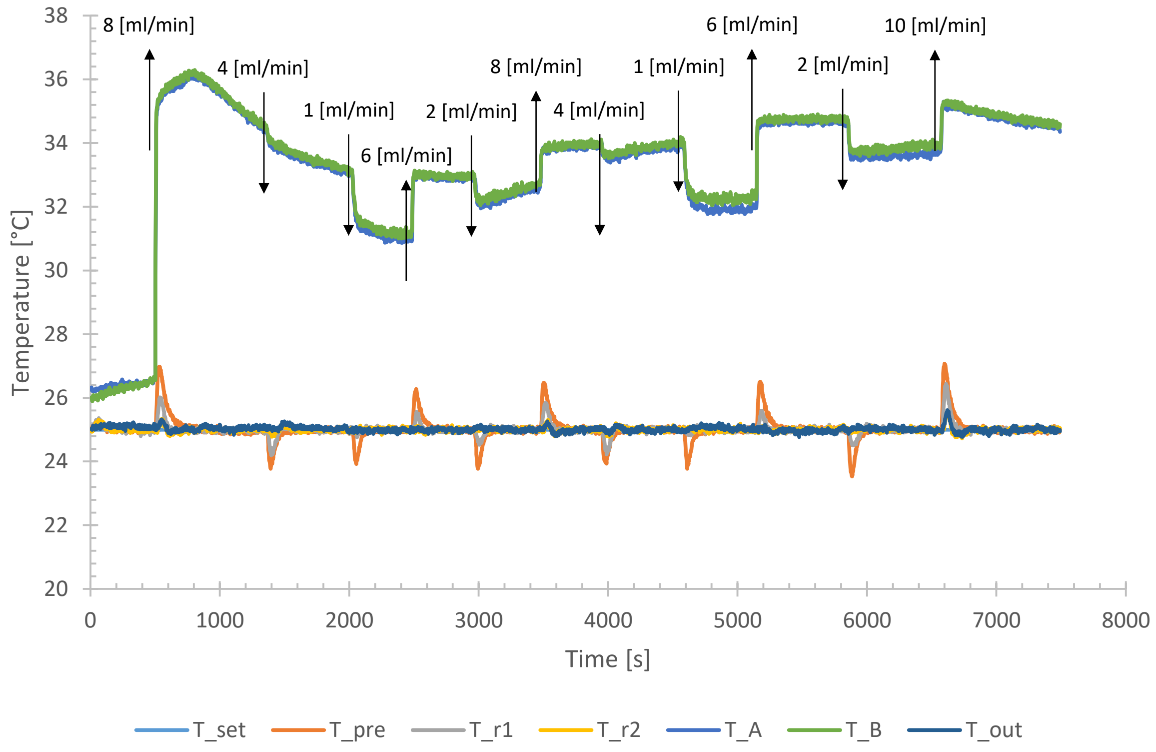


Figure S5 Warm water experiment. Shown are the measured temperatures at different positions and at different flow rates (given in ml/min) of the fed water.

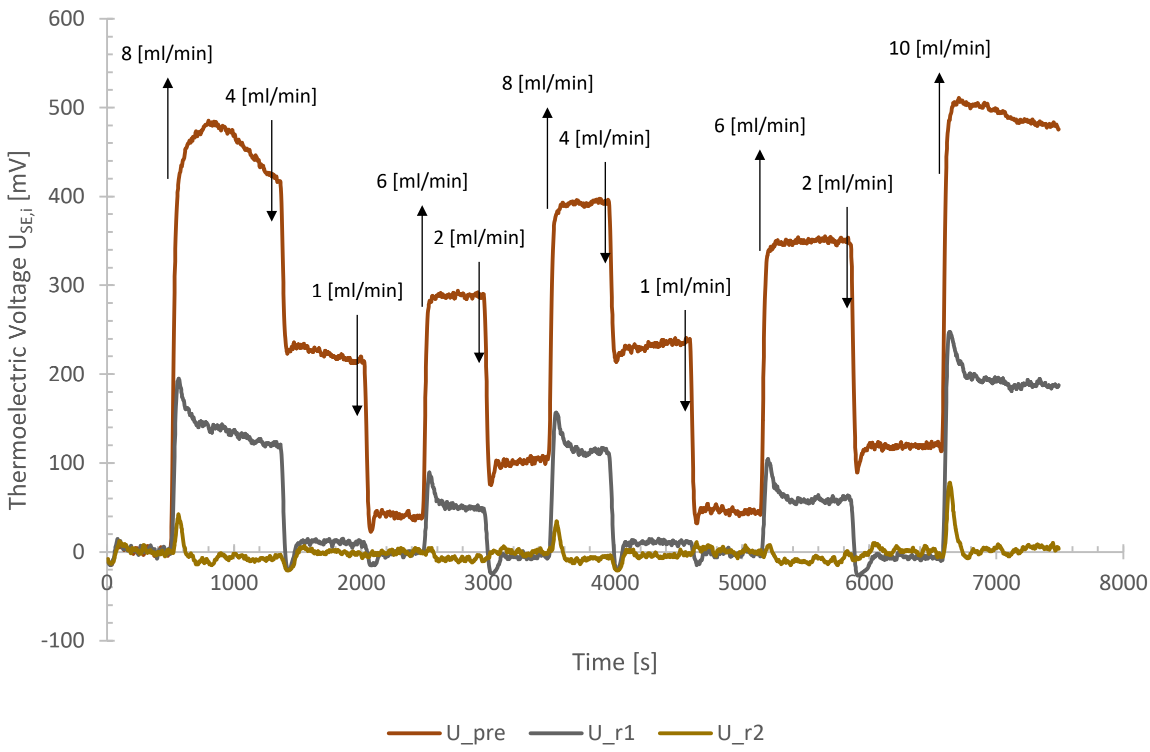


Figure S6 Warm water experiment. Shown are the measured voltages at different positions and at different flow rates (given in ml/min) of the fed water.

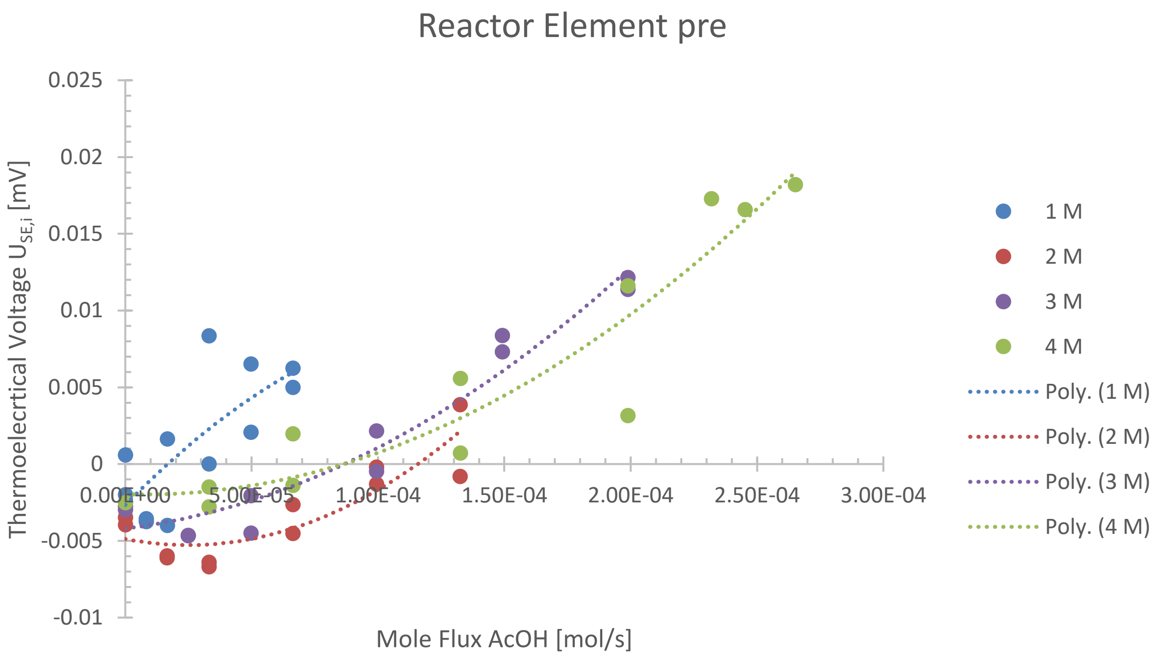


Figure S7 Neutralization of acetic acid with sodium hydroxide. Heat flux measured at the precooling element.

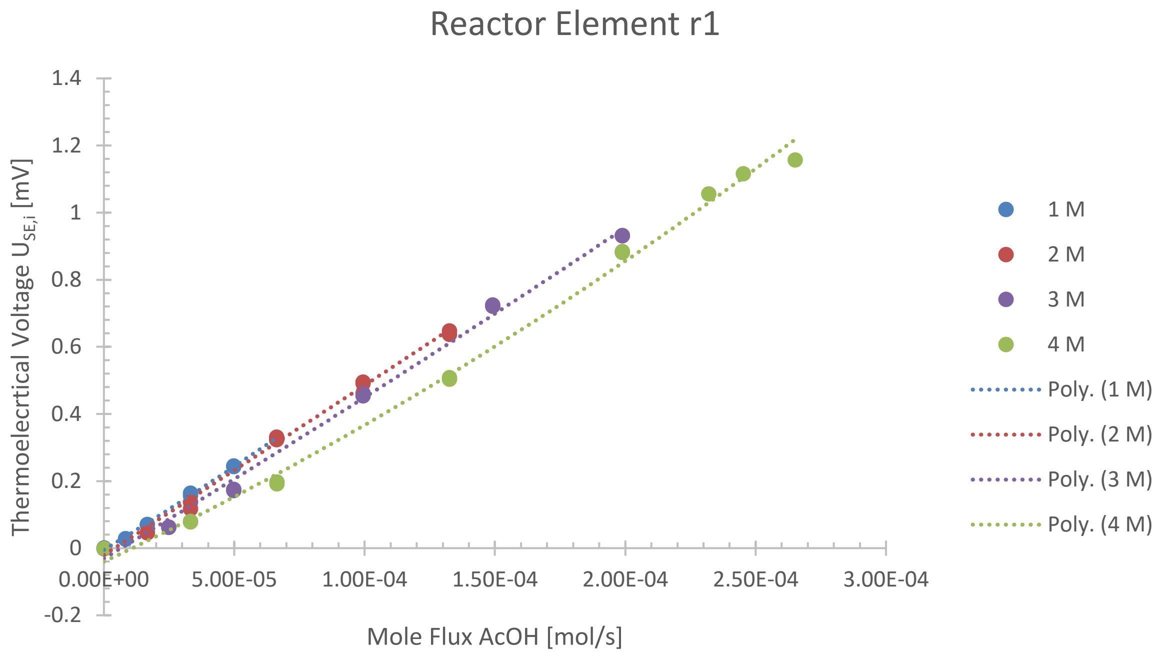


Figure S8 Neutralization of acetic acid with sodium hydroxide. Heat flux measured at the reactor element r1.

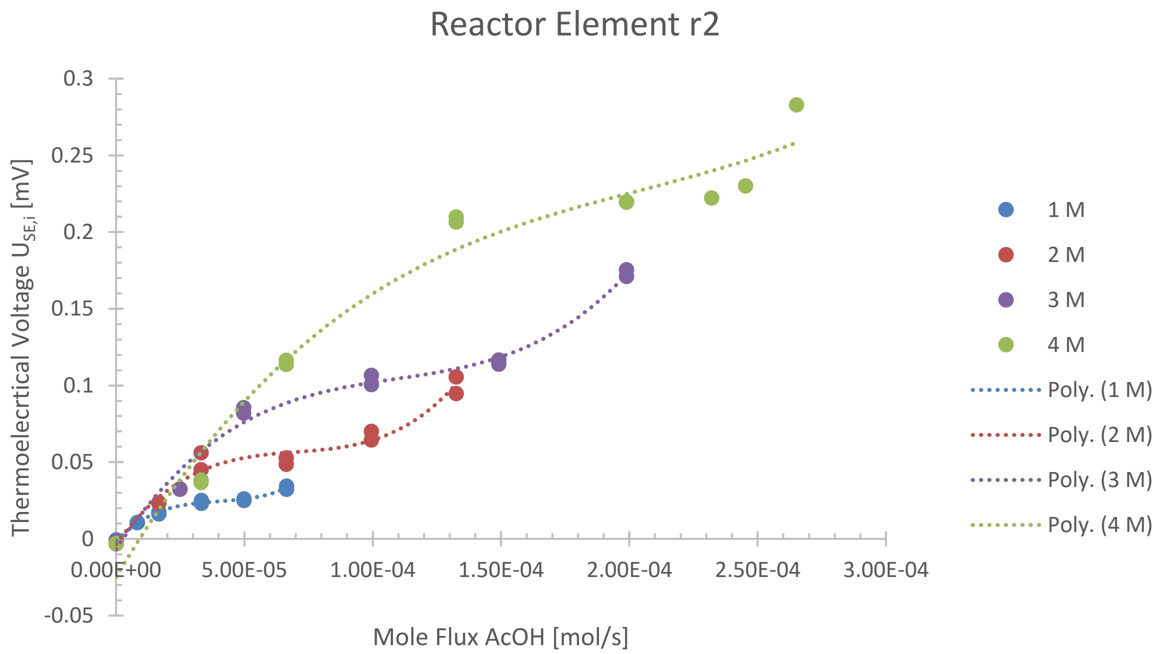


Figure S9 Neutralization of acetic acid with sodium hydroxide. Heat flux measured at the reactor element r2.

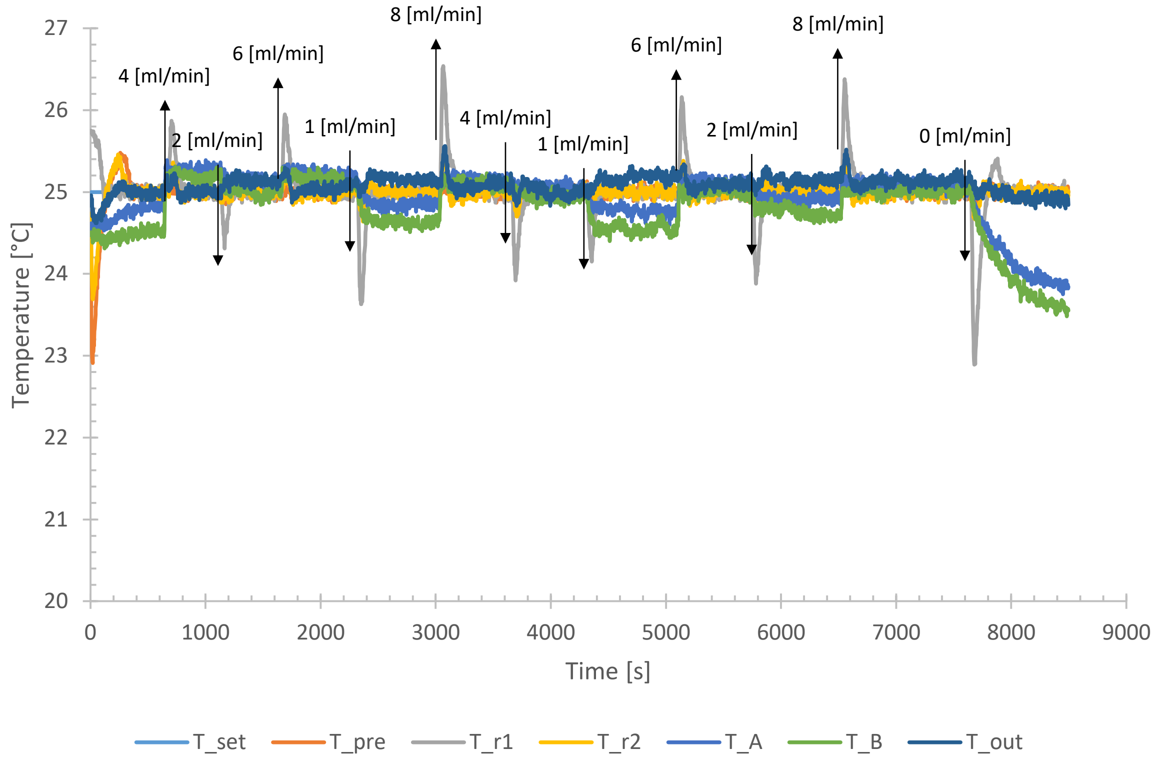


Figure S10 Neutralization of 1 M acetic acid with 1 M sodium hydroxide. Temperatures measured at different total flow rates.

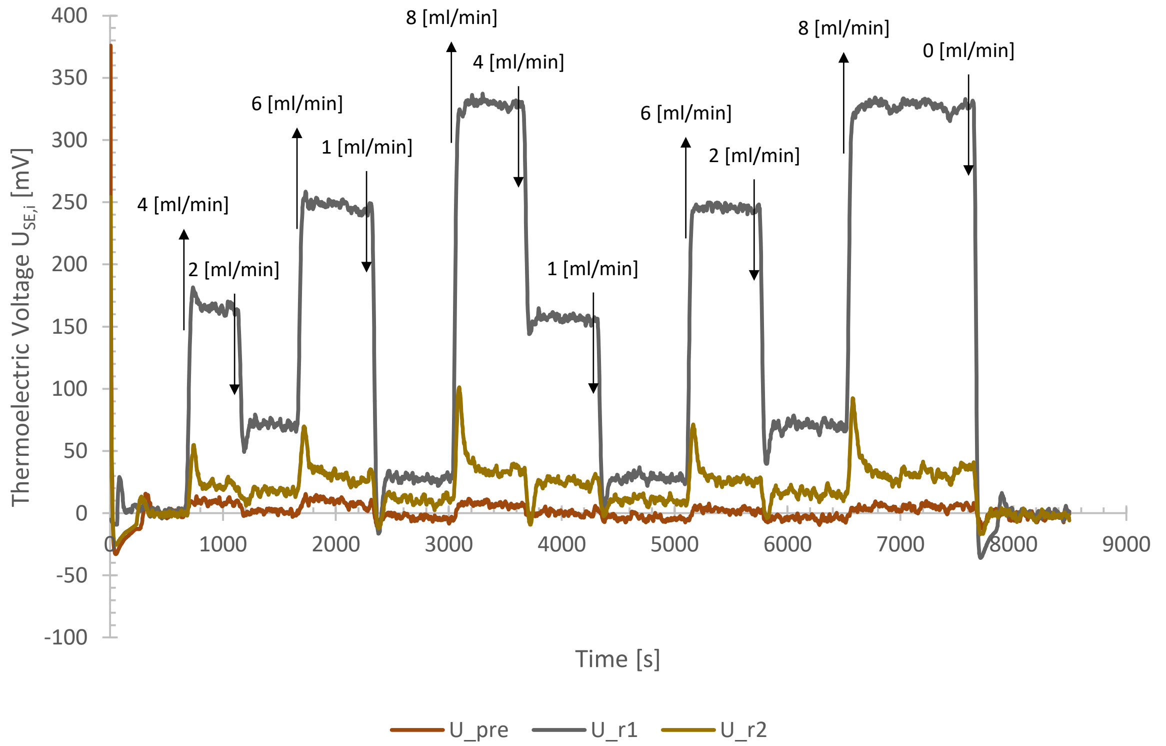


Figure S11 Neutralization of 1 M acetic acid with 1 M sodium hydroxide. Voltages measured at different total flow rates.

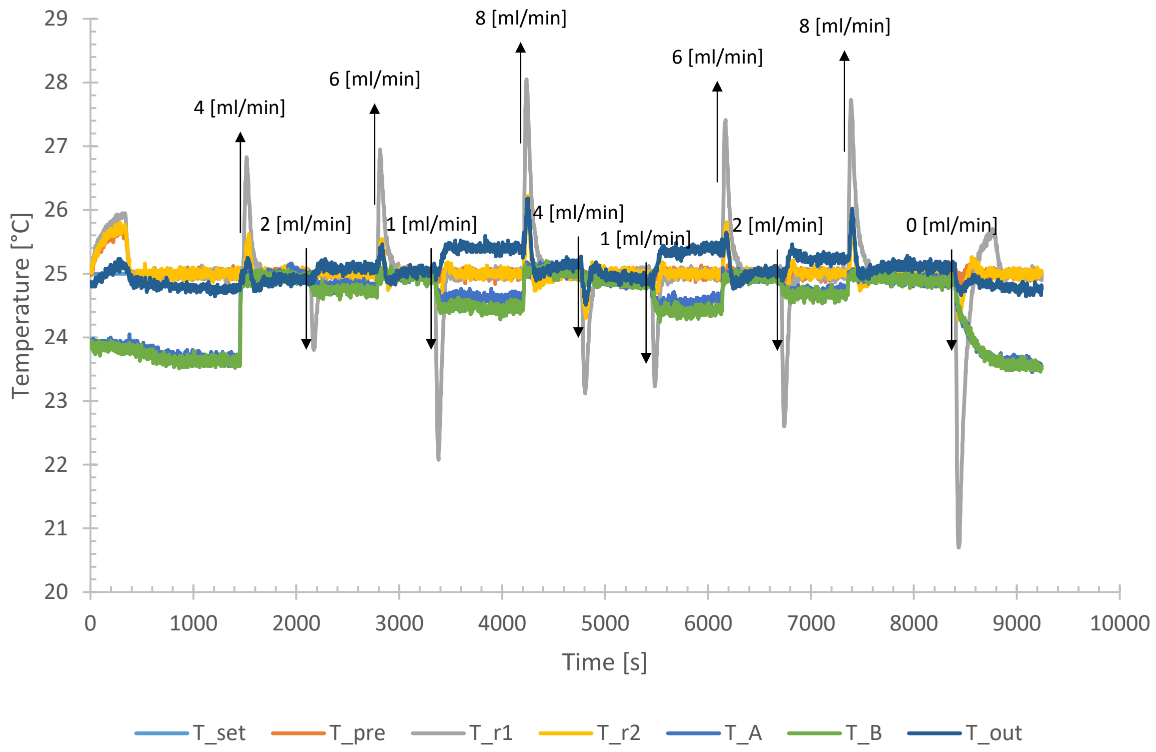


Figure S12 Neutralization of 2 M acetic acid with 2 M sodium hydroxide. Temperatures measured at different total flow rates.

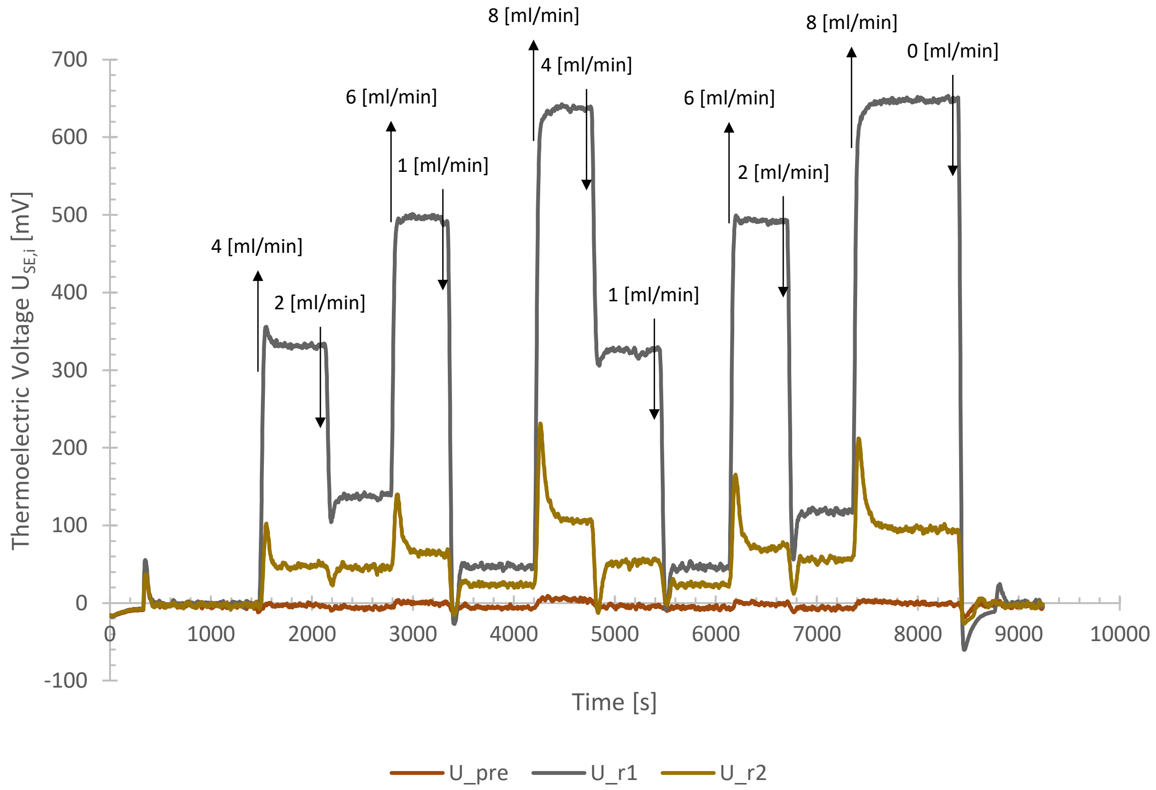


Figure S13 Neutralization of 2 M acetic acid with 2 M sodium hydroxide. Voltages measured at different total flow rates.

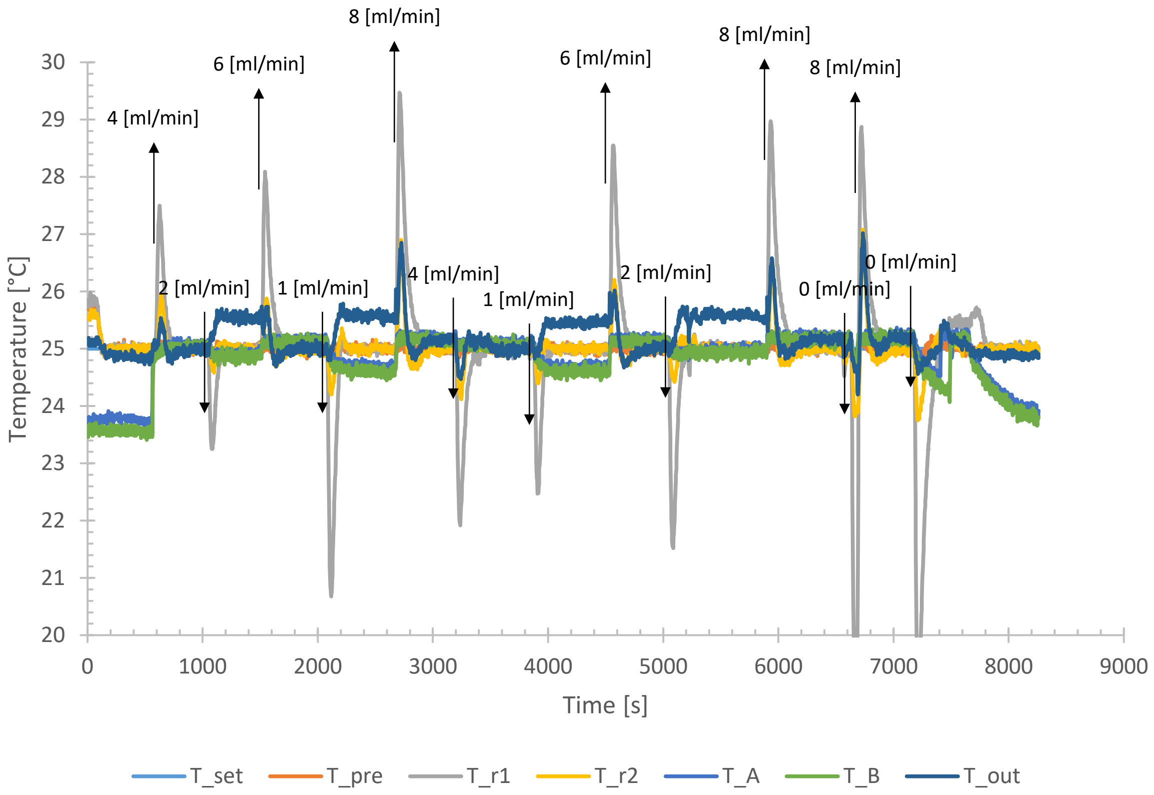


Figure S14 Neutralization of 3 M acetic acid with 3 M sodium hydroxide. Temperatures measured at different total flow rates.

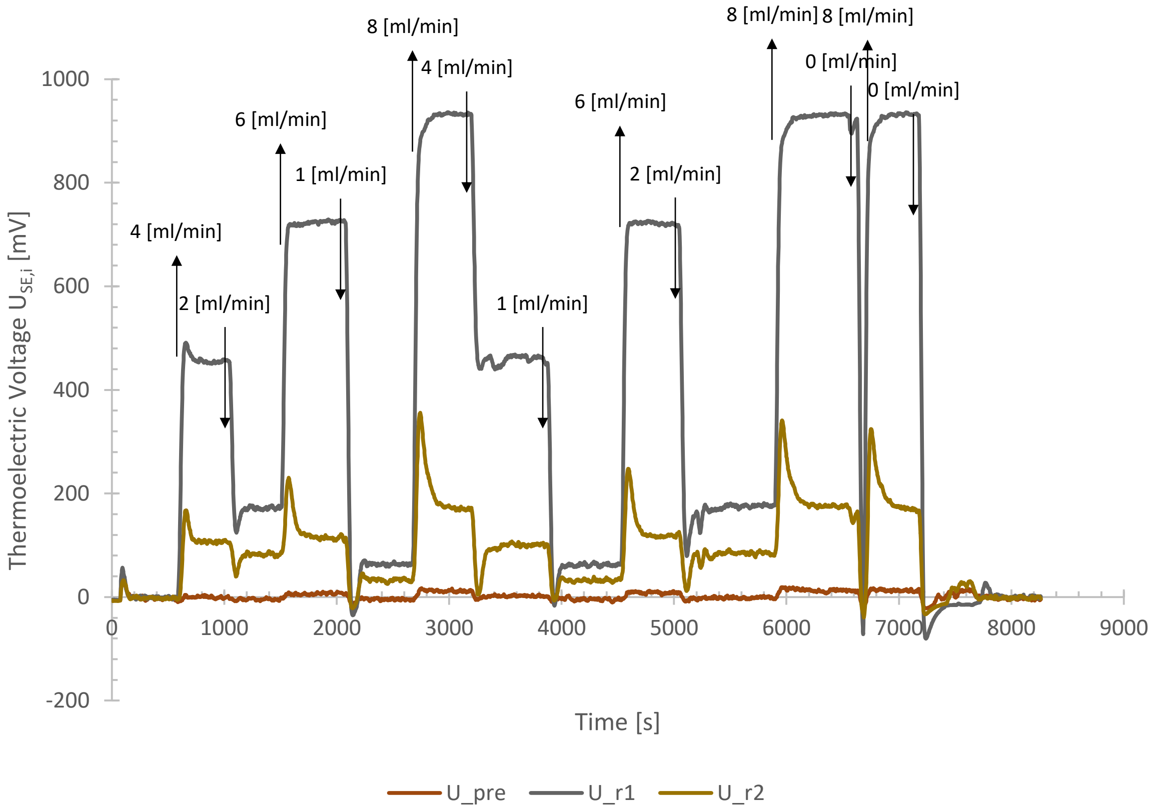


Figure S15 Neutralization of 3 M acetic acid with 3 M sodium hydroxide. Voltages measured at different total flow rates.

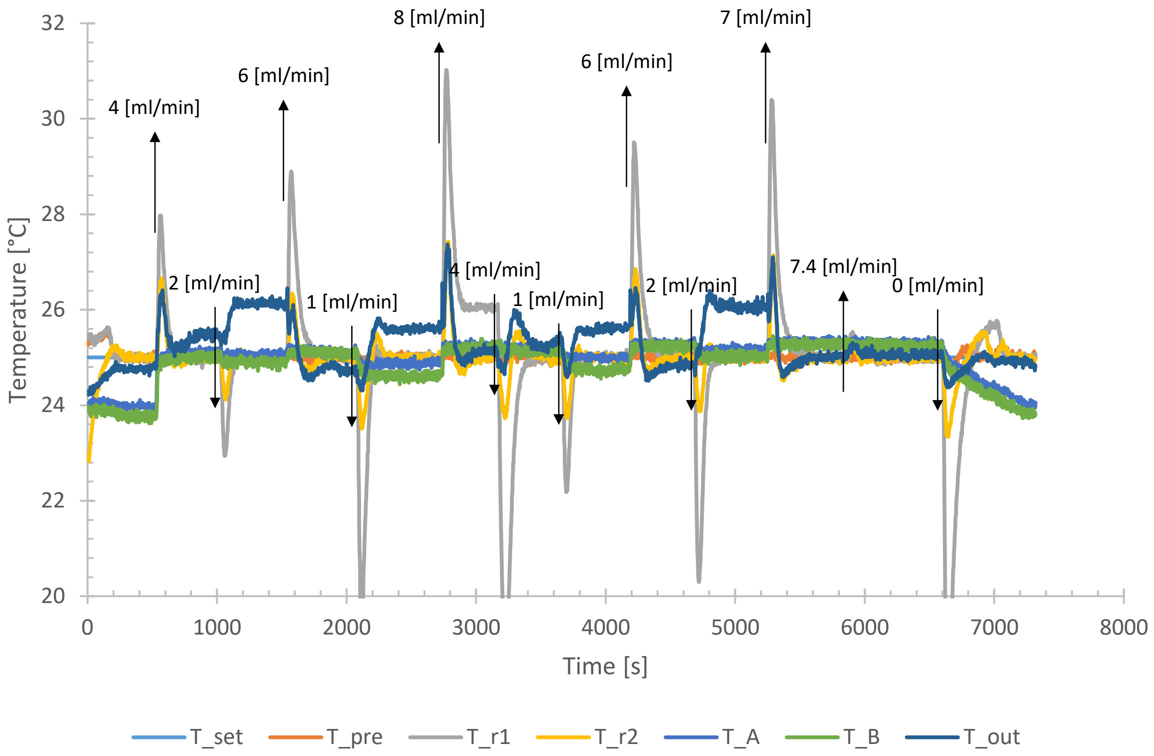


Figure S16 Neutralization of 4 M acetic acid with 4 M sodium hydroxide. Temperatures measured at different total flow rates.

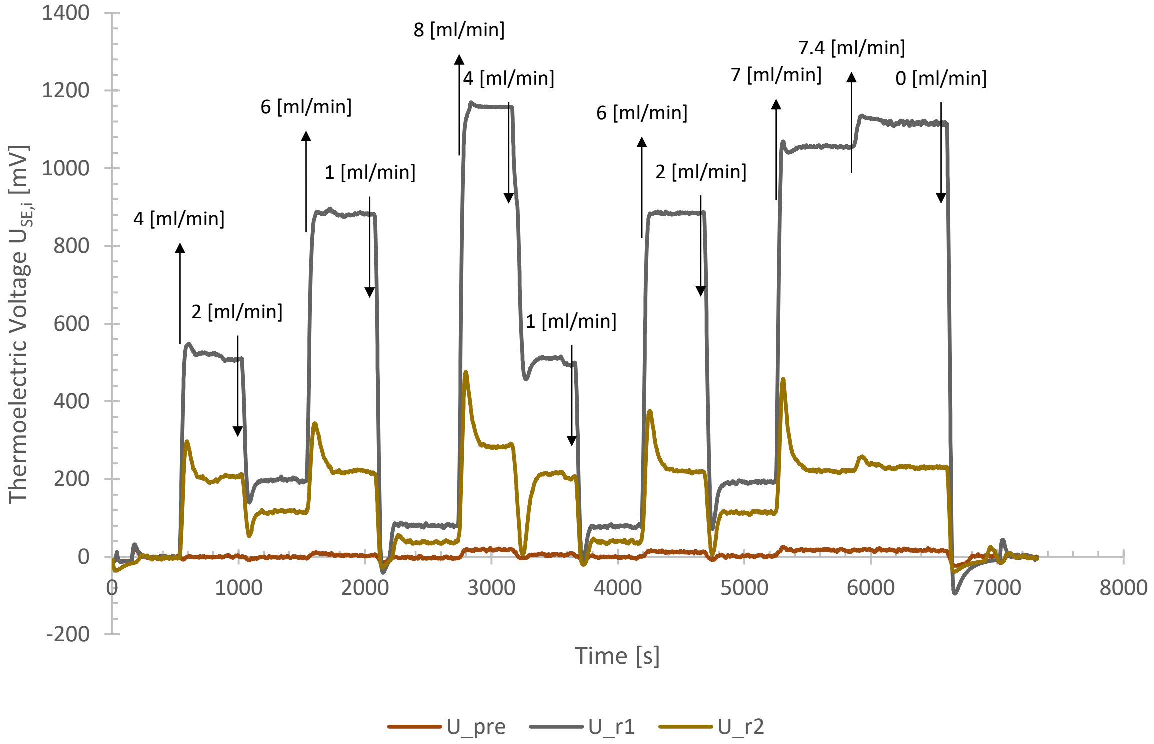


Figure S17 Neutralization of 4 M acetic acid with 4 M sodium hydroxide. Voltages measured at different total flow rates.

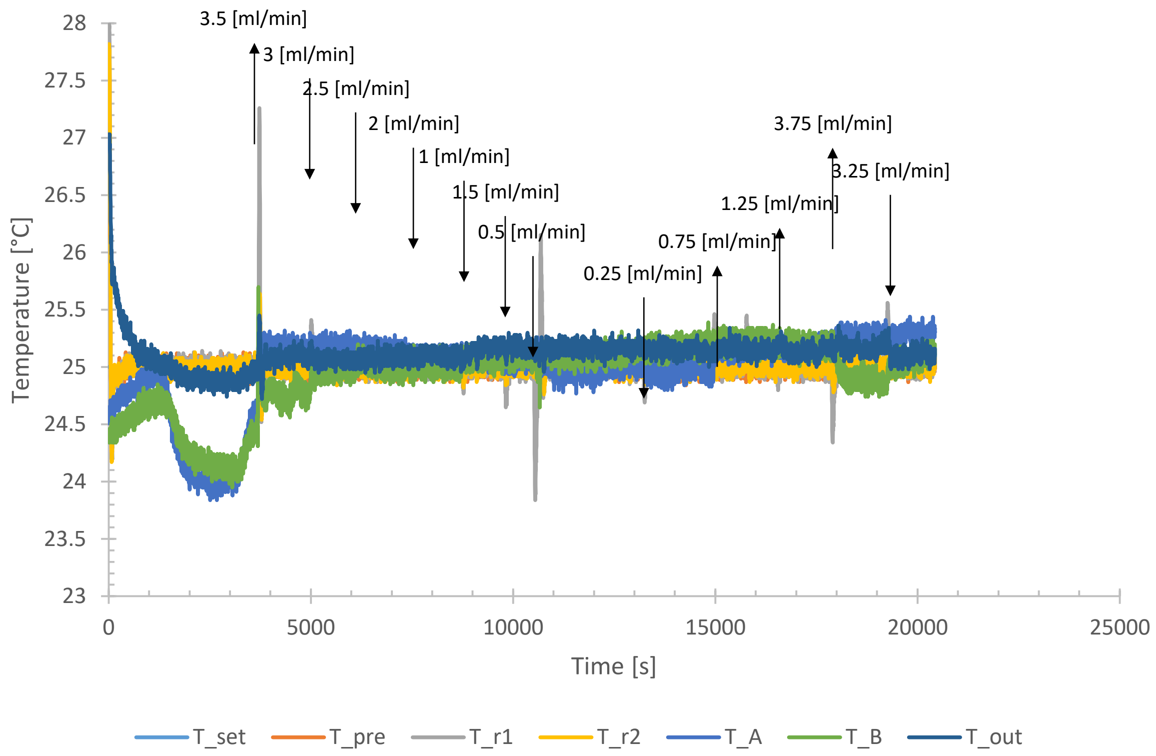


Figure S18 Mixing heat of MeOH and water. Temperatures during measurement. Total flow rate was 4 ml/min for all operation points and the shown arrows indicate water flow rate.

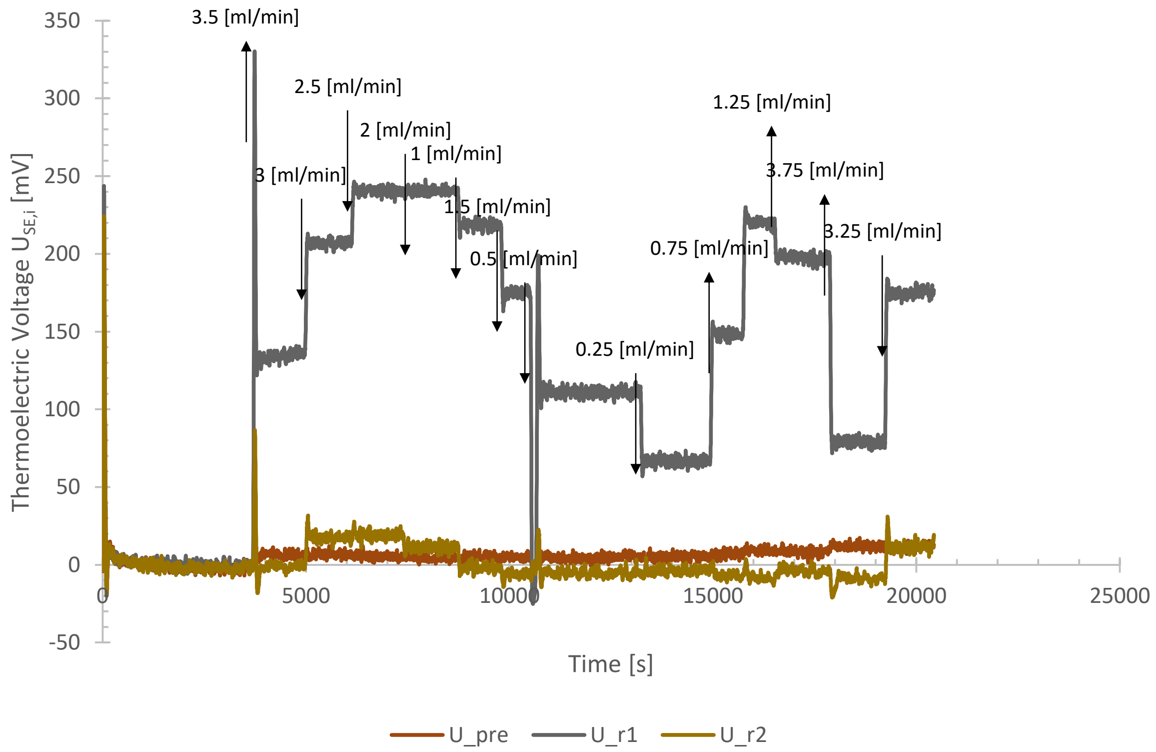


Figure S19 Mixing heat of MeOH and water. Voltages during measurement. Total flow rate was 4 ml/min for all operation points and the shown arrows indicate water flow rate.

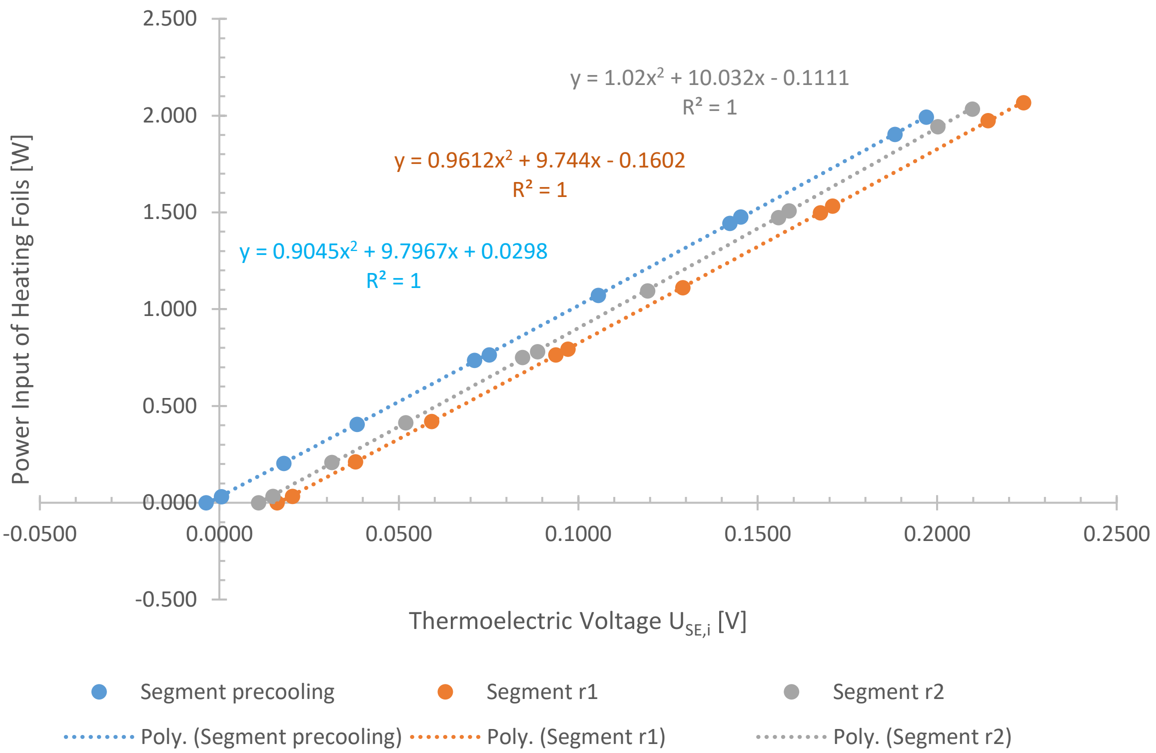


Figure S20 New calibration for the heat capacity measurement. This calibration was needed since cooling of the reactor segments to 23 °C also reduced the temperature in the precooling element. Therefore, the thermostat was set to a higher value to provide enough heat for the precooling element to be held at 25 °C.

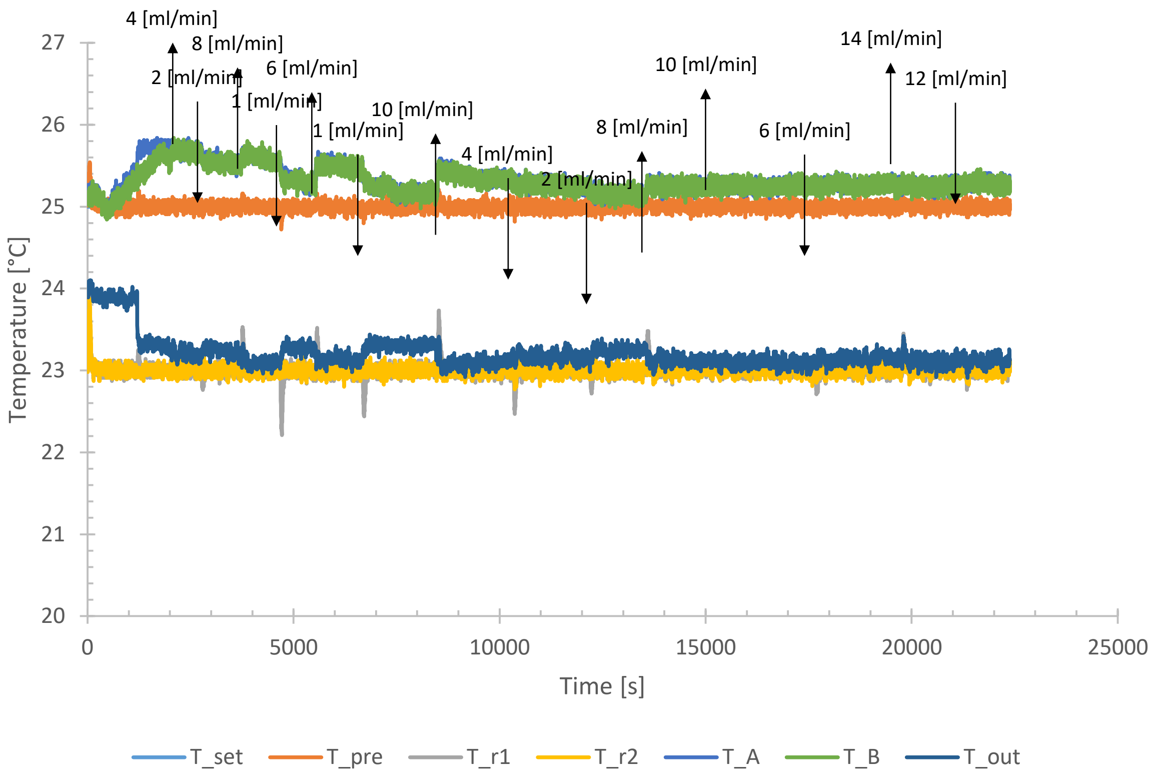


Figure S21 Heat capacity measurement of water. Temperatures measured at different total flow rates.

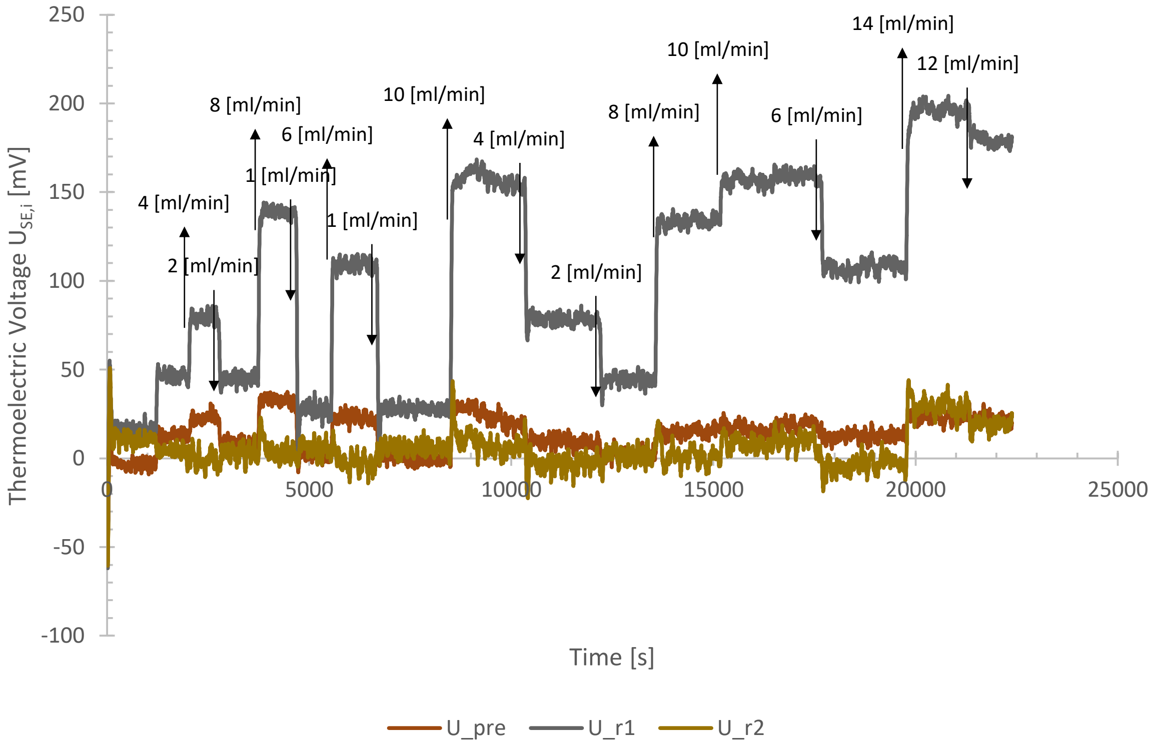


Figure S22 Heat capacity measurement of water. Voltages measured at different total flow rates.