Temperature data logging for faulty temperature controller error measurement

Date: 2021-03-29
Tags: *Synthesis Article 1 Synthesis Optimisation*
Created by: James Bird

Goal : Measure variation in temperature to gauge error introduced in synthesis temperature control

Procedure :

- Runs #14 and 16 in [Experiment] Optimisation of MXene Synthesis - Execution of Plackett-Burman Screening Design had an additional temperature probe present in the oil bath, which was attached to a data logger, for which data was recorded for some of the duration of each etch
- Run #14 used the 400 mL PTFE oil bath with carbon base and the faulty temperature controller, while Run #16 used the 500 mL PTFE oil bath with a fully-functioning temperature controller
- The data logger used is an Omega Universal Thermocouple Connector UTC-USB with K-type fine wire thermocouple (0.010 mm diameter with glass insulator). Accuracy given as ± 1.0 °C or ± 0.5 % of reading, whichever is higher in range - 100 ⎕ T / °C ⎕ 1260 (hence ~ 1.49 K at 298 K) while the Stuart SCT1 Temperature Controller has accuracy ± 0.5 °C

Results :

The functioning temperature controller stabilised at the target tempeature within the first hour and remained at the target temperature then throughout; temperature logged at 41.53 ± 1.57 °C measurement error and ± 0.60 °C standard deviation from 1 to 8 hours since all reactants added. The dysfunctional/faulty temperature controller only stabilised the oilbath temperature after around 4 hours (a sixth of the total reaction time): temperature logged at 39.73 ± 1.56 °C measurement error and ± 0.62 °C standard deviation between 4 and 8 hours. The rate of temperature rise of each oil bath was about equal at ~ 0.75 K/min, which is an indication that the size of the oil bath, volume of oil and oil bath material base may not have had an impact between measurements, and that any differences observed are purely due to the temperature control unit.

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In the period between the 40 °C target temperature first being surpassed (0.4 hours for each set-up) and temperature stabilisation being achieved (1 and 4 hours), the temperature fluctuation was 41.43 ± 0.96 °C and 41.12 ± 4.49 °C for the functioning and dysfunctional controllers, respectively.

Attached .csv files contain columnar data produced by the datalogger while .png files are associated plots of the data outputs.

Conclusions:

Considering the length of each reaction with comparison to the period of temperature instability, it is hoped that this instrument error has limited impact on measurements; nonetheless, one should be wary of discrepancies that could stem from this.

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Attached files

ControllerBroken_Run14.csv
sha256: 6ed6ea5d75ea121228c8b1a11d0d5911a1ee0c80467ee70d76fb87b064f9217a

ControllerFixed_Run16.csv
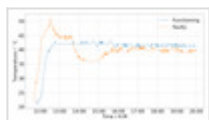sha256: 0b26a50581035b66860d9bebce3cfec81f0463cd30ac219d44c962ffea72700a

TemperatureControllerComparisonBetter.png
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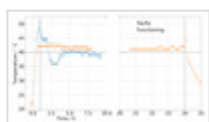
TemperatureControllerComparison.png
sha256: 7cfb06ad5bb9885c39dbc156a2e0408d035ffea16b43846d2d7642060916c272