Supplementary Information

Silver nanofluids based broadband solar absorber obtained by tuning nanosilver geometries

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**Supplementary information**

# Concentrations of nanofluids

The concentration of silver in the nanofluids employed are given in *Table S1*. Note that this is the concentration of silver in the starting solution and is not necessarily the concentration of nanoparticles. The starting concentrations for P-A, P-B and P-C were selected based on prior knowledge of the synthesis to ensure ease and consistency of reaction and to give a final Hpeak of < 1.6 au for the mixture M using a 10 mm path length cuvette without the need to centrifuge to concentrate the nanofluids.

*Table S1 Concentration of nanofluids*

|  |  |  |
| --- | --- | --- |
| Nanofluid | Concentration Ag / mM | Concentration Ag / wt% Ag |
| P-A | 0.100 | 0.00108 |
| P-B | 0.300 | 0.00324 |
| P-C | 0.457 | 0.00493 |
| P-D | 0.247 | 0.00266 |

# Calculation of *AE(300-1350nm)* to determine the optimum mixture

The values obtained for the UV-vis-IR spectra for the three repeats of each of the three nanofluids (P-A1, A2, A3, P-B1, B2 and B3 and P-C1, C2 and C3) were averaged and *AE(300-1350nm)* for various mixtures calculated. To allow for the dilution of P-B and P-C, the spectra for P-B was times by 3 (diluted 1 ml in 3 ml) and for P-C by 5 (diluted 0.6 ml in 3 ml).

The results are given in *Table S2*.

*Table S2 Calculations of optimum mixture. Note although not the optimum in terms of AE(300-1350nm), the recipe corresponding to calculation 7 was chosen as it minimized the amount of P-B, the least stable nanofluid.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Calculation number | P-A / % | P-B / % | P-C / % | Calculated *AE(300-1350nm)* / % | Concentration Ag / mM | Concentration Ag / wt% |
| 1 | 70 | 10 | 20 | 80.28 | 0.1914 | 0.00207 |
| 2 | 70 | 20 | 10 | 80.79 | 0.1757 | 0.00190 |
| 3 | 60 | 10 | 30 | 80.93 | 0.2271 | 0.00245 |
| 4 | 60 | 20 | 20 | 82.45 | 0.2114 | 0.00228 |
| 5 | 60 | 30 | 10 | 82.20 | 0.1957 | 0.00211 |
| 6 | 50 | 10 | 40 | 80.33 | 0.2628 | 0.00283 |
| 7 | **50** | **20** | **30** | **82.52** | **0.2471** | **0.00267** |
| 8 | 50 | 30 | 20 | 83.14 | 0.2314 | 0.00250 |
| 9 | 50 | 40 | 10 | 82.61 | 0.2157 | 0.00233 |
| 10 | 40 | 10 | 50 | 78.71 | 0.2985 | 0.00322 |
| 11 | 40 | 20 | 40 | 81.43 | 0.2828 | 0.00305 |
| 12 | 40 | 30 | 30 | 82.63 | 0.2671 | 0.00288 |
| 13 | 40 | 40 | 20 | 82.86 | 0.2514 | 0.00271 |
| 14 | 40 | 50 | 10 | 82.31 | 0.2357 | 0.00254 |

# Measurements of Intensityfor the Xenon lamp

Measurement performed using a ReRA System calibrated silicon cell connected to a Keithly Power supply. Cell calibrated at Radboud University Nijmegen PV measurement facility. The calibration is performed using an NREL calibrated reference cell. This type of reference is well suited for indoor solar simulator applications.

The fill factor (FF) of a PV cell is defined as:

Equation S1

Where *Vmax* in volts is the maximum voltage obtained from the cell, *Imax* is the maximum current (A), *Voc* is the open circuit voltage and *Isc* is the short circuit current. This can then be used to calculate the cell efficiency *ηcell*:

Equation S2

Where *Pin* is the power incident on the cell (equivalent to the intensity) in W. If the area of the cell is then known this can be equated to the intensity of the light.

When the value of *Isc* is equal to the calibration value of the cell the output from the lamp is 1000 W/m2. The calculated value of *ηcell* is then used to determine the new value of *Pin* with the lamp at the setting used in the experiments from rearranging Equation S2.

Table S3 Measurements of Is / Wm-2using a ReRA System calibrated silicon cell (area of cell 3.6 cm2).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Isc* / mA | *Voc* / V | *Imax* /mA | *Vmax* / V | *FF /* % | *ηcell* | *Pin* / W | *Intensity Is* / Wm-2 |
| Calibration value | 89.7 |  |  |  |  |  |  |  |
| Measured value (1000 W/m2) | 89.9 ± 3.5 (n=4) | 0.547 | 79.55 | 0.374 | 60.46 | 8.26 ± 0.25 | 0.36 | 1000 |
| At lamp setting (n = 9) | 107.46 ± 5.7 | 0.554 | 103.14 ± 6.38 | 0.344 ± 0.02 | 59.54 ± 2.72 | 8.26 | 0.429 ± 0.01 | 1191.2 ± 40.29 |

# Uncertainty Analysis

Table S4 Uncertainty of constant CwMw/IsAs for SSL tests. The half width between the upper and lower limits is denoted by a. The standard deviation is denoted by s and n is the number of measurements

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source of Uncertainty | Comment | Value / % | Probability distribution | Divisor | Standard uncertainty | Unit |
| Change in *Cw* with temperature | *Cw* changes from 4.184 to 4.180 KJKg-1K-1 over range 20 - 40°C | 0.11 | rectangular | a/√3 | 0.07 | % |
| Uncertainty in measuring *Mw* | 1000 µl Micropipette used to measure amount with accuracy of ± 0.3% | 0.3 | rectangular | a/√3 | 0.17 | % |
| Change in As with temperature | Due to thermal expansion of liquid | 2.0 | rectangular | a/√3 | 1.15 | % |
| Variation in Is due to lamp output variation | Lamp output varies by ± 6% | 6.0 | rectangular | a/√3 | 3.46 | % |
| Uncertainty in measuring *Is* | Using ReRA calibrated PV cell I is 1191.16 ± 40.29. n is 9 | 3.38 | normal | s/√n | 1.13 | % |
| Uncertainty of temperature measurement because of thermocouples | Assumed to be ± 0.5°C which equates to 0.5/20\*100 % | 2.50 | rectangular | a/√3 | 1.44 | % |
| Combined standard uncertainty |  |  | Assumed normal |  | 4.09 | % |
| Expanded uncertainty (k = 2 is approximately 95% confidence level) |  |  | assumed normal (k = 2) |  | 8.18 | % |

Table S5 Values obtained for the expanded uncertainty (total of type A and Type B) for the different nanofluids measured under SSL. A coverage factor (k) of 2 has been used which corresponds to a confidence interval of approximately 95%

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | ∆T / °C | Combined total uncertainty (A + B) / % | Expanded uncertainty (k = 2) / % |
| Water | 3.641 ± 0.177 (n = 3) | 4.96 | 9.92 |
| M | 10.590 ± 0.165 (n = 9) | 4.12 | 8.24 |
| P-A | 8.231 ± 0.619 (n = 9) | 4.80 | 9.59 |
| P-B | 8.538 ± 0.817 (n = 9) | 5.19 | 10.37 |
| P-C | 6.822 ± 0.419 (n = 9) | 4.57 | 9.15 |

Table S6 Uncertainty of UV-visible-IR measurements (type B only). The half width between the upper and lower limits is denoted by a. The standard deviation is denoted by s and n is the number of measurements

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source of Uncertainty | Comment | Value / % | Probability distribution | Divisor | Standard uncertainty | Unit |
| Resolution of wavelength | Step rate 1 nm. Max uncertainty is at 200 nm | 0.5 | rectangular | a/√3 | 0.29 | % |
| Ability to determine Hpeak | Assumed similar to wavelength resolution | 0.5 | rectangular | a/√3 | 0.29 | % |
| AE calculations | Taken as the combined standard uncertainty of Hpeak x λmax |  | Assumed normal |  | 0.41 | % |
| Expanded uncertainty for λmax | Using k = 2 |  | Assumed normal |  | 0.58 | % |
| Expanded uncertainty for Hpeak | Using k = 2 |  | Assumed normal |  | 0.58 | % |
| Expanded uncertainty for AE calculations | Using k = 2 |  | Assumed normal |  | 0.82 | % |

Table S7 Values obtained for the expanded uncertainty (total of type A and Type B) for the calculation of AE from UV-visible-IR spectroscopy. A coverage factor (k) of 2 has been used which corresponds to a confidence interval of approximately 95%

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | AElamp (330 – 1100 nm) | Combined total uncertainty (A + B) / % | Expanded uncertainty (k = 2) / % |
| M | 92.75 ± 1.37 (n = 12) | 0.59 | 1.18 |
| P-A | 57.81 ± 1.78 (n = 9) | 1.10 | 2.21 |
| P-B | 73.97 ± 2.02 (n = 9) | 1.00 | 2.00 |
| P-C | 46.29 ± 4.61 (n = 9) | 3.34 | 6.69 |

Table S8 Uncertainty of TEM measurements using P-A triangles and P-A thickness as examples. The half width between the upper and lower limits is denoted by a. The standard deviation (StDev) is denoted by s and n is the number of measurements

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source of Uncertainty | Comment | Value / % | Probability distribution | Divisor | Standard uncertainty | Unit |
| calibration of line length (type B) | Resolution of 100 nm line used to calibrate line length 200 pixels - assumed to be ± 1 nm | 1.00 | rectangular | a/√3 | 0.58 | % |
| Resolution of TEM (type B) | Assumed to be ± 1 nm - for a particle of 50 nm | 2.00 | rectangular | a/√3 | 1.15 | % |
| For P-A triangles before SSL (Type A) | Mean = 52.2 ± 17.6 where n = 153 | 33.72 | normal | s/√n | 2.73 | % |
| For P-A thickness before SSL (Type A) | Mean = 5.9 ± 2.6 where n = 102 | 44.07 | normal | s/√n | 4.36 | % |
| Expanded uncertainty for P-A triangles | Using k = 2 |  | Assumed normal |  | 6.03 | % |
| Expanded uncertainty for P-A thickness | Using k = 2 |  | Assumed normal |  | 9.10 | % |

# IR results before exposure to SSL

## P-A

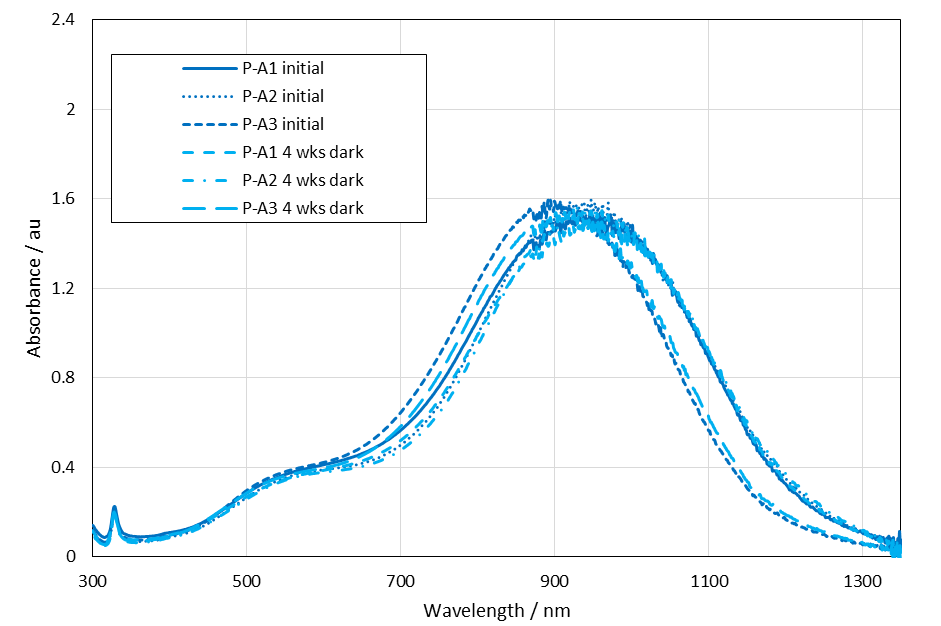
Figure S1 UV-visible-IR spectra for P-A samples initially and after storage in the dark for 4 weeks. All measured with a 10mm path length cuvette

Table S9 λmax and Hpeak values for P-A samples initially and after 4 weeks storage in the dark

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | λmax / nm | Hpeak / au | Sample | λmax / nm | Hpeak / au |
| P-A1 initial | 946 | 1.542 | **P-A1 4 wks dark** | 947 | 1.517 |
| P-A2 initial | 948 | 1.595 | **P-A2 4 wks dark** | 930 | 1.560 |
| P-A3 initial | 892 | 1.595 | **P-A3 4 wks dark** | 913 | 1.538 |
| Average | 929 | 1.577 | **Average** | 930 | 1.538 |
| Standard deviation (StDev) | 31.8 | 0.031 | **StDev** | 16.5 | 0.022 |
| N | 3 | 3 | **N** | 3 | 3 |

## Significance testing of change for P-A

Using a two sample T-test (see below) the significance of the change in spectra after 4 weeks storage in the dark at 4oC was calculated. For λmax and Hpeak the difference was not significant at the 95% confidence interval.

## Definition of T-test

A T-test is a hypothesis test that allows you to compare means. A two-sample T-test allows the comparison between two means from two different sets of samples. The null hypothesis is that the two means are the same. The formula is:

Equation S3

Where *t* = T value (which can be looked up in standard T-tables or using a statistical software package to determine significance). = Mean of sample 1 and = Mean of sample 2, *n1* and *n2* are the number of results in each sample set and *s2* is the pooled sample variance given by the equation:

Equation S4

## P-B

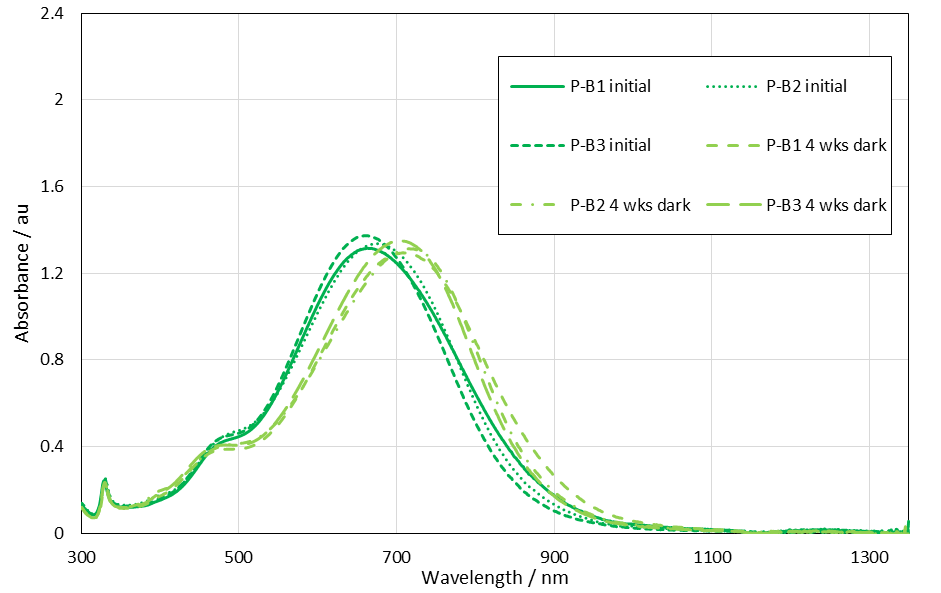
Figure S2 UV-visible-IR spectra for P-B samples initially and after storage in the dark for 4 weeks. All measured with a 10mm path length cuvette. Note that P-B samples diluted 1 ml in 3 ml from initial concentration

Table S10 λmax and Hpeak values for P-B samples initially and after 4 weeks storage in the dark

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | λmax / nm | Hpeak / au | Sample | λmax / nm | Hpeak / au |
| P-B1 initial | 664 | 1.315 | **P-B1 4 wks dark** | 708 | 1.294 |
| P-B2 initial | 676 | 1.336 | **P-B2 4 wks dark** | 716 | 1.312 |
| P-B3 initial | 661 | 1.374 | **P-B3 4 wks dark** | 704 | 1.352 |
| Average | 667 | 1.342 | **Average** | 709 | 1.319 |
| StDev | 7.9 | 0.030 | **StDev** | 6.1 | 0.030 |
| N | 3 | 3 | **N** | 3 | 3 |

## Significance testing of change for P-B

Using a two sample T-test the significance of the change in spectra after 4 weeks storage in the dark at 4oC was calculated. For Hpeak the difference was not significant at the 95% confidence interval, however, for λmax the difference was significant.

## P-C

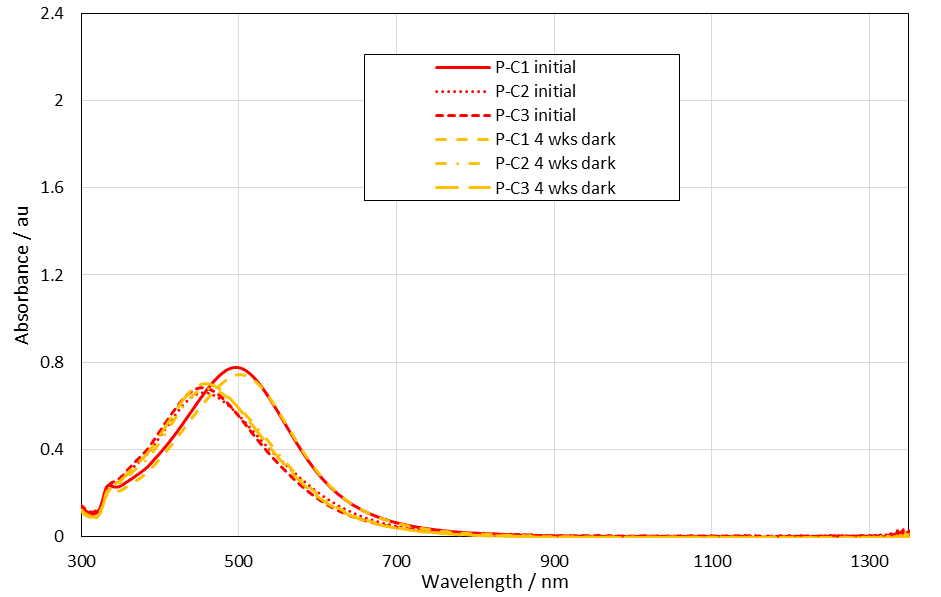
Figure S3 UV-visible-IR spectra for P-C samples initially and after storage in the dark for 4 weeks. All measured with a 10mm path length cuvette.P-C samples diluted 0.6 ml in 3 ml.

Table S11 λmax and Hpeak values for P-C samples initially and after 4 weeks storage in the dark

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | λmax / nm | Hpeak / au | Sample | λmax / nm | Hpeak / au |
| P-C1 initial | 497 | 0.777 | **P-C1 4 wks dark** | 499 | 0.744 |
| P-C2 initial | 454 | 0.662 | **P-C2 4 wks dark** | 460 | 0.679 |
| P-C3 initial | 454 | 0.684 | **P-C3 4 wks dark** | 457 | 0.704 |
| Average | 468 | 0.708 | **Average** | 472 | 0.709 |
| StDev | 24.8 | 0.061 | **StDev** | 23.4 | 0.033 |
| N | 3 | 3 | **N** | 3 | 3 |

## Significance testing of change for P-C

Using a two sample T-test the significance of the change in spectra after 4 weeks storage in the dark at 4oC was calculated. For λmax and Hpeak the difference was not significant at the 95% confidence interval.

## Mixture M

Figure S4 UV-visible-IR spectra for M samples calculated from component nanofluid spectra. Mixture recipe 50% P-A, 20% P-B, 30% P-C. All initial measurements performed with a 10mm path length cuvette.

Table S12 λmax and Hpeak values for M samples calculated from absorption values of component nanofluids

|  |  |  |
| --- | --- | --- |
| Sample | λmax / nm | Hpeak / au |
| M1 - calculated | 504 | 1.576 |
| M2 - calculated | 470 | 1.319 |
| M3- calculated | 466 | 1.358 |
| Average | 480 | 1.418 |
| StDev | 20.9 | 0.138 |
| N | 3 | 3 |

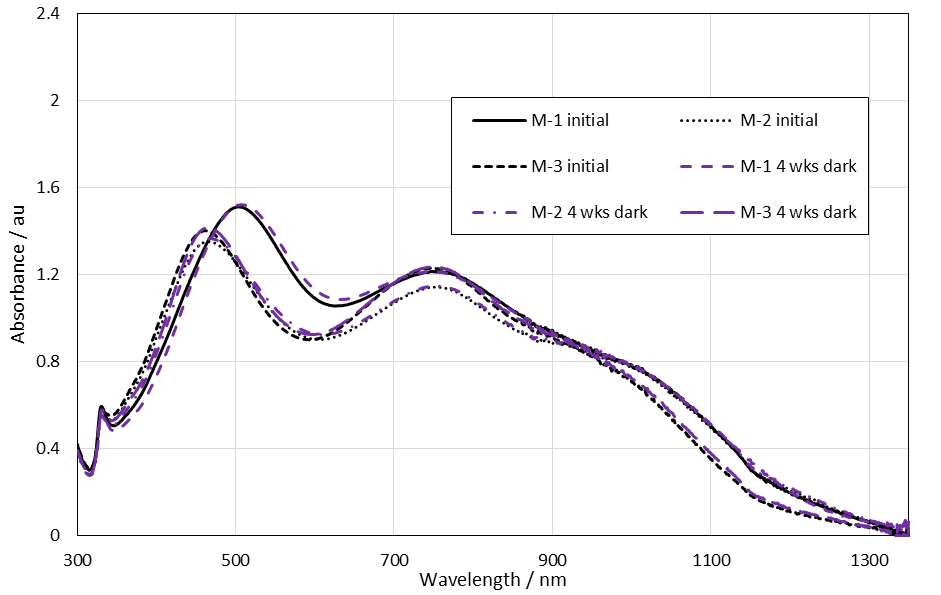
Figure S5 UV-visible-IR spectra for M samples initially and after storage in the dark for 4 weeks. All measured with a 10mm path length cuvette..

Table S13 λmax and Hpeak values for M samples initially and after 4 weeks storage in the dark. Only the primary peak position shown

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | λmax / nm | Hpeak / au | Sample | λmax / nm | Hpeak / au |
| M-1 initial | 502 | 1.511 | **M-1 4 wks dark** | 506 | 1.520 |
| M-2 initial | 463 | 1.351 | **M-2 4 wks dark** | 468 | 1.365 |
| M-3 initial | 462 | 1.400 | **M-3 4 wks dark** | 466 | 1.417 |
| Average | 476 | 1.421 | **Average** | 480 | 1.434 |
| StDev | 22.8 | 0.082 | **StDev** | 22.5 | 0.079 |
| N | 3 | 3 | **N** | 3 | 3 |

## Significance testing of change for M

Using a two sample T-test the significance of the change in spectra after 4 weeks storage in the dark at 4oC was calculated. For λmax and Hpeak the difference was not significant at the 95% confidence interval.

# Size analysis from TEM before solar simulator testing

Table S14 Size analysis initial

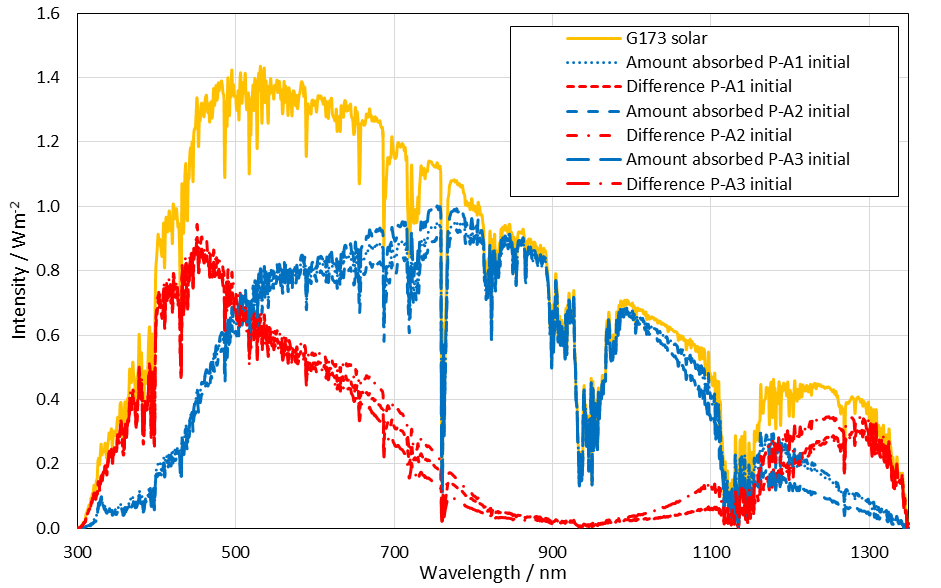
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **P-A** | **P-B** | **P-C** | **M** |
| **Triangles** | Mean / nm | 52.2 | 27.5 | 27.3 | 31.2 |
| StDev / nm | 17.6 | 7.6 | 15.9 | 13.9 |
| N | 153 | 157 | 5 | 67 |
|  | % | 68.6 | 43.8 | 1.0 | 7.7 |
| **Rounded corner triangles** | Mean /nm | 22.8 | 23.7 | 17.3 | 19.4 |
| StDev /nm | 7.2 | 6.7 | 4.5 | 5.7 |
| N | 13 | 89 | 30 | 75 |
|  | % | 5.8 | 24.9 | 6.1 | 8.7 |
| **Other** | Mean / nm | 17.6 | 18.2 | 15.9 | 15.1 |
| StDev / nm | 8.0 | 6.7 | 4.2 | 5.1 |
| N | 32 | 58 | 204 | 347 |
|  | % | 14.4 | 16.2 | 41.6 | 40.0 |
| **Small (< 10 nm)** | Mean / nm | 6.1 | 5.8 | 6.3 | 6.4 |
| StDev / nm | 1.6 | 1.2 | 1.6 | 2.2 |
| N | 25 | 54 | 252 | 378 |
|  | % | 11.2 | 15.1 | 51.3 | 43.6 |
| **Thickness** | Mean / nm | 5.9 | 4.7 | 5.0 | 4.1 |
| StDev / nm | 2.6 | 1.3 | 1.1 | 1.2 |
| N | 102 | 75 | 143 | 103 |

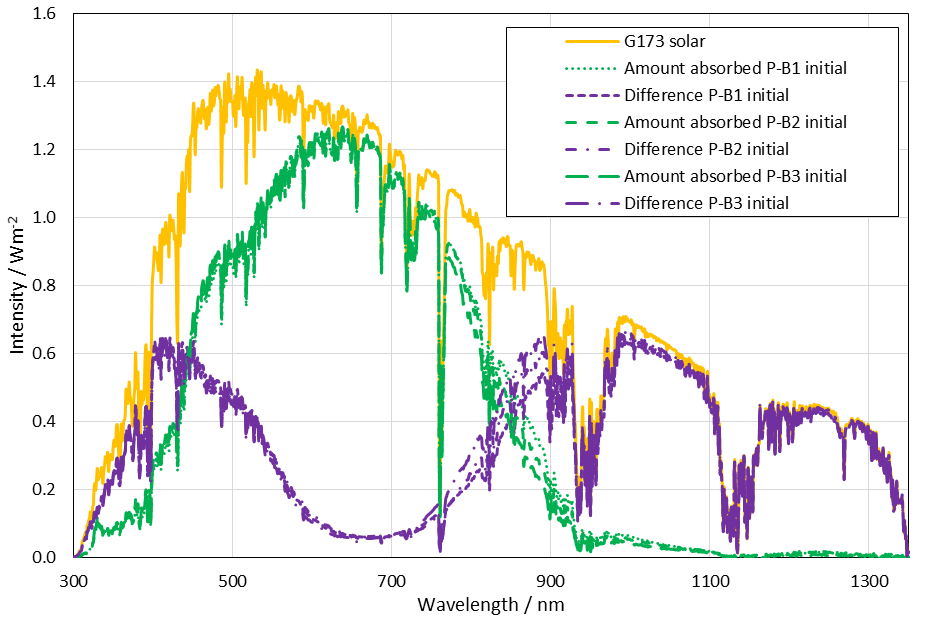
P-A thickness significantly thicker compared to P-B thickness according to a two sample T-test at a confidence level of 95%. Range of values for P-A thickness = 5.4 -6.4 nm (95% confidence interval (CI) for mean) and for P-B = 4.4 – 5.0 nm (95% CI). This analysis excludes the measurement uncertainty for the technique (2.6%).

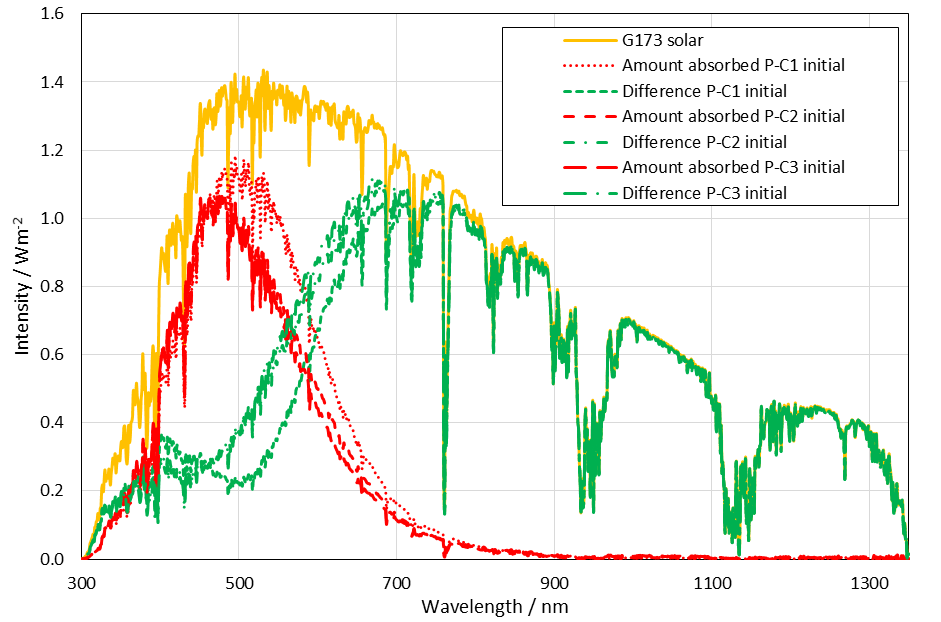
P-A thickness significantly thicker compared to P-C again using a two sample T-test. P-C range of thickness = 4.8 – 5.2 nm (95% CI).

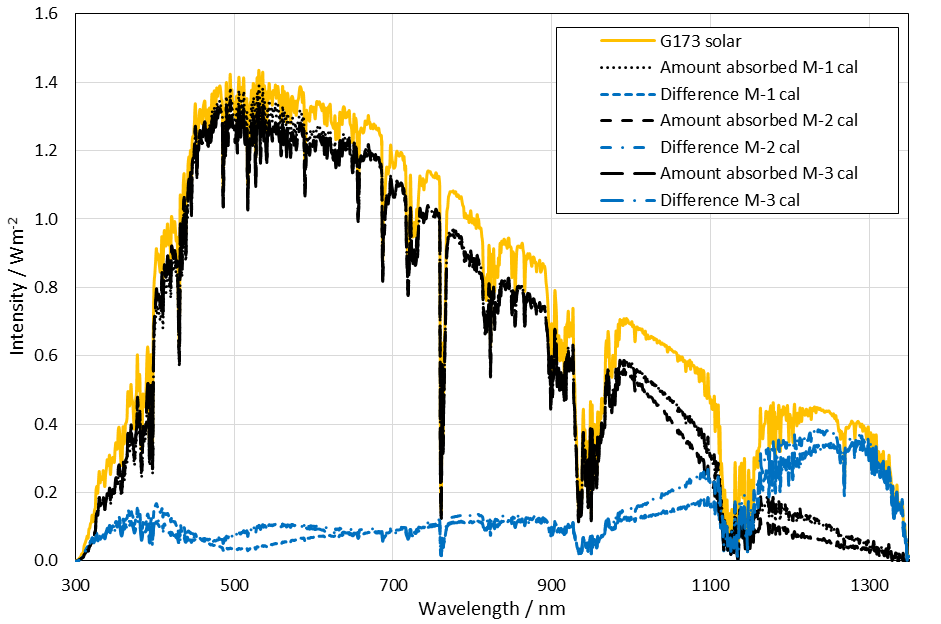
P-B thickness the same as P-C thickness according to a two sample T-Test.

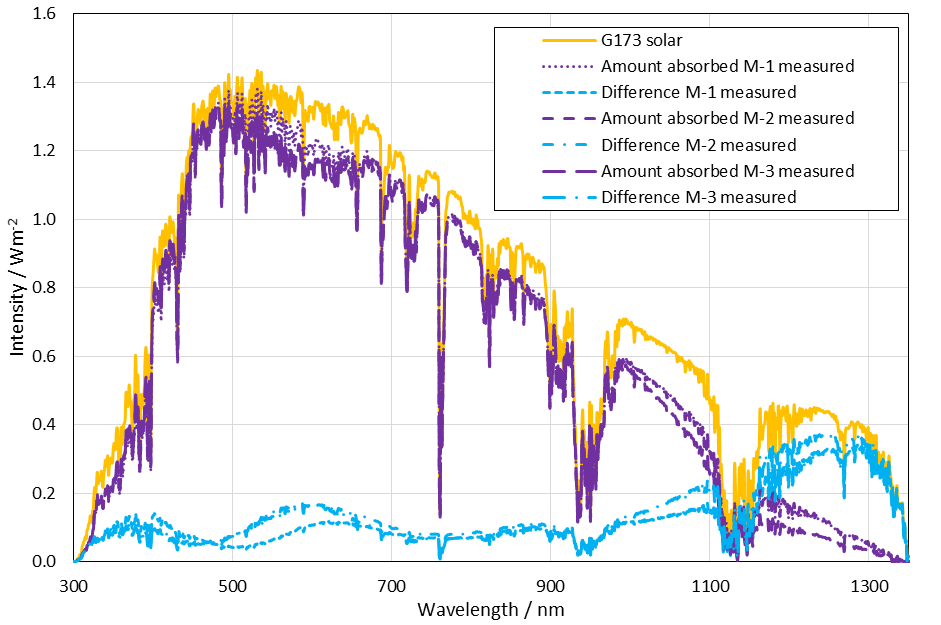
# Amount of G173 solar spectra absorbed

Figure S6 Amount of G173 solar reference spectra power absorbed and not absorbed (labeled as difference) at different wavelength for the P-A samples calculated from the UV-visible-IR measurements undertaken initially

Figure S7 Amount of G173 solar reference spectra power absorbed and not absorbed (labeled as difference) at different wavelength for the P-B samples calculated from the UV-visible-IR measurements undertaken initially

Figure S8 Amount of G173 solar reference spectra power absorbed and not absorbed (labeled as difference) at different wavelength for the P-C samples calculated from the UV-visible-IR measurements undertaken initially

Figure S9 Amount of G173 solar reference spectra power absorbed and not absorbed (labeled as difference) at different wavelength for the M samples calculated from the UV-visible-IR measurements undertaken on the componet nanofluids P-A, P-B and P-C

Figure S10 Amount of G173 solar reference spectra absorbed and not absorbed (labeled as difference) at different wavelength for the M samples calculated from the UV-visible-IR measurements undertaken initially

## Analysis of variance (ANOVA)

One way ANOVA is a generalisation of the two sample t-test for more than two samples. The null hypothesis is that all the means are equal and the alternative hypothesis is that at least one mean is different. Normally equal variances and normally distributed data are assumed for the analysis. Instead of a T value an F statistic is used (again this can be looked up in standard tables or using a statistics software package). In this case:

Equation S5

Where MST is the mean square between different groups and MSE is the mean square due to error.

Equation S6

Where *Ti* is the total for one group, *G* is the total for all observations, *k* is the number of means*, ni* is the number of observations in group i and *n* is the total number of observations.

Equation S7

Where *MSE* is the mean square due to error and *Yij* is an observation or measurement. In this work a standard software package (Minitab version 17.3.1) was used to undertake ANOVA analysis. The output from this software package assigns a different letter to each group that is significantly different from another group.

Table S15 Results of calculating AE(300-1350 nm) from the UV-visible-IR data. The initial, after 4 weeks storage and after exposure to SSL for 30 minutes has been used giving N = 9. In addition for M the calculated spectral data has been included (hence for M, N = 12). Means that do not share the same letter are significantly different (see analysis of variance section in SI)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Nanofluid type** | **N** | **Grouping** | **Mean *AE(300-1350 nm)* / %** | **StDev / %** | **95% CI** |
| M | 12 | A | 81.80 | 2.23 | 80.11 – 83.48 |
| P-A | 9 | B | 62.80 | 1.96 | 60.86 – 64.75 |
| P-B | 9 | C | 52.93 | 4.65 | 50.99 – 54.88 |
| P-C | 9 | D | 28.32 | 1.95 | 26.38 – 30.27 |

# UV-visible-IR after SSL testing

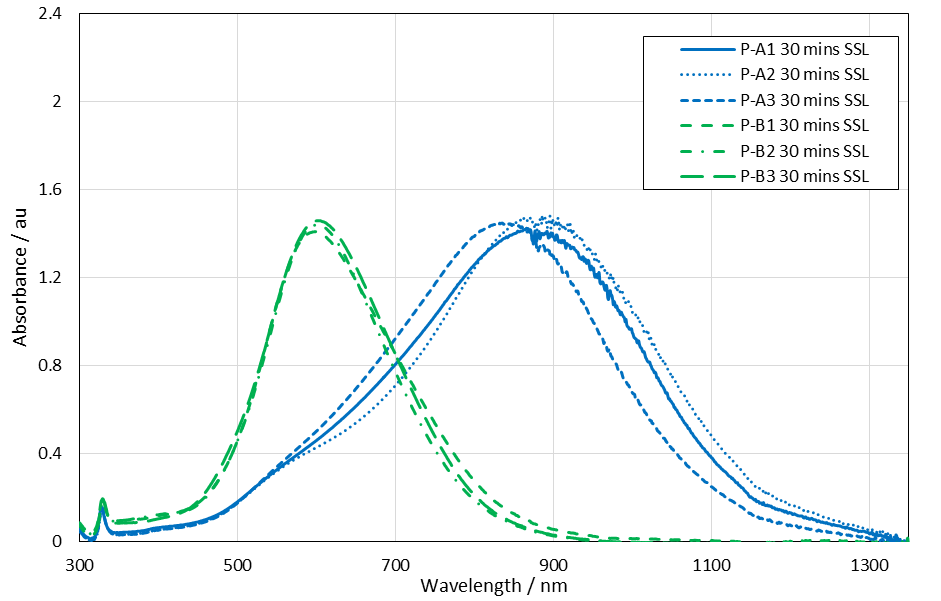
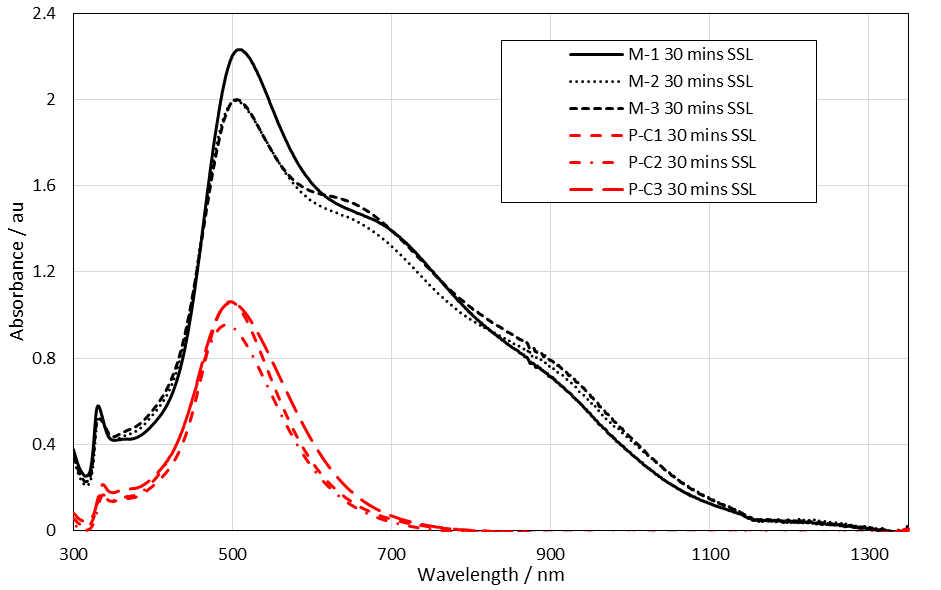
Figure S11 UV-visible-IR spectra for P-A and P-B samples after 30 minutes exposure to SSL. All measured with a 10mm path length cuvette.P-B samples diluted 1 ml in 3 ml.

Table S16 λmax and Hpeak values for P-A and P-B samples after 30 minutes exposure to SSL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | λmax / nm | Hpeak / au | Sample | λmax / nm | Hpeak / au |
| P-A1 30 minutes SSL | 866 | 1.423 | **P-B1 30 minutes SSL** | 598 | 1.409 |
| P-A2 30 minutes SSL | 886 | 1.481 | **P-B2 30 minutes SSL** | 602 | 1.441 |
| P-A3 30 minutes SSL | 840 | 1.447 | **P-B3 30 minutes SSL** | 601 | 1.457 |
| Average | 864 | 1.451 | **Average** | 600 | 1.436 |
| StDev | 23.1 | 0.029 | **StDev** | 2.1 | 0.024 |
| N | 3 | 3 | **N** | 3 | 3 |

## Significance testing of change after SSL testing for P-A and P-B

Using a two sample T-test the significance of the change in spectra after SSL exposure for 30 minutes compared with the spectra after 4 weeks storage in the dark at 4oC was calculated. For P-A and P-B λmax and Hpeak were both significantly different after 30 minutes of exposure to SSL.

Figure S12 UV-visible-IR spectra for P-C and M samples after 30 minutes exposure to SSL. All measured with a 10mm path length cuvette.P-C samples diluted 0.6 ml in 3 ml.

It should be noted that the value of Hpeak for the mixture was on average >2 which is not ideal due to potential linearity issues when Hpeak > 2 but it was felt important to use the same path length for the mixture as used previously.

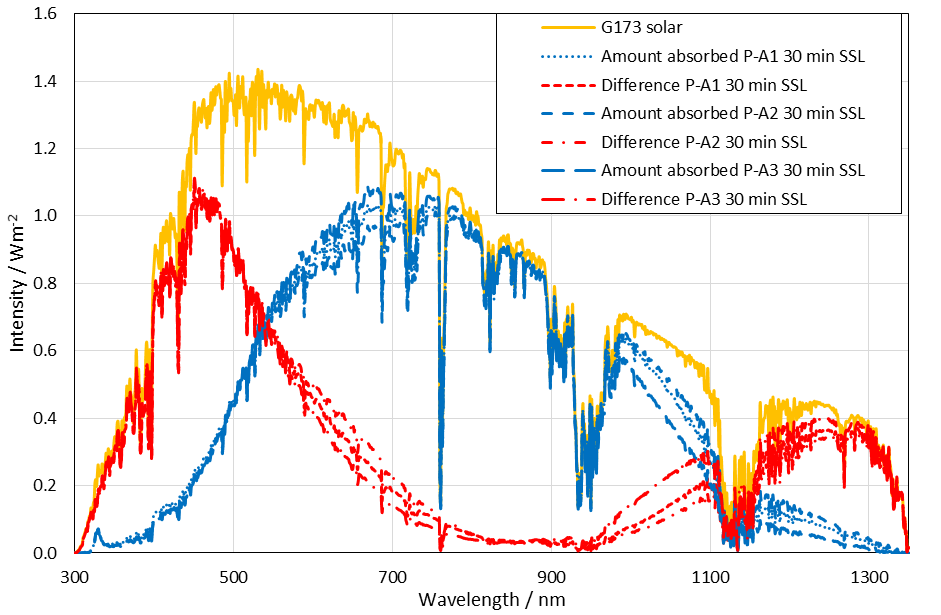
Table S17 λmax and Hpeak values for P-C and M samples after 30 minutes exposure to SSL. Note that for M samples only the position and height of the primary peak is shown

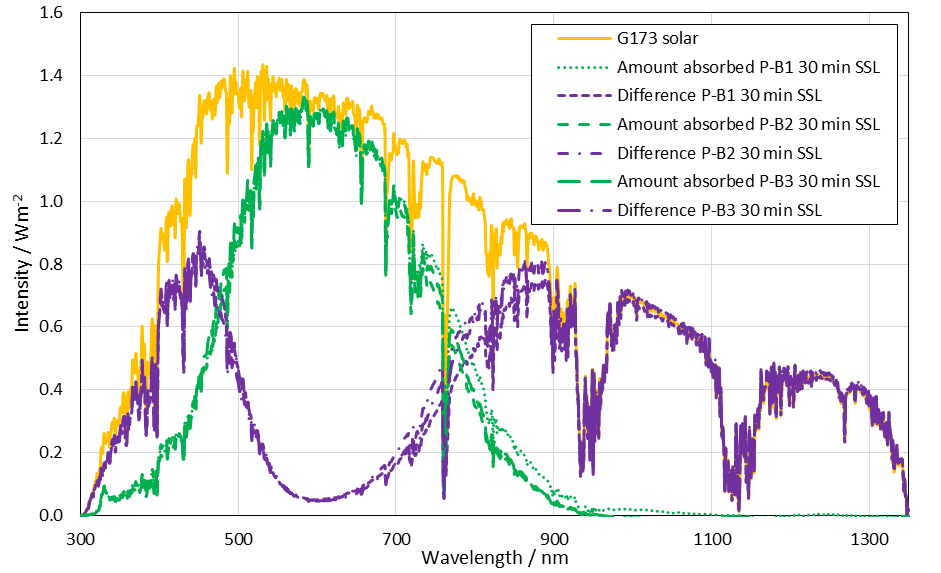
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | λmax / nm | Hpeak / au | Sample | λmax / nm | Hpeak / au |
| P-C1 30 minutes SSL | 497 | 1.060 | **M-1 30 minutes SSL** | 509 | 2.231 |
| P-C2 30 minutes SSL | 493 | 0.957 | **M-2 30 minutes SSL** | 505 | 1.993 |
| P-C3 30 minutes SSL | 498 | 1.059 | **M-3 30 minutes SSL** | 506 | 2.000 |
| Average | 496 | 1.025 | **Average** | 507 | 2.075 |
| StDev | 2.6 | 0.059 | **StDev** | 2.1 | 0.136 |
| N | 3 | 3 | **N** | 3 | 3 |

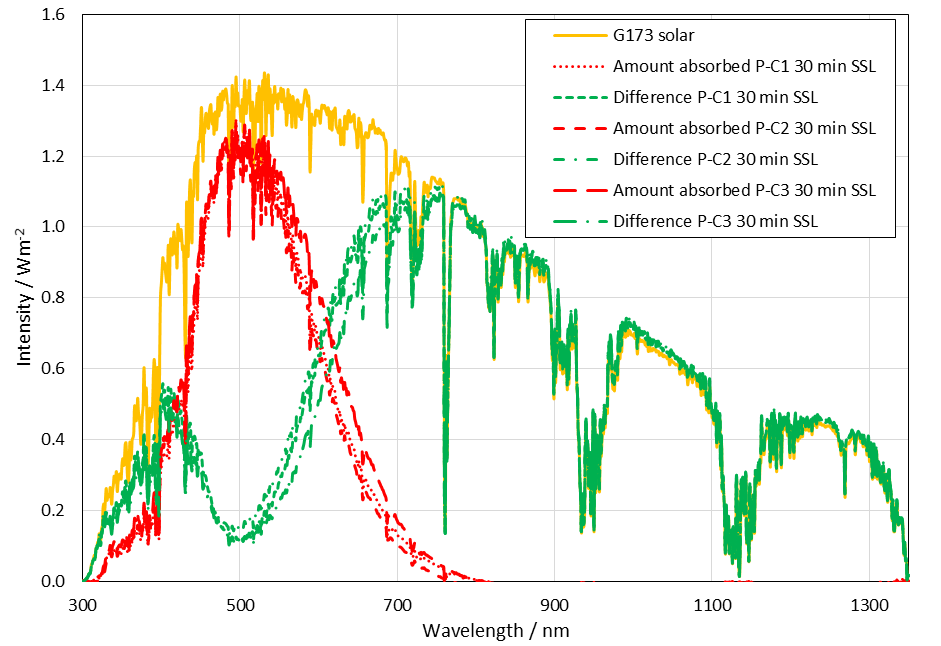
## Significance testing of change after SSL for P-C and M

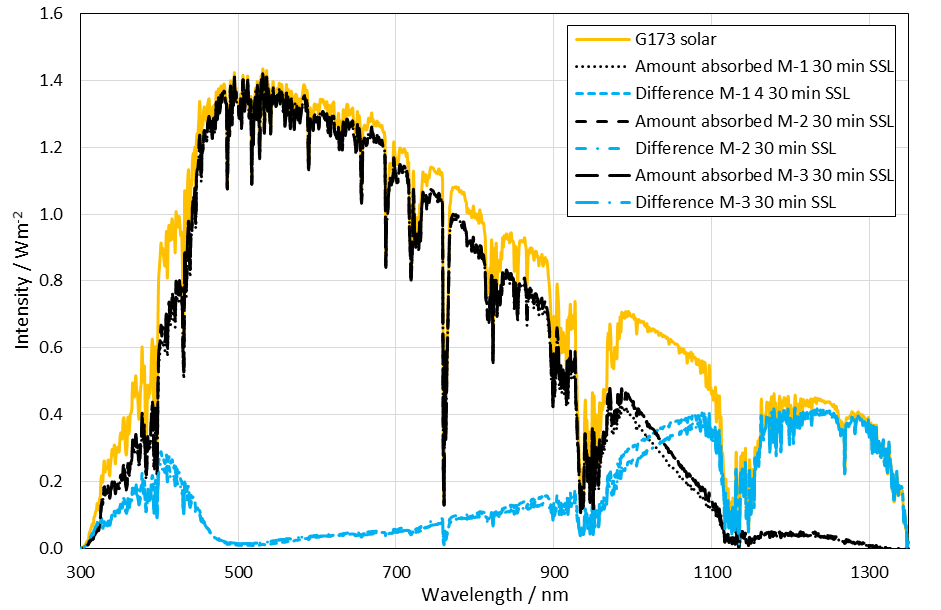
Using a two sample T-test the significance of the change in spectra after SSL exposure for 30 minutes compared with the spectra after 4 weeks storage in the dark at 4oC was calculated. For P-C and M the change in λmax was not significant but the change in Hpeak was at a confidence interval of 95% after 30 minutes of exposure to SSL.

# Amount of solar spectrum absorbed after exposure to SSL

Figure S13 P-A after SSL amount of reference spectra absorber / not absorbed

Figure S14 P-B after SSL amount of reference spectra absorber / not absorbed

Figure S15 P-C after SSL amount of reference spectra absorber / not absorbed

Figure S16 Mixture M after SSL amount of reference spectra absorber / not absorbed

# Size analysis from TEM after exposure to SSL

Table S18 Size analysis from TEM micrographs after 30 minutes SSL exposure

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **P-A** | **P-B** | **P-C** | **M** |
| **Triangles** | Mean / nm | 54.5 | 30.6 | 27.9 | 27.5 |
| StDev / nm | 15.4 | 7.2 | 12.1 | 10.3 |
| N | 95 | 27 | 4 | 71 |
|  | % | 32.2 | 11.0 | 1.3 | 6.0 |
| **Rounded corner triangles** | Mean /nm | 37.9 | 23.3 | 18.6 | 21.2 |
| StDev /nm | 9.4 | 6.1 | 6.2 | 7.4 |
| N | 114 | 50 | 10 | 110 |
|  | % | 38.7 | 20.3 | 3.3 | 9.2 |
| **Other** | Mean / nm | 36.1 | 20.8 | 15.6 | 15.3 |
| StDev / nm | 19.7 | 6.4 | 4.8 | 4.2 |
| N | 57 | 141 | 142 | 475 |
|  | % | 19.3 | 57.3 | 47.0 | 39.9 |
| **Small (< 10 nm)** | Mean / nm | 7.3 | 6.5 | 6.3 | 6.6 |
| StDev / nm | 1.8 | 1.9 | 2.0 | 2.1 |
| N | 29 | 28 | 146 | 534 |
|  | % | 9.8 | 11.4 | 48.4 | 44.9 |
| **Thickness** | Mean / nm | 5.6 | 5.0 | 4.6 | 4.5 |
| StDev / nm | 1.6 | 1.5 | 1.3 | 0.9 |
| N | 49 | 69 | 67 | 180 |

P-A thickness range at 95% confidence interval = 5.2 – 6.1 nm, P-B thickness range – 4.6 – 5.3 nm and P-C thickness 4.3 – 4.9 nm and the mixture M thickness range = 4.4 – 4.7 nm.