



Transmission IR Experiments using 2 Membranes

Report Number: H57A

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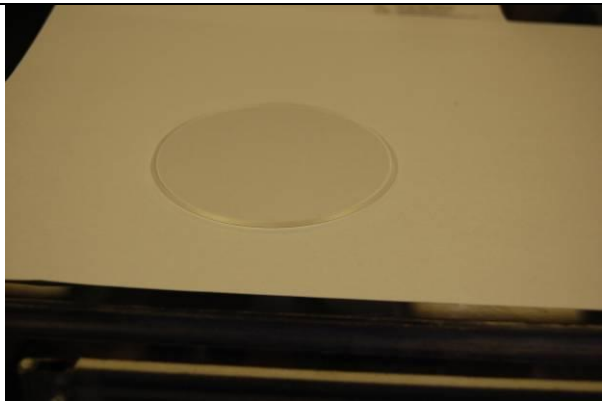
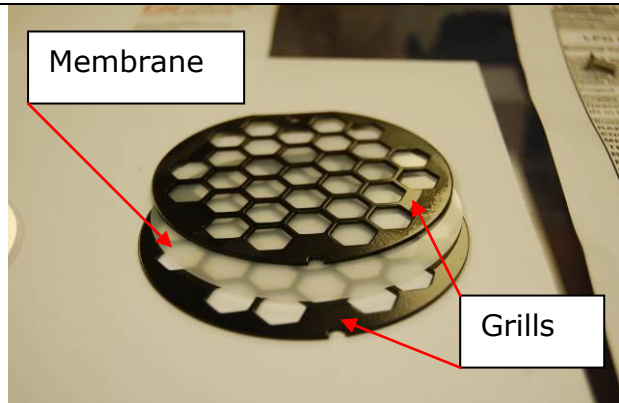
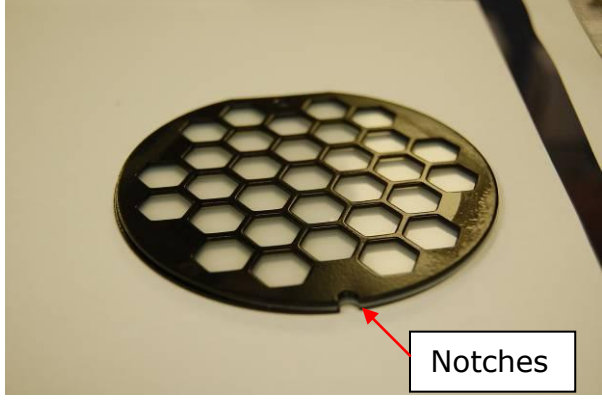

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Description

Two sample membranes were supplied for testing using IR (Infrared) radiation in transmission mode.

The membranes were identified as: -

1. CaF₂ polymer – transparent glass like disc
2. Opaque flexible polymer membrane – polymer reinforced IR viewing pane with protected support grills on both sides

| | |
|--|---|
|  |  |
| <p>Transparent CaF₂ polymer membrane</p> | <p>Opaque polymer membrane with supporting grills both sides 'exploded' to show arrangement of grills with the membrane</p> |
|  |  |
| <p>Arrangement of the polymer reinforced IR viewing pane opaque polymer membrane & grills with 'notches'</p> | <p>Protective polymer reinforced IR viewing pane housing and 'exploded' membrane</p> |

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| | |
|---|--|
| aligned (as fitted into protective housing) | |
|---|--|

Sampling using the FTIR Instrument

An FTIR (Fourier Transform Infrared) Spectrophotometer (JASCO 4100 FT/IR instrument) was used for all the Infrared testing over the range $1250 - 714 \text{ cm}^{-1}$, using appropriate accessories where required to support the membranes.

With the sample compartment empty, a background scan was performed and stored in the instruments memory, and the beam energy was initially measured. Such energy measurements are normally only used during auto alignment checks on the performance of the FTIR's interferometer. The energy measurements are independent of the range to be scanned on the FTIR instrument.

Each membrane was aligned vertically within the sample compartment of the FTIR spectrophotometer, so that the infrared beam would strike each membrane in a normal fashion.

The beam energy was also recorded with the CaF2 membrane in-place, and the FTIR spectrum of the membrane was then recorded.

The beam energy was also recorded with the polymer reinforced IR viewing pane opaque flexible polymer membrane in-place without supports, and the FTIR spectrum of the membrane was then recorded.

Further tests were carried out with the polymer reinforced IR viewing pane opaque flexible polymer membrane with both supporting grills in place and the notches aligned. Energy levels were minimised and maximised by moving the position of the 'supported membrane' configuration, and an average energy level was then determined. At the minimum, average, and maximum energy positions an FTIR spectrum was recorded.

FTIR Spectra are collected in .jws format in the JASCO measurement software and are converted into .dx format to be read by "Essential FTIR software" where the absolute transmission data can be exported to .xls format for averaging.

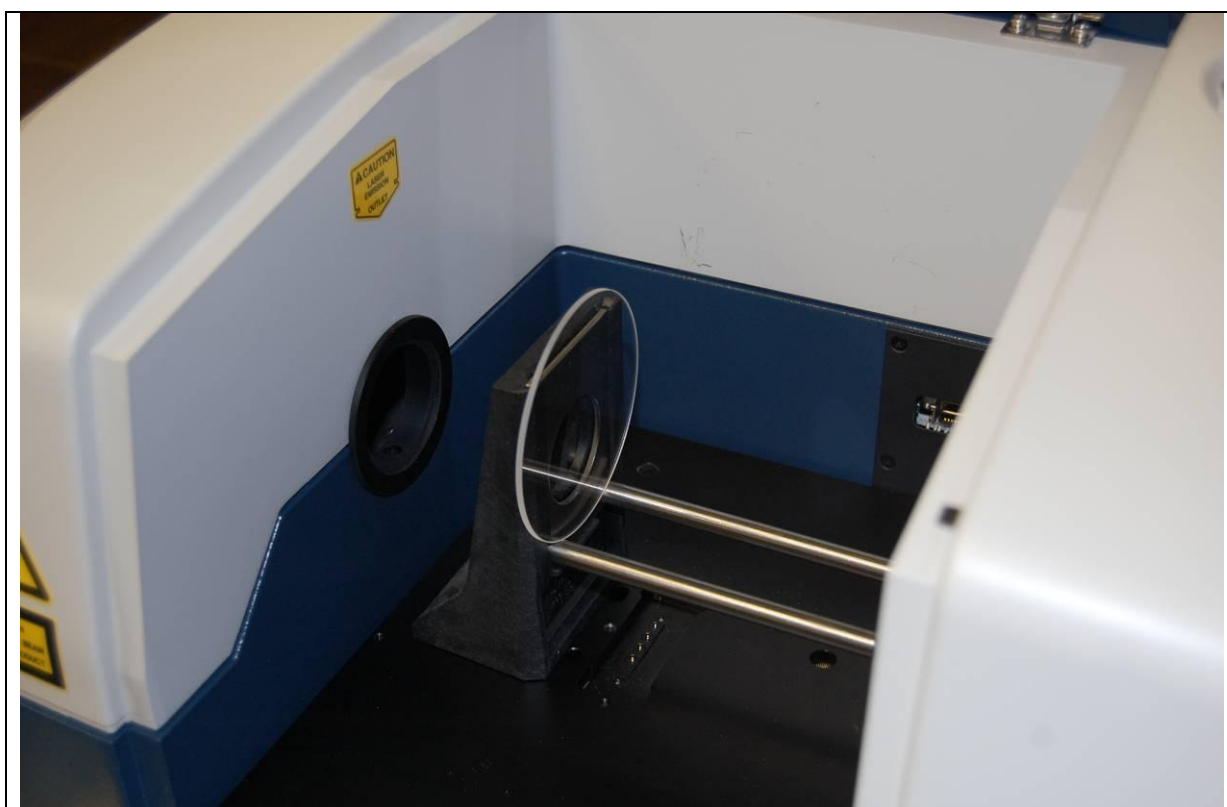
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FTIR Spectra in .jws format were also pasted into templates from "JASCO Canvas software" along with accompanying data and saved in .jcd format and printed to file as .pdf for inclusion in this WORD report.

Results

1. CaF₂ membrane

The image below show the position of the glass like CaF₂ polymer disc in-place just before the beam energy was monitored and the FTIR spectrum recorded.



Sample compartment of the FTIR Instrument with the glass like CaF₂ polymer disc in place

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Beam energies were recorded as follows: -

Table 1 – Beam Energies for CaF2 polymer disc

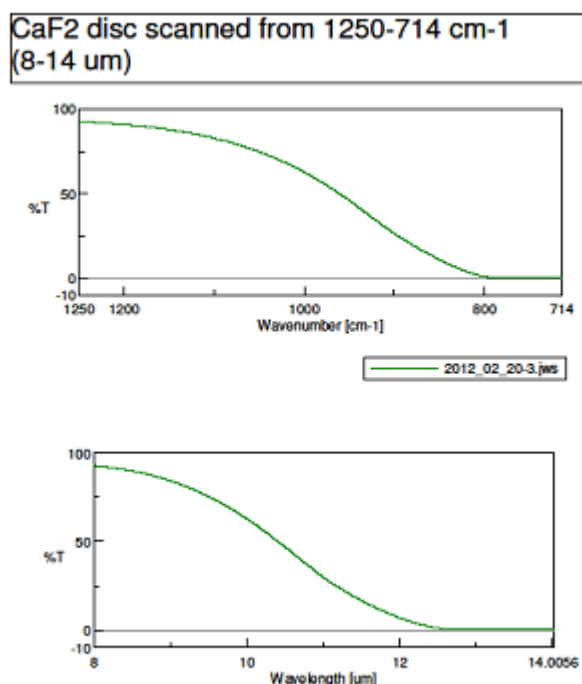
| Sample | Energy reading 1 | Energy reading 2 | Energy reading 3 | Average Energy reading | % Energy Transmitted |
|-------------------|------------------|------------------|------------------|------------------------|----------------------|
| Compartment empty | 24360 | 24374 | 24366 | 24367 | 100 |
| CaF2 polymer disc | 22226 | 22235 | 22218 | 22226 | 91 |

Across the full instrument spectrum, with the CaF2 polymer disc inserted into the FTIR beam, about 91% of the energy is transmitted i.e. there is an energy drop on average of about 9% across the full instrument spectrum. The FTIR Spectrum is shown below.

The average absolute transmission level has been evaluated at 49.37% Transmission over the narrower range of 8 – 14 micron wavelength by exporting the raw data into “Excel spreadsheets” or similar and taking averages.

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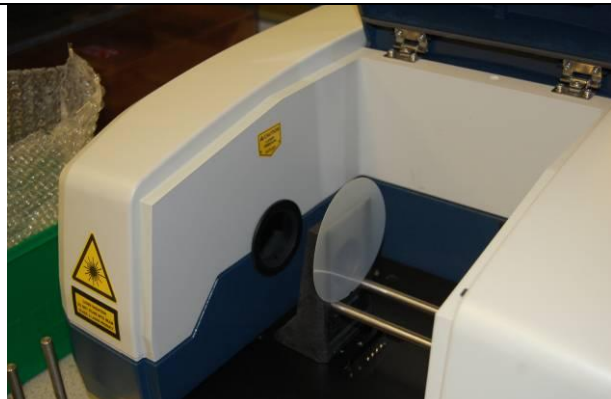



The full FTIR spectrum shows the CaF2 polymer disc is very transparent below the wavelength of 8 microns (not shown). Above 8 microns the transmission drops off reaching the 0% transmission level above 12.6 microns.

The average absolute transmission level on the FTIR data collected has been evaluated at 49.37% over the range 8 – 14 micron wavelength.

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2. Polymer reinforced IR viewing pane opaque flexible polymer membrane

The image below show the position of the opaque flexible polymer membrane in-place just before the beam energy was monitored and the FTIR spectrum recorded.

| | |
|---|---|
|  |  |
| <p>Unsupported membrane in FTIR beam path prior to measuring beam energy and recording an FTIR spectrum over the range $1250 - 714 \text{ cm}^{-1}$ (8 – 14 micron).</p> | <p>Membrane supported with the grills on both sides (notches aligned) and the membrane rotated to give MIN beam energy and recording an FTIR spectrum over the range $1250 - 714 \text{ cm}^{-1}$ (8 – 14 micron).</p> |
|  |  |
| <p>Membrane supported with the grills on both sides (notches aligned) and the membrane rotated to give MAX beam energy and recording an FTIR spectrum over the range $1250 - 714 \text{ cm}^{-1}$ (8 – 14 micron).</p> | <p>Membrane supported with the grills on both sides (notches aligned) and the membrane rotated to give AVERAGE beam energy and recording an FTIR spectrum over the range $1250 - 714 \text{ cm}^{-1}$ (8 – 14 micron).</p> |

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Beam energies were recorded as follows: -

Table 2 – Beam Energies for polymer reinforced IR viewing pane opaque flexible polymer membrane

| Sample | Energy reading 1 | Energy reading 2 | Energy reading 3 | Average Energy reading | % Energy Transmitted |
|--|------------------|------------------|------------------|------------------------|----------------------|
| Compartment empty | 24360 | 24374 | 24366 | 24367 | 100 |
| Flexible polymer membrane - no grills | 12488 | 12483 | 12481 | 12484 | 51 |
| Flexible polymer membrane - both grills MIN energy | 6864 | 6866 | 6866 | 6865 | 28 |
| Flexible polymer membrane - both grills MAX energy | 9915 | 9909 | 9913 | 9912 | 41 |
| Flexible polymer membrane - both grills AVERAGE energy | 8402 | 8401 | 8402 | 8402 | 34 |

Across the full instrument spectrum, with the polymer reinforced IR viewing pane opaque flexible polymer membrane inserted into the FTIR beam, only about 51% of the energy is transmitted without the

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supporting grills i.e. there is an energy drop on average of about 49% across the full instrument spectrum.

The amount of energy transmitted falls even further when both supporting grills are in place and the notches on the grills and membrane are all aligned. The transmitted energy falls to between 28 – 41% depending how the grills are presented to the FTIR beam.

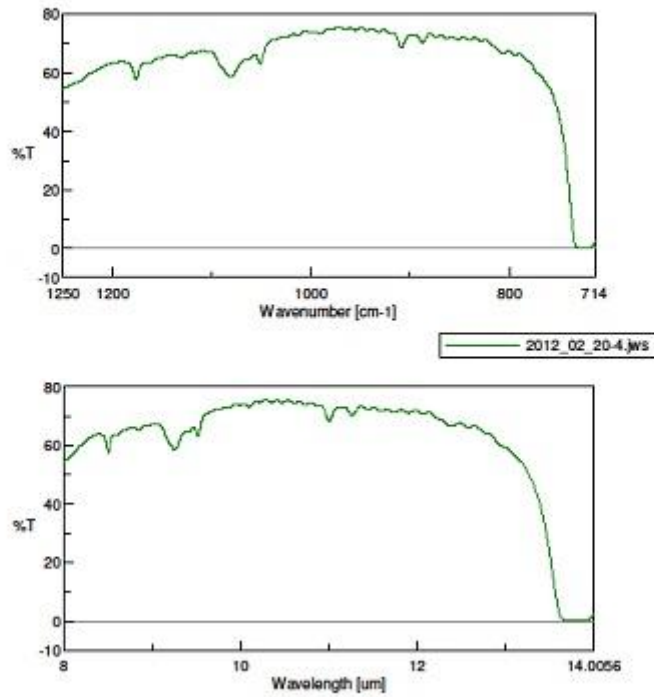
The average absolute transmission level has been evaluated at 63.36% Transmission over the narrower range of 8 – 14 micron wavelength for the polymer reinforced IR viewing pane membrane in an unsupported state.

With the polymer reinforced IR viewing pane membrane in a supported state, the average absolute transmission level has been evaluated at between 33.37 – 49.44% Transmission over the range 8 – 14 micron wavelength depending how the grills are presented to the FTIR beam.

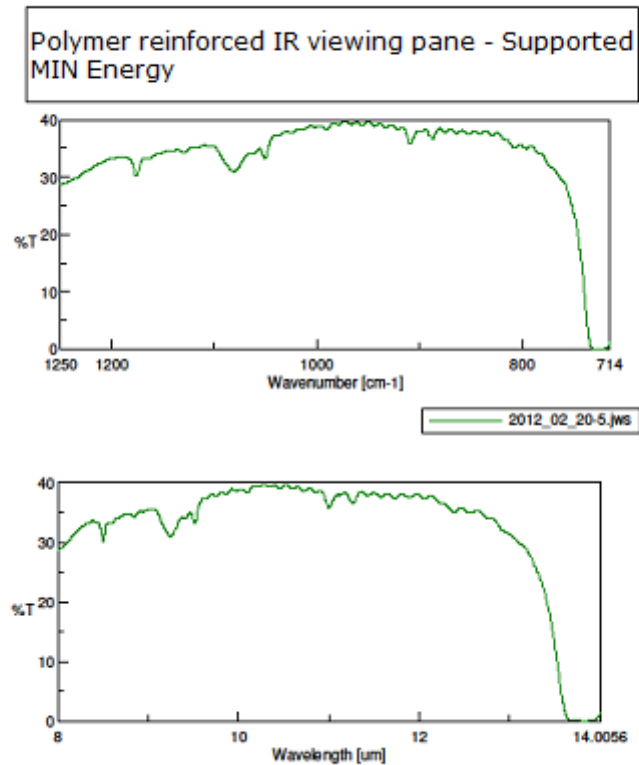
The FTIR Spectra are shown below.

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Polymer reinforced IR viewing pane - Unsupported

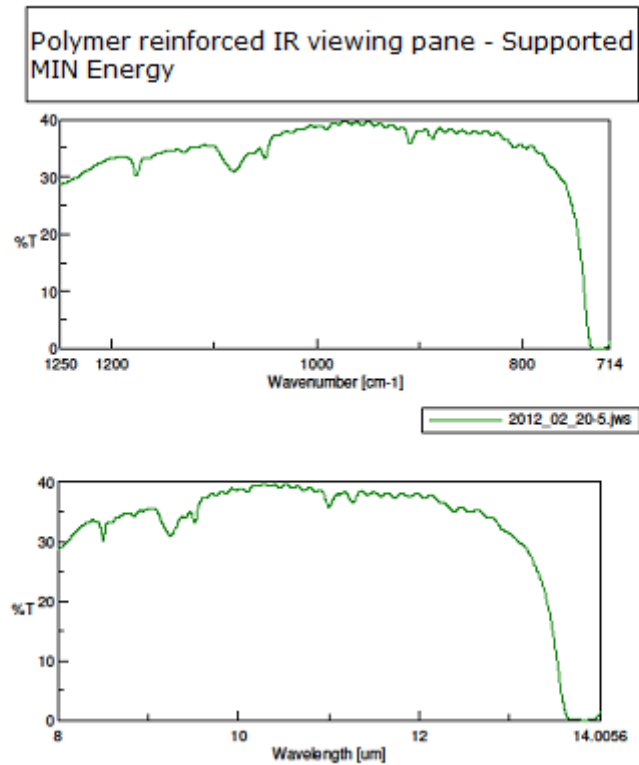


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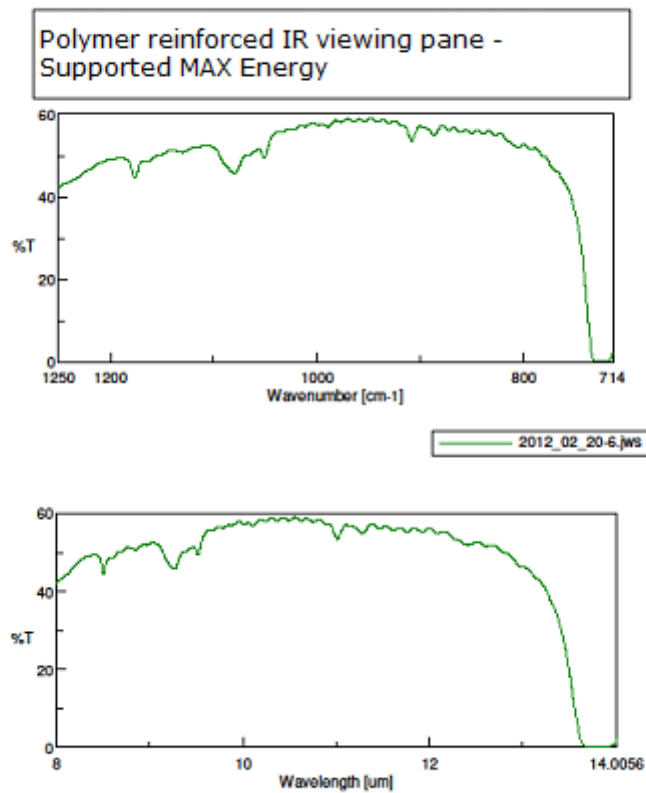
With the polymer reinforced IR viewing pane membrane in a supported state, the average absolute transmission level has been evaluated at 33.37 % Transmission over the range 8 – 14 micron wavelength with the beam at MIN energy.

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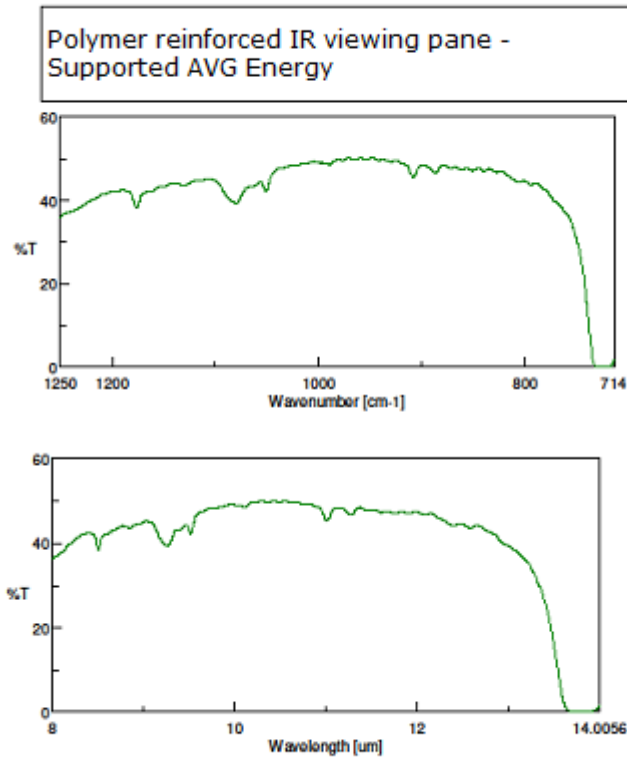
With the polymer reinforced IR viewing pane membrane in a supported state, the average absolute transmission level has been evaluated at 49.44 % Transmission over the range 8 – 14 micron wavelength with the beam at MAX energy.

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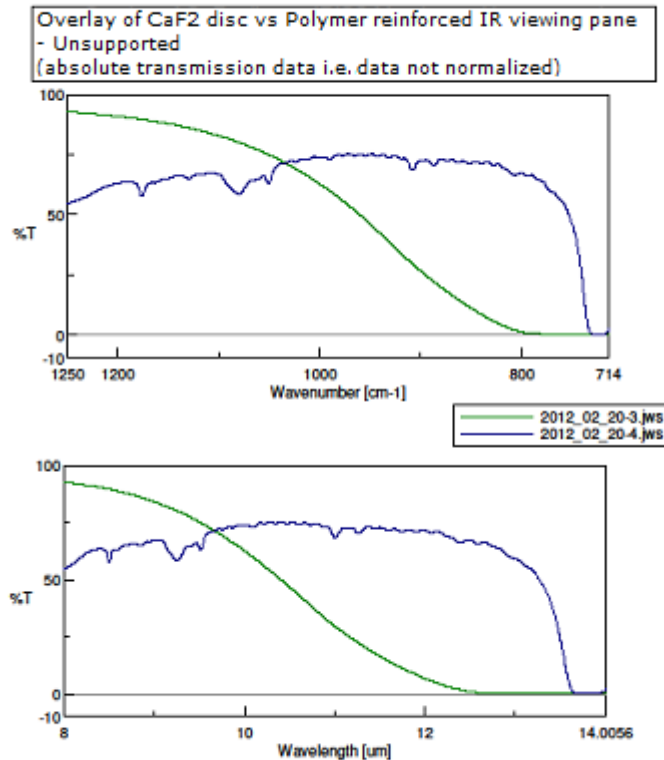
With the polymer reinforced IR viewing pane membrane in a supported state, the average absolute transmission level has been evaluated at 42.18 % Transmission over the range 8 – 14 micron wavelength with the beam at AVG energy.

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The % transmission qualities of the CaF2 disc and polymer reinforced IR viewing pane polymer membrane are compared over the range 8 – 14 micron wavelength. The average absolute % transmission of the polymer reinforced IR viewing pane polymer membrane when not supported by the 2 grills is higher (at 63.36% T) than the CaF2 disc (at 49.37% T).

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The unsupported polymer reinforced IR viewing pane membrane (green line) clearly transmits more IR radiation over the range 8 – 14 micron wavelength. An absolute average transmission of 63.36% has been evaluated.

With the 2 grills in place and aligned, the % transmission falls off as the beam energy is reduced from MAX (red line) to AVG (olive green line) to MIN (blue line).

With the beam energy at MAX the absolute average transmission = 49.44% T, AVG = 42.18%, MIN = 33.37% respectively.

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Conclusions

The CaF₂ membrane appears to offer very good transmission over the majority of the IR region of the electromagnetic spectrum tested, although above 8 micron the transmission drops off reaching the 0% level above 12.6 micron wavelength.

An infrared window made from this material would be expected to transmit about 91% of the incident radiation over the full instrument spectrum, although this falls to 49.37% across the narrower range of 8 – 14 micron wavelength.

The unsupported (no grills) polymer reinforced IR viewing pane polymer membrane is transmitting very little energy of the spectrum at certain wave numbers in the full instrument spectrum, especially just below 3000 cm⁻¹, and additionally at 1450 cm⁻¹, and 750 cm⁻¹ (full spectrum not shown).

As a result, an infrared window made from this material would be expected to transmit only about 51% of the incident IR radiation across the full instrument spectrum, although the use of supporting grills that are correctly aligned and do not transmit IR radiation may reduce this even further to 28 – 41% of the incident radiation. The grills merely obstructing rather than filter out particular wave numbers of IR radiation.

Across the narrower range of 8 – 14 micron wavelength, the unsupported membrane has an average absolute transmission of 63.36%, although the use of supporting grills that are correctly aligned and do not transmit IR radiation may reduce this even further to 33.37 – 49.44% transmission.

This report supplemental to report H57 previously issued.

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Signature: (hard copy only)_____

End of Report