Specification Document

Scope

The Fourier Transform Infra-red (FTIR) Imaging system and Microscope to be used for analysis of small plastic pieces (ranging from 5 mm down to ideally 1µm) termed microplastics in environmental particle samples.

It must be understood that the quote include total costs for the following 4 elements:

- all equipment needed to have a fully working FTIR and microscope setup.
- the costs for any auxiliary elements needed for the functional use and operation as per the specifications below.
- The offered warranty
- Extended service contract for planned preventative maintenance and call outs.

Requirement

The FTIR imaging system must meet the following **general requirements**:

- Ability to rapidly detect and image small particles down to 10 µm or smaller (FTIR transmission/reflectance). Fast scanning/data acquisition for numeration and sizing of microplastics is a priority for our work; the spectral data quality for polymer characterisation is also important.
- As the areas to image will be 13mm diameter filters the scan times may be long and requires the system quoted for to be able to run data acquisition unattended and in automated mode overnight.
- There must be a guarantee that scientists from any country may potentially use the instrument at CEH, and we must be able to potentially move it between our UK CEH sites.
- Potential for NIR imaging upgrade in the future is advantageous.
- The bidder must provide answers to the questions at the end of the specification in support of their bid meeting the required specifications.

Specific requirements for the FTIR Microscope and Imaging System are summarised below.

FTIR Spectrometer design and performance

- **IR source** will have the following characteristics:
    - Operates primarily in Mid-IR region (4000 – 400 cm^{-1}). Extension to Near-IR spectral region and/or possibility for dual (mid-near IR) operation are advantageous.
    - Have high short- and long-term stability and reproducible output.
    - The IR source must be user-replaceable.

    - Sealed/desiccated or purged optical enclosure.
- **Humidity monitor** to ensure that the ambient levels of CO_2 and H_2O vapour in the optical unit are known and can be automatically corrected for during or after analysis.
- **Beam-splitter** characteristics will include:
    - Optimisation for mid-IR region (>4000 – ≤400 cm^{-1})
    - Controlled mirror alignment .
    - Extension to Near-IR spectral region and/or possibility for dual (mid-near IR) operation are advantageous.
- **IR detector element(s)**
    - Must have broad spectral range in order to enable separation of all common polymers.
    - Having the widest available spectral range will also allow greater flexibility of the system for future use.
    - High-sensitivity and throughput in the mid-IR region.
    - Detector that also offer dual range (NIR-MIR) sensitivity without compromising the MIR sensitivity will be regarded advantageous.
    - Spectral resolution should be better than 0.5 cm^{-1} (FTIR spectrometer) and better than 4cm^{-1} (imaging).

IR Imaging and Microscope design and performance

- High-sensitivity and throughput in the mid-IR region.
- Can operate in both transmission and reflectance modes producing high quality IR images
- Collection of multiple IR images from different sample areas in a single experiment (alternative designs enabling high speed mapping of large areas (i.e. to cover the 13mm diameter filters most effectively) are acceptable).
- Variable IR spatial/pixel resolution
    - Having the capability to scan at different pixel sizes with a core range between 50 and 10µm (or smaller) to allow more flexibility will be a benefit. As an example, a large area can be image quickly with large pixel mode (e.g. 25µm), while other images might require the best possible spatial resolution i.e. 10µm or smaller.
- Rapid scan rate with >100 (the higher the better) full-range spectra/second at 16 cm^{-1} resolution.
- Fast IR imaging of large and small areas at high spatial resolution.
- High resolution visible camera fully integrated with the microscope stage motion and IR data acquisition both in transmission and reflectance modes.
- Visible LED light source that lasts the lifespan of the system.
- Mechanically stable when switching between IR and Visible modes.
- Fully automated microscope/imaging, including but not limited to:
    - Illumination
    - Focus
    - Stage control
    - Switch between Visible and IR modes (simultaneous view is acceptable)
    - Switch between transmittance and reflectance modes
    - Throughput correction
- Atmospheric correction utility/algorithm for H_2O and CO_2 without nitrogen purge (alternative designs ensuring that sample spectra are not influenced by H_2O and CO_2 spectra are acceptable).
- Chemical identification.
- Automated particles finder from visible image.
- Post-processing.
- The system must be upgradable to incorporate Attenuated Total Reflectance (ATR) objective with ATR imaging accessory.

Micro-ATR objective

- Fully automated.
- Must be completely controlled by the software.
- High refractive index (e.g. Germanium).
- Crystal tip made of material which ensures both robustness and high spatial resolution
- Wide spectral range.

ATR imaging accessory would be a preferable addition, but is not mandatory.

- Small pixel size for the best spatial resolution.
- ATR imaging crystal diameter in contact with sample > 400 µm to analyse large areas while avoiding cross-contamination.
- Wide spectral range.

Software

- Ability to perform real-time imaging to enhance speed, quality control and flexibility of IR data collection (equivalent designs meeting this requirement are acceptable).
- Includes extensive polymer reference spectral library (> 3000 polymer types or more).
- Multicomponent search software for multicomponent identification.
- Multiple areas can be analysed/imaged in a single experiment.
- Results export to Microsoft Office Excel and Word.
- Batch process and export of multiple spectra (i.e. ability to process, export and save multiple spectra at the same time).
- Suite of IR image analysis options and post-processing functions with multivariate analysis package with PCA and PLS.
- Multiple IR image and line-scan display modes, including interpolated false colour, false colour/contour, contour, 3-D wire grid and 3-D rendered surface.
- Export IR and visible images to other image analysis, display or reporting packages.

Customer training/support

- On-site training for initial familiarisation after installation at our site in Wallingford.
- Access to application and method development support and advice by a fully trained application specialist either visiting us in Wallingford or us visiting them at a demo site ideally local in the UK.
- Ongoing local scientific, technical and mechanical support through an included service agreement would be advantageous.

Required from the bidder

- The bidder is required to upload full details of the equipment being provided, including life expectancy of the equipment proposed assuming maintenance & support is kept up, spares and consumables, training, warranty, software upgrades and any options that can be offered.

- The bidder to specify the IR light source lifespan of the FTIR Microscope/Imaging system.

- It is important that the FTIR Microscope/Imaging system has detectors covering a wide wavelength range. Detector(s) that also offer NIR sensitivity without compromising the MIR sensitivity will be advantageous.

- The bidder to specify the variable spatial resolution the FTIR Microscope/Imaging system.

- The bidder specify lead time for the delivery and installation completion time for the new FTIR Microscope/Imaging system assuming contract awarded mid-August 2018, and any constraints on this. We must ideally have the system delivered, installed and operational by mid-September 2018.

- The bidder to confirm that all MCT linear array and FPA detectors will have high sensitivity throughout the whole spectral range for microplastics analysis. The bidder to provide SNR (p-p) achieved at 2200-2000cm^{-1} wavelength, 4cm^{-1}, 8cm^{-1}, 16cm^{-1} spectral resolution over a 4 seconds scan time per spectra in transmittance and reflectance modes of < 100µm PE and PP particles. Provide SNR obtained from a single spectrum generated by a single pixel (co-added spectra from multiple pixels is not acceptable). Summarize your response in a table with the following categories
  - Type of detector
  - Sampling mode (transmittance/reflectance)
  - Wavelength range
  - Spectral resolution
  - SNR (p-p)
  - Successful spectral search and match with database? (Y/N)

- Bidder should explain how the SNR (p-p) was calculated.

- The bidder to specify the variable spatial and pixel resolution for the imaging detector included in the FTIR imaging system. The ability to operate at multiple spatial and pixel resolutions should be described and specified.

- Bidder to describe how the infrared imaging system will image large and small areas at variable spectral resolution. For imaging of 10mm x 10mm (large) and 12µm x 12µm (small) sample areas at 4, 8 and 16 cm^{-1}, the bidder summarise the performance in a table with the following categories.
  - Type of detector
  - Sampling mode (transmittance/reflectance)
  - Spectral resolution
  - Area scanned
  - SNR (p-p) 2200-2000cm^{-1} wavelength for a single spectrum
  - Total scanning/imaging time
  - Number of spectra collected

- Bidder to provide information on licence(s) required to operate/use the system.

- Bidder to provide information how they are planning to support CEH to implement their method for microplastic analysis.

- Bidder must specify the expected running costs both per sample (if special slides or other consumables needed, they should be included in this calculation).

- Bidder must specify the expected per annum maintenance costs and service contracts.

- Bidder to describe how the costs per sample were calculated, as well as the per annum costs indicated above.

All questions will be scored based on the 0 – 100 methodology

0	The Question is not answered or the response is completely unacceptable.
10	Extremely poor response – they have completely missed the point of the question.
20	Very poor response and not wholly acceptable. Requires major revision to the response to make it acceptable. Only partially answers the requirement, with major deficiencies and little relevant detail proposed.
40	Poor response only partially satisfying the selection question requirements with deficiencies apparent. Some useful evidence provided but response falls well short of expectations. Low probability of being a capable supplier.
60	Response is acceptable but remains basic and could have been expanded upon. Response is sufficient but does not inspire.
80	Good response which describes their capabilities in detail which provides high levels of assurance consistent with a quality provider. The response includes a full description of techniques and measurements currently employed.
100	Response is exceptional and clearly demonstrates they are capable of meeting the requirement. No significant weaknesses noted. The response is compelling in its description of techniques and measurements currently employed, providing full assurance consistent with a quality provider.

Timetable

The bidder must specify lead time for the delivery and installation completion time for the new FTIR Microscope/Imaging system assuming contract awarded mid-August 2018, and any constraints on this. We must ideally have the system delivered, installed and operational by mid-September 2018 or access to alternative analysis options be made available in the meantime.