Exemption Request Form

PerkinElmer®

Date of submission: 23rd December 2019

1. Name and contact details

1) Name and contact details of applicant:

Company: PerkinElmer Ltd

Tel.: +44(0)1494 679014

Name: Ralph Carter

E-Mail: ralph.carter@perkinelmer.com

Function: Molecular Spectroscopy Research Leader

Address: Perkin Elmer, Chalfont Road, Seer Green, Beaconsfield, Bucks, HP9 2FX, United Kingdom

2) Name and contact details of responsible person for this application (if different from above):

Company: PerkinElmer Ltd

Tel.: +44 (0)1494 679317

Name: Rupert Aries

E-Mail: rupert.aries@perkinelmer.com

Function: Program Manager – Small Projects and Sustaining

Address: Perkin Elmer, Chalfont Road, Seer Green, Beaconsfield, Bucks, HP9 2FX, United Kingdom

---

2. Reason for application:

Please indicate where relevant:

☐ Request for new exemption in:

☐ Request for amendment of existing exemption in

☒ Request for extension of existing exemption in

☐ Request for deletion of existing exemption in:

☐ Provision of information referring to an existing specific exemption in:

☐ Annex III ☒ Annex IV

No. of exemption in Annex III or IV where applicable: 1c

Proposed or existing wording: Lead, cadmium and mercury in infra-red light detectors

Duration where applicable: Maximum validity period required

☐ Other: _____

3. Summary of the exemption request / revocation request

Infra-red (IR) spectrometers provide a rapid, accurate analysis of materials to provide information on the chemical composition, surface properties and spatial distribution of substances. The technology is utilised by a wide variety of industry sectors, researchers and for educational purposes, examples of which are given in Section 4(b).

IR detectors need the following technical requirements, which are crucial to its function:

- Photoconductor with an electrical resistance that decreases as the level of incident infra-red light increases;
- High sensitivity to small infra-red light level changes producing a strong signal;
- Low dielectric constant, ensuring that the signal to noise ratio is maximised;
- Relatively low electrical resistance when not exposed to infra-red light;
- Low noise, otherwise averaging methods have to be used which increases measurement time by a factor of 4 for an improvement of the signal to noise ratio of two due to a square law relationship;
- Ability to detect over a wide range of IR regions therefore requiring both low and high carrier concentrations; and
- FTIR spectrometers for kinetics studies must have very fast response to changes in concentration of substances with typical requirements being the ability to measure spectra in times that are 1000 times shorter than the overall changes in concentration.

The choice of semi conductors intrinsically affects the IR range detectable and usefulness of the signal produced. Mercury Cadmium Telluride is the only detector material currently available which is able to provide all of these characteristics on a technical basis.

---

4. Technical description of the exemption request / revocation request

(A) Description of the concerned application:

1. To which EEE is the exemption request/information relevant?

   Name of applications or products: Infra-red detectors of Fourier Transform Infra-red (FTIR) spectrometers and microscopes

   a. List of relevant categories: (mark more than one where applicable)

☐ 1	☐ 7
☐ 2	☐ 8
☐ 3	☒ 9
☐ 4	☐ 10
☐ 5	☐ 11
☐ 6	

   b. Please specify if application is in use in other categories to which the exemption request does not refer: Category 8 applications

   c. Please specify for equipment of category 8 and 9:

      The requested exemption will be applied in

      ☒ monitoring and control instruments in industry

      ☐ in-vitro diagnostics

      ☐ other medical devices or other monitoring and control instruments than those in industry

2. Which of the six substances is in use in the application/product?

   (Indicate more than one where applicable)

   ☐ Pb ☒ Cd ☒ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

3. Function of the substance: Detecting infra-red radiation

4. Content of substance in homogeneous material (%weight): Mercury is 41.8%, cadmium is 6.6%

5. Amount of substance entering the EU market annually through application for which the exemption is requested: Mercury- 0.20 g
   Cadmium- 1.00 g

   Please supply information and calculations to support stated figure.
   Based on 2018 sales, estimated market share and quantity values. For calculations, refer to confidential information supplied.

6. Name of material/component: Mercury Cadmium Telluride (MCT)

7. Environmental Assessment: _____
   LCA: ☐ Yes
   ☒ No

(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

Infra-red (IR) covers a broad portion of the electromagnetic spectrum from 1.0 to 30 µm. IR spectrometers provide a rapid, accurate analysis of materials to provide information on the chemical composition, surface properties and spatial distribution of a wide variety of materials. This technology is utilised by a wide variety of industry sectors, researchers and for educational purposes.

Most IR spectrometers use a semiconductor to detect IR, with the choice of semiconductor affecting the range of IR able to be detected and the ability to produce a useful signal. Detection occurs when an IR photon of sufficient energy causes the excitation of an electron in the semiconductor to move from the valence band to the conduction band(the energy difference of these bans is known as the bandgap). Dependent on the chemical composition of the detector material the bandgap is altered, with the minimum energy required to cause the excitation equal to the bandgap. Therefore the choice of detector material intrinsically affects the performance of the IR spectrometer, especially the wavelength range that is detected and its sensitivity.

Mercury Cadmium Telluride (MCT) consists of cadmium and mercury tellurides as a single phase non-stoichiometric (meaning that it cannot be represented by a ratio of small natural numbers) semiconducting compound.

Cadmium telluride (CdTe) is a semiconductor with a bandgap of approximately 1.5 electronvolts (eV) at room temperature. Mercury telluride (HgTe) is a semimetal, which means that its bandgap energy is zero. Combining these two substances into a single semiconducting material allows a tunable bandgap between 0 and 1.5 eV which is dependent on the composition ratio of HgTe to CdTe, resulting in infrared sensitivity within the 1-30 µm range, spaning the shortwave infra-red to the very long wave infra-red regions.

Several properties of MCT qualify it as highly useful for IR detection:

- Large optical coefficients that enable high quantum efficiency (how efficiently photons are converted to electrical signals) resulting in a strong signal with minimal noise;
- Strong optical absorption allows MCT detector structures to absorb a very high percentage of the signal while being relatively thin (around 10–20 µm). Minimizing the detector thickness helps to minimize the volume of material, which in turn minimises the generation of electrical noise and thermal excess carriers in the diffusion-limited operating mode, equating to minimal noise generation while a strong signal is produced; and
- MCT demonstrates near theoretical values of detectivity (the normalised signal-to-noise ratio) for medium wavelength IR to long wavelength IR spectral ranges, surpassing

numerous detectors based on other materials[1]. Although averaging can be used to improve signal to noise this comes at the expense of measurement time due to its square law relationship. Resulting in a measurement time of 4x as long if the signal-to-noise ratio is improved by a factor of 2. Therefore, to ensure that measurement times are practical, detectivity of the material is key.

MCT detectors are widely used in civil and military applications. Military equipment (such as night vision equipment) is excluded from RoHS so the main in-scope uses of MCT are in spectrometers and analysis equipment including for applications such as manufacturing, forensics, pharmaceuticals, environmental testing, research and development. The MCT detectors of this renewal request are utilised in both Fourier Transform Infra-red (FTIR) spectrometers and in FTIR Microscopes, each of which are discussed in more detail below.

FTIR Spectrometers

FTIR spectrometry works by passing modulated IR radiation through a sample that is detected by the MCT detector. Data can be acquired at rates up to 100 scans per second in commercial instruments[2]. The interferograms, which are plots of IR intensity versus time, are signal-averaged at intervals of less than 1 second and stored on the hard disk of the spectrometer's computer system. The data system then executes a Fourier transform of the interferograms, which are compared against a background spectrum interferogram to produce an IR spectrum of absorbance (or percentage transmittance) versus wave number or wavelength, an example of which is demonstrated in Figure 1.

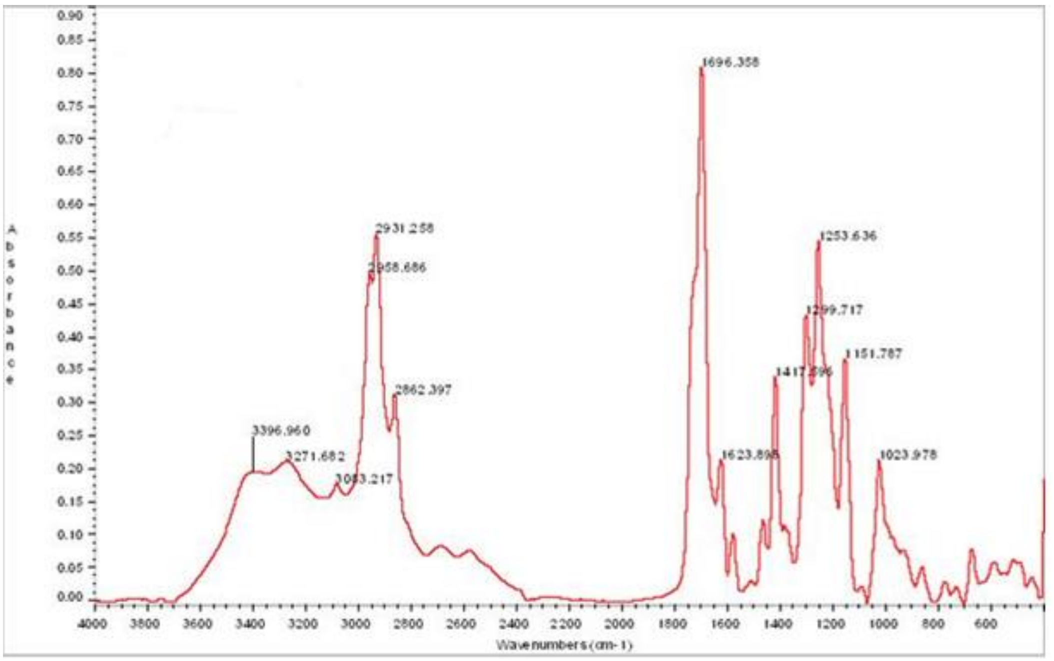

Figure 1 Example IR spectrum

1 https://deepblue.lib.umich.edu/bitstream/handle/2027.42/91390/aitsuno_1.pdf?sequence=1

2 Encyclopedia of Spectroscopy and Spectrometry, 2000

FTIR spectrometers are used for a variety of applications, some of which are detailed below:

- Identification and characterisation of unknown materials, used in forensic applications[3] including drug identification[4] as well as research and academia;
- Gain deeper understanding of product formulations, used in applications in the pharmaceutical industry as well as many others;
- Quality verification of incoming/outgoing materials allowing for greater control over processes such as feedstock manufacture or food production[5,6], as well as facilitation of troubleshooting of manufacturing issues;
- Performing counterfeit studies[7];
- Identification of contamination in or on a material, including oxidation, decomposition or uncured monomers in product safety studies. Example uses are for failure investigation or contamination in water[8] or soil[9];
- Identification of additives after extraction from a polymer matrix;
- Analysis of thin films and coatings[10];
- Monitoring of automotive[11] or smokestack emissions;
- Kinetics studies and for analysis of materials with low concentrations; and
- A tool for gaining deeper insights into the properties of novel and advanced materials.

Figure 2 FTIR spectrometers

[3] https://tools.thermofisher.com/content/sfs/brochures/AN51517-E-ForensicCrime1013M-H-0115.pdf

[4] https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0202059&type=printable

[5] https://tools.thermofisher.com/content/sfs/brochures/D10253~.pdf

[6] https://www.perkinelmer.com/lab-solutions/resources/docs/APP_Quality_Control_of_Olives_by_Near-Infrared-Spectroscopy_and_AssureID_Software.pdf

[7] https://www.researchgate.net/publication/286155695_Counterfeit_Tablet_Investigations_Can_ATR_FTIR_Provide_Rapid_Targeted_Quantitative_Analyses

[8] https://tools.thermofisher.com/content/sfs/brochures/AN52663-E-0215M-Oil-in-Water.pdf

[9] https://www.perkinelmer.com/uk/libraries/APP_SoilbyTG-IR

[10] https://tools.thermofisher.com/content/sfs/brochures/D21282~.pdf

[11] https://tools.thermofisher.com/content/sfs/brochures/D10248~.pdf

The large spectral range supported by the use of MCT is critical for the applications it is used in, as it allows all of the required infrared frequencies to be detected simultaneously, rather than by undertaking the lengthy process of detecting and measuring singular frequencies in turn. Perkin Elmer have developed systems such as the Spotlight's patented detector, which incorporates a narrow band MCT array detector and single point medium band MCT detector on a single substrate; allowing the measurement of 7800-720cm^{-1} (1.28-13.88 μm)[12] with the wide band array detector capable of measurements up to 570cm^{-1} (17.5 μm)[13].

FTIR also has the advantage that many spectra can be added due to the short period of time it takes to obtain each spectrum, thereby creating a clearer signal as random electrical noise is averaged out to increasingly small signals and increasing the sensitivity of the technique (referred to as "Fellgett's advantage").

FTIR spectrometers for kinetics studies

As a consequence of the speed of detection and high detectivity of MCT, FTIR is fast enough to measure a number of complete IR spectra in real time during the evolution of a chromatographic peaks and allowing chemical reactions to be measured in real time, which is of particular importance for kinetic studies.

Chemical reactions can be monitored by obtaining many infra-red spectra of the material during the chemical reaction. This shows the spectral peaks of the starting materials decreasing and the spectral peaks of the end products increasing. The rate at which this occurs is used to study the mechanisms of chemical reactions allowing for research into new chemical processes, such as pharmaceuticals and chemicals manufacture. The time taken for chemical reactions to take place can vary from milliseconds to many hours depending on the substances, temperature and other parameters. To study reactions that take only a few tens of minutes, or less, requires FTIR spectrometers that can obtain clear spectra with negligible noise and the ability to measure each spectrum in very short time frames. If the time taken to obtain a spectrum during a reaction taking 5 - 10 minutes to completion is more than one minute, the kinetics of a chemical reaction cannot be measured as the largest change in composition occurs in the first 2 - 3 minutes. One spectrum during this timescale is far too few; ideally at least 10 are needed, so measurements must be fast.

FTIR Microscopes

FTIR microscopes are used to identify the spatial distribution of materials within a sample, or the detection of small, isolated contaminants, for example:

[12] https://www.perkinelmer.com/content/relatedmaterials/brochures/bro_spectrumspotlightftirimaging.pdf

[13] https://www.perkinelmer.com/uk/product/spotlight-200i-sp2-system-na-l1862105

- Particulate contamination such as on medicine tablets, electronic components, etc. An example shown in Figure 3;

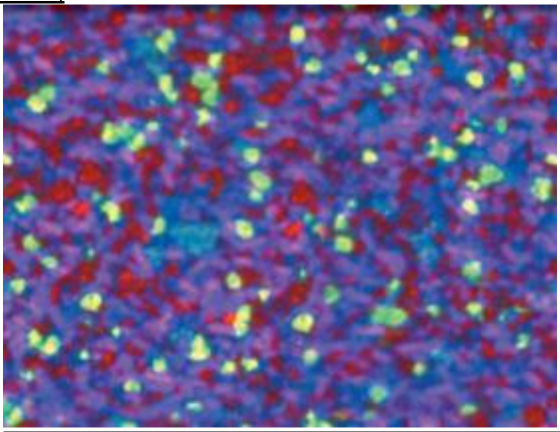

Figure 3 Distribution of ingrdients in an over the counter pharmacetical tablet showing particle of <5µm in size

- Identification of inorganic additives:
    - In polymers, such as titanium dioxide and antimony trioxide can only be identified in the wavenumber range 700-450 cm^{-1} (14.3 to 22.2 µm) where the use of MCT is critical to be able to measure these longer wavelengths;
    - Titanium dioxide is also used as an excipient in pharmaceutical formulations with the distribution of the titanium dioxide in the tablet being an important measurement for tablet quality. As mentioned above the measurement of the longer wavelengths for titanium dioxide is achivable using MCT but not by other technologies as outlined in Table 1;
    - Pigments used in paints often rely on inorganic components and FTIR microscopes are used to examine the spatial distribution of pigment particles. It is also used in art conservation the measurement of the pigments used and their distribution is critical for repair;
        - Analysis of thin layers by examination of a cross-section to reveal and analyse the separate thin layers, an example of which is shown in Figure 4. Can be used for surface coatings such as paints and with multiple layers of paints, inks and polymers to study surface degradation of layers[14];

[14] https://www.perkinelmer.com/CMSResources/Images/March%20-%20Analysis%20of%20Defects%20in%20Metal%20Panel%20Coating%20in%20Metallurgical%20Industries%20Using%20ATR-FTIR%20Microscopy.pdf

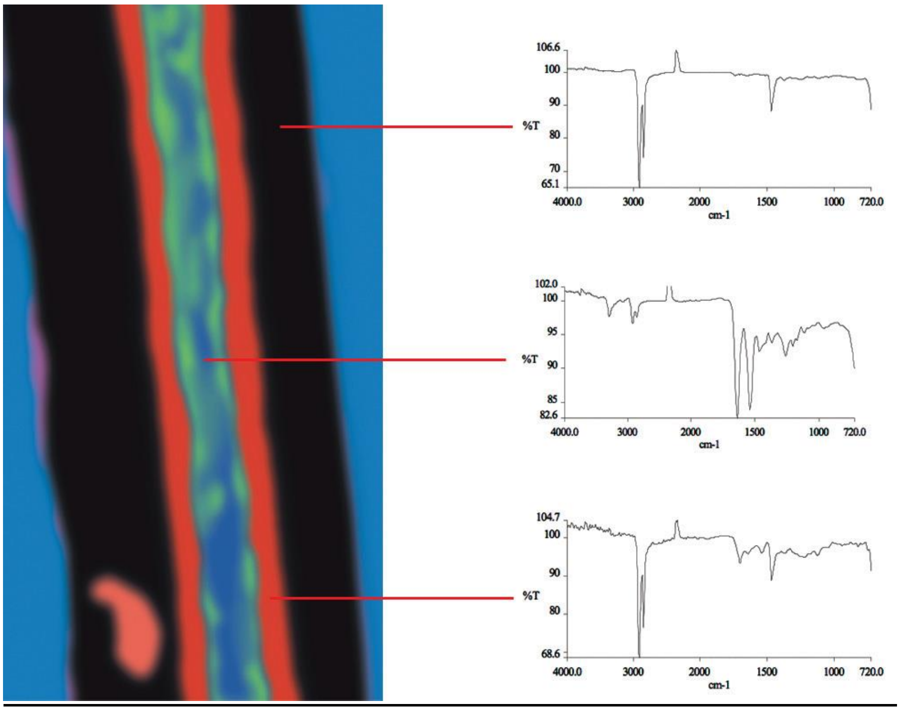

Figure 4 Polymer laminate showing individual layer of <10μm thickness

- Crystallinity measurements in polyethylenes – it is important to know the crystallinity of these materials and how the spatial distributions of the levels of crystallinity vary within a sample. This measurement is performed between 730-700 cm^{-1} (13.7 to 14.3μm) and if the detector were to cut off at 700 cm^{-1} (14.3μm) it would be impossible to get good data in this region;
- Forensic analysis of particles, stains, fibres[15]:
  - The measurement of mircoplastics in the environment[16;] and
  - The measurement of bone materials[17], with phosphate content in bones is measured using bands from 900cm^{-1} (11.1μm) to confirm the presence of phosphate to around 600 cm^{-1} (16.67μm) to give an indication of crystallinity.

[15] http://www.unitedstatesbd.com/images/unitedstatesbdcom/bizcategories/2961/files/JASTEE_2015_6_1_1.pdf

[16] https://tools.thermofisher.com/content/sfs/brochures/Microplastics-in-the-Environment-LowRes.pdf

[17] http://www.ehu.eus/sem/macla_pdf/macla6/Macla6_45.pdf

Figure 5 Spotlight 200i FT-IR Mircoscope

All of these applications analyse very small quantities of material and so the detector must be extremely sensitive. FTIR microscopes can also analyse an area to produce a 2D map of a surface showing variation in composition and an array of MCT detectors is used to obtain this data in a manageable timescale.

Trace analysis

If a solution contains only a small amount of a substance, standard infra-red spectrometers will not detect this substance as the level of electrical noise is larger than the signal required to be detected. FTIR is required as it is able to add the absorption peaks of the substance from multiple spectra and noise is cancelled out to increase sensitivity. The lower the substance concentration is the larger the number of spectra are required to reveal the spectrum of the substance from the background noise and the longer this takes. The relationship between sensitivity and processing time is a square law; so to double sensitivity would require 4 times longer.

A busy laboratory may have to analyse a large number of samples and so long analysis times are impractical. Under these circumstances, only an MCT detector will be suitable, with a comparison to alternative technology processing time provided in Section 6.

(C) What are the particular characteristics and functions of the RoHS-regulated substance that require its use in this material or component?

The infra-red detector must have the following properties to be able to produce a strong useful signal:

- Photoconductor with an electrical resistance that decreases as the level of incident infra-red light increases;
- High sensitivity to small infra-red light level changes. MCT is able to have multiple photons excited (single-carrier multiplication) and therefore a strong signal is produced, as well as having low noise;
- Low dielectric constant, ensuring that the signal to noise ratio is maximised;
- Relatively low electrical resistance when not exposed to infra-red light (measured as MΩ/square);
- Low noise (measured as $\mu V/Hz^{1/2}$);
- Ability to obtain both low and high carrier concentrations and thus be able to detect over a wide range of IR regions;
- FTIR spectrometers for kinetics studies must have very fast response to changes in concentration with typical requirements being 1000 times shorter than the changes in concentration;
- Analysis of organic and inorganic substances by infra-red spectroscopy requires detection of infra-red light in the range 400 to 7000 wavenumbers (cm^{-1}) equating to 1.4 to 25 µm. The tuneable bandgap of MCT allows optimal access to this range, especially to the longer wavelengths.

---

5. Information on Possible preparation for reuse or recycling of waste from EEE and on provisions for appropriate treatment of waste

1) Please indicate if a closed loop system exist for EEE waste of application exists and provide information of its characteristics (method of collection to ensure closed loop, method of treatment, etc.)

No closed loop system exists

2) Please indicate where relevant:

☐ Article is collected and sent without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

- ☐ The following parts are refurbished for use as spare parts: _____
- ☐ The following parts are subsequently recycled: _____

☐ Article cannot be recycled and is therefore:

- ☐ Sent for energy return
- ☐ Landfilled

3) **Please provide information concerning the amount (weight) of RoHS substance present in EEE waste accumulates per annum:**

☐ In articles which are refurbished ______

☒ In articles which are recycled ______

☒ In articles which are sent for energy return ______

☐ In articles which are landfilled ______

---

6. Analysis of possible alternative substances

(A) Please provide information if possible alternative applications or alternatives for use of RoHS substances in application exist. Please elaborate analysis on a life-cycle basis, including where available information about independent research, peer-review studies development activities undertaken

Perkin Elmer undertake regular reviews of available technologies currently on the market that would allow the substitution of RoHS restricted substances. Generally, most of the developments in technology have been understood for a considerable amount of time but are limited in their development due to known shortcomings of substitute detectors in comparison with MCT.

Photon emission or photoelectic effect detectors can be divided into the following subgroups:

1) Intrinsic direct band gap like MCT, photon-induced optical transitions primarily occur between the valence and conduction bands;

2) Extrinsic type such as Si doped with Ga or As to facilitate photon absorption from the impurity band within the forbidden gap to the conduction band;

3) Photoemissive-type such as metal silicides and negative electron affinity materials; and

4) Quantum wells and quantum dot IR photodetectors (III-V and II-VI ternary and quaternary compounds). Which use intra-band absorption mechanisms involving transitions within the same band, rather than inter-band absorption, resulting in transitions between the conduction and valence bands.

However there are also other mechanisms for detection such as thermal detectors such as bolometers which measure the power if incident electromagnetic radiation via the heating of a material with a temperature-dependent electrical resistance. There are also pyroelectric detectors which detect photons through the heat generated and the subsequent voltage generated in pyroelectric materials.

A limitation of this technology is infrared photons also cause a temperature rise, which in turn causes an electrical effect, masking desirable measurements and lowering the sensitivity. A thermal detector that is able to access the long wavelengths is typically 100 times less sensitive than MCT. To get equivalent performance to MCT a thermal detector would require

10,000 times the measurement time. Therefore, a 1-minute measurement with MCT would take 1-week using thermal detectors. Consequentially any studies that are time critical, such as the previously mentioned kinetic studies would not be remotely possible. Any other measurement would also be impractical due to the extreme time penalty experienced using this technology for long wavelength measurements. The stability of samples over such a long period will often also be a limitation for heat detectors.

Table 1 compares the performance and characteristics of detectors that operate in the infra-red range.

Type	Detector	Wavelength range and peak (µm)	Typical detectivity (cm Hz½/W)[18]	Responsivity	Suitability
Intrinsic II-VI	MCT	2 to 20 (various versions available)	10^{10} to 10^{11}	Time constant <1µsec	
Intrinsic IV-VI	PbSe	1 to 4.7 (4.0 peak)	10^{9} to 10^{10}	Time constant 4µsec	Due to the inclusion of lead would also be impacted by RoHS and therefore is not a suitable alternative. The wavelength range is smaller than MCT Poorer data quality due to a high thermal expansion coefficient.
	PbS	1 to 3.3 (2.4 peak)	10^{10} to 10^{11}		
Intrinsic III-V	InSb	Photovoltaic types 1 to 5.5 (5.3 peak) Photoconductor types 1 to 6.7 (5.5 peak)	10^{9} to 10^{10}		The wavelength range is smaller than MCT
	InAs	1 to 3.5 (peak 2.8)	10^{9}		
	InGaAs (2.6 micron cut-off)	0.5 to 2.6	Ca. 10^{11} [19]	Relatively fast	
	InGaAs (1.7 micron cut-off)	0.5 to 1.7	Ca. 10^{13} [16]		
	InSbAs	1 to up to 11	7 x 10^{7} [20]		Detectivity of 11µm cut-off detector is too low
Quantum wells	Type I	6 to 10 (peak around 8.9 dependent on type)	10^{10} to 10^{11} [21]		Poorer data quality due to high thermal generation

[18] Dectectivity results taken from https://spie.org/samples/PM280.pdf unless otherwise referenced in table

[19] https://www.wat.edu.pl/review/optor/12(1)139.pdf

[20] Hamamatsu data sheet https://www.hamamatsu.com/resources/pdf/ssd/p13894_series_kird1133e.pdf

Type	Detector	Wavelength range and peak (µm)	Typical detectivity (cm Hz½/W)[18]	Responsivity	Suitability
	(GaAs/AlGaAs, InGaAs/AlGaAs)				Due to complicated design and difficulty of manufacture, these are not commercially available The wavelength range is smaller than MCT
	Type II (InAs/InGaSb, InAs/InAsSb)	2 to 30 by changing the layer thicknesses	10^8		Due to complicated design and difficulty of manufacture, these are not commercially available Lower detectivity than MCT
Quantum dots	InAs/GaAs, InGaAs/InGaP, Ge/Si				Due to complicated design and growth it is not commercially available
Thermal	Pyroelectric	Responds to heat in all of heat spectrum	10^8	Much slower than MCT	Same wavelength as MCT range but much lower sensitivity/detectivity. Would require repetition of tests to a completely impractical level to reduce noise so that test time would rise exponentially as a consequence.
	Bolometer	Responds to heat in all of heat spectrum	10^8	Much slower than MCT, typically 50msec	

Table 1 Potential alternative detector materials and properties

[21] https://aip.scitation.org/doi/10.1063/1.345829

Quantum well detectors are a type of infrared devices that were first researched in the late 1980s[22], originally as optical telecommunications detectors. These have not been successfully commercialised and a recent paper explains that this is because the performance is limited by intrinsic material properties such as lattice mismatch, dislocations and intervalley scattering of carriers[23].

Quantum dot detectors have been the subject of research since the mid 1990s, but have so far not resulted in viable commercial detectors. Most published research using quantum dots has used cadmium or mercury compounds and so would not be considered as suitable substitutes for spectromers in scope of RoHS. Research with other substances is at a releatively early stage and so far performance is unsuitable for use in infrared spectrometers.

Recent developments within the industry, such as Hamamatsu's publication on the 27th August 2019 showcasing their InAs/GaSb alternative to MCT, are indicative of the efforts expended by industry to move away from RoHS restricted substances. The technology offered by Hamamatsu offers wavelengths of up to 14.3 µm, which is lower than that of MCT (20 µm) so is not a direct substitute for MCT[24].

Additionally, the currently stated maximum detectivity of the Hamamatsu alternative is 1.6 x10^{10}, in comparision with the the 16.6 µm detector Perkin Elmer which is 4.5 x10^{10} and commerical avaliable alternative from Teledyne Judson detectors of around 6 x10^{10} [25]. As previously discussed due to the square law relationship between the detectivity and measurement time the implications of the differences in detectivity will result in measurement times which are orders of magnitude longer. Another issue is that the shape of the dectivity / wavelength curve of the Hamatsu detector is very different to the shape of MCT detectors so that at higher wavelenths, the detectivity values of the Hamamatsu detector are much lower than those of MCT. Further more the photosensitive area offered by the Hamamatsu alternative is 0.1mm^2 in comparision with 0.15mm x 0.15mm offered by Perkin Elmer, resulting in a 50% reduction in sensitivity.

Hamamatsu currently only offers a slow increase of production that is expected to reach 1000 units per year only after three years (i.e. by 2022). In addition to this, the technology currently offered by Hamamatsu would only be able to replace the single point detector and not the array detectors used in FTIR spectrometers and microscopes and also 2D imaging with the technology would not be possible.

Due to the unique combination of properties, MCT is currently the only available technology which is commerically available which provides all of required charteristics.

---

[22] Quantum-dot infraredphotodetectors: Status andoutlook, P. Martyniuk,A.Rogalski. Progress in Quantum Electronics 32 (2008) 89–120.

[23] Two-band ZnCdSe/ZnCdMgSe quantum well infrared photodetector,Y. Kaya et. Al., AIP Advances 8, 075105 (2018)

[24] https://www.hamamatsu.com/resources/pdf/news/2019_08_27_en.pdf

[25] http://www.teledynejudson.com/prods/Product%20Documents/mercadpc_08_254A.pdf

(B) Please provide information and data to establish reliability of possible substitutes of application and of RoHS materials in application

No alternatives possible

---

7. Proposed actions to develop possible substitutes

(A) Please provide information if actions have been taken to develop further possible alternatives for the application or alternatives for RoHS substances in the application.

Manufacturers have stopped using MCT in infrared spectrometers with lower performance than the types described in Section 4 that require MCT detectors. For general-purpose analysis, pyroelectric detectors can be used. However, it has not been possible to substitute MCT where analysis of very small quantities of materials is required and in applications such as infrared microscopes or kinetic studies.

(B) Please elaborate what stages are necessary for establishment of possible substitute and respective timeframe needed for completion of such stages.

A new type of sensor is required that meets all of the essential criteria listed in section 4(C). It is not possible to predict when one might be discovered as all known commercially available semiconductor detectors and other types of detectors have been evaluated and none of these meet all of the essential criteria listed in section 4(C). Semiconductor development is now relatively mature so that it seems unlikely that a new one will be discovered that could replace MCT in the near future. If a detector was to be discovered, although this seems unlikely based on current knowledge, then this would need to be thoroughly tested for performance under all conditions of use with consideration given to aspects such as reliability, stability and reproducibility of results. The alternative product would have to be commercially available, with the manufacture of the detectors in sufficient numbers to meet the demand for the alternative. The only promising recent development is the new single point detector from Hamamatsu. However this is not yet available in sufficient numbers and has technical limitations – lower detectivity, smaller wavelength range and cannot yet be made as an array detector.

The timescale needed for substitution of MCT detectors, once such a suitable detector becomes available, is likely to take 3 to 5 years.

8. Justification according to Article 5(1)(a):

(A) Links to REACH: (substance + substitute)

1) Do any of the following provisions apply to the application described under (A) and (C)?

☐ Authorisation

☐ SVHC

☐ Candidate list

☐ Proposal inclusion Annex XIV

☐ Annex XIV

☐ Restriction

☐ Annex XVII – although cadmium and mercury are included in Annex XVII, these restrictions do not include MCT infrared detectors

☐ Registry of intentions

☐ Registration

Based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemptions would not weaken the environmental and health protection afforded by the REACH Regulation.

2) Provide REACH-relevant information received through the supply chain.
Name of document: _____

(B) Elimination/substitution:

1. Can the substance named under 4.(A)1 be eliminated?

☐ Yes. Consequences? _____

☒ No. Justification: No substitutes exist that meet all essential criteria

2. Can the substance named under 4.(A)1 be substituted?

☐ Yes.

☐ Design changes:

☐ Other materials:

☐ Other substance:

☒ No.

Justification: No substitutes exist that meet all essential criteria. See Section 6

3. Give details on the reliability of substitutes (technical data + information): N/A

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts:
   2) Health impacts:
   3) Consumer safety impacts:

⇨ Do impacts of substitution outweigh benefits thereof? Not applicable as no alternatives exist

Please provide third-party verified assessment on this: ______

(C) Availability of substitutes:

a) Describe supply sources for substitutes: None exist

b) Have you encountered problems with the availability? Describe: No substitutes exist

c) Do you consider the price of the substitute to be a problem for the availability? No substitutes exist

☐ Yes ☐ No

d) What conditions need to be fulfilled to ensure the availability? Development and sufficient availability of a substitute that meets all essential criteria

(D) Socio-economic impact of substitution:

⇨ What kind of economic effects do you consider related to substitution?

☐ Increase in direct production costs –

☐ Increase in fixed costs

☐ Increase in overhead

☒ Possible social impacts within the EU – There would be many negative impacts if this exemption were not to be renewed:

EU industry would become less competitive if MCT detectors were available outside of the EU but not in the EU.

A large number of academic research is dependent upon the use of IR detectors as an analysis tool for novel material developments as well as industries like pharmaceuticals. Without the exemption, there would be job losses as these roles and funding for research are transferred outside the EU.

The use of IR detectors in many forensic applications, such as criminal cases and failure investigations would be impossible without FTIR spectrometers and microscopes.

FTIR spectrometers utilising MCT detectors are used in environmental monitoring in applications such as the measurement of mircroplastics in water or emissions measurement and could no longer be carried out if the exemption renewal is not granted. This would have the consequence of reducing the ability to support environmental initiatives and monitoring pollution within the EU

FTIR spectrometers utilising MCT detectors are used to identify counterfeit products, which without this exemption would have to be identified by other means, potentially affecting consumer safety. Similarly, the identification of contamination that is sometimes undertaken in support of product safety assessments would also not be able to be undertaken if the exemption were not to be granted.

The production costs of many types of manufacturing process would be adversely affected as quality control of substances would either not be available or would have to use a less sensitive detector. Consequentially other, less suitable control measures as part of the manufacture would have to be used. If these are less effective so that product quality is unsuitable and so must be disposed of, this would increase product prices and the amount of waste.

☐ Possible social impacts external to the EU

☐ Other: _____

⇨ Provide sufficient evidence (third-party verified) to support your statement: _____

9. Other relevant information

Please provide additional relevant information to further establish the necessity of your request:

_____

10. Information that should be regarded as proprietary

Please state clearly whether any of the above information should be regarded to as proprietary information. If so, please provide verifiable justification:

The calculation method for the quantity of mercury and cadmium used for this application in the EU annually is confidential and is provided separately.