Exemption Request Form

Date of submission: 19.1.2022

1. Name and contact details

1) Name and contact details of applicant:

Company:	BBT – Materials Processing	Tel.:	+420 724 875 729
Name:	Ing. Ondřej Ballada	E-Mail:	ballada@calomel.cz
Function:	Technical Project manager	Address:	U Továrny 1 250 66 Zdiby – Přemyšlení Praha-východ, Česká republika

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

Company:	BBT – Materials Processing	Tel.:	+420 284 890 447
Name:	Ing. Čestmír Barta, CSc	E-Mail:	barta@calomel.cz
Function:	CEO	Address:	U Továrny 1 250 66 Zdiby – Přemyšlení Praha-východ, Česká republika

---

2. Reason for application:

Please indicate where relevant:

- ☒ Request for new exemption in: Annex III
- ☐ 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: _____

Proposed or existing wording: Optical components made of mercurous chloride monocrystal (Calomel).

Duration where applicable: Maximum validation duration (i. e. 7 years).

☐ Other: _____

3. Summary of the exemption request / revocation request

Products made of mercurous chloride monocrystals (solid state, stable crystal) represents a unique, synthetically prepared optical components with extraordinary properties, especially in the infra-red part of the electromagnetic spectrum. Nowadays, there are no other materials that can offer such a strong birefringence (Δn = 0,6) and simultaneously broadband transparency reaching from visible (0.38 μm) up to mid-thermal IR region (17 μm). These extraordinary properties will find application mainly in ground sector applications such as polarization optics and, spectroscopy, acousto-optics, microscopy, etc., as well as in the space environment sector, too. Calomel is only crystal transparent in MWIR and birefringent too, what makes him a great candidate for a polarization optics with many technical advantages over the wire-grid systems used today. Even if the optical products made of mercurous chloride monocrystals are not directly electronic devices, many of the final Calomel based components is used as a subcomponent for the electronic devices. Calomel windows, prisms, cubes, plates and other forms of products are usually mounted into the protective housing for its particular use and then distributed to the final customers reaching from private companies and corporates, up to technology institutes, universities and scientific centres producing or using corresponding electronic devices.

Even though Calomel is mercurous based compound, handling represents no health risk[1] since the mercury molecules are firmly bonded in the crystal lattice. The material is insoluble in water and no harmful substances can be absorbed through the skin or mucous membranes.

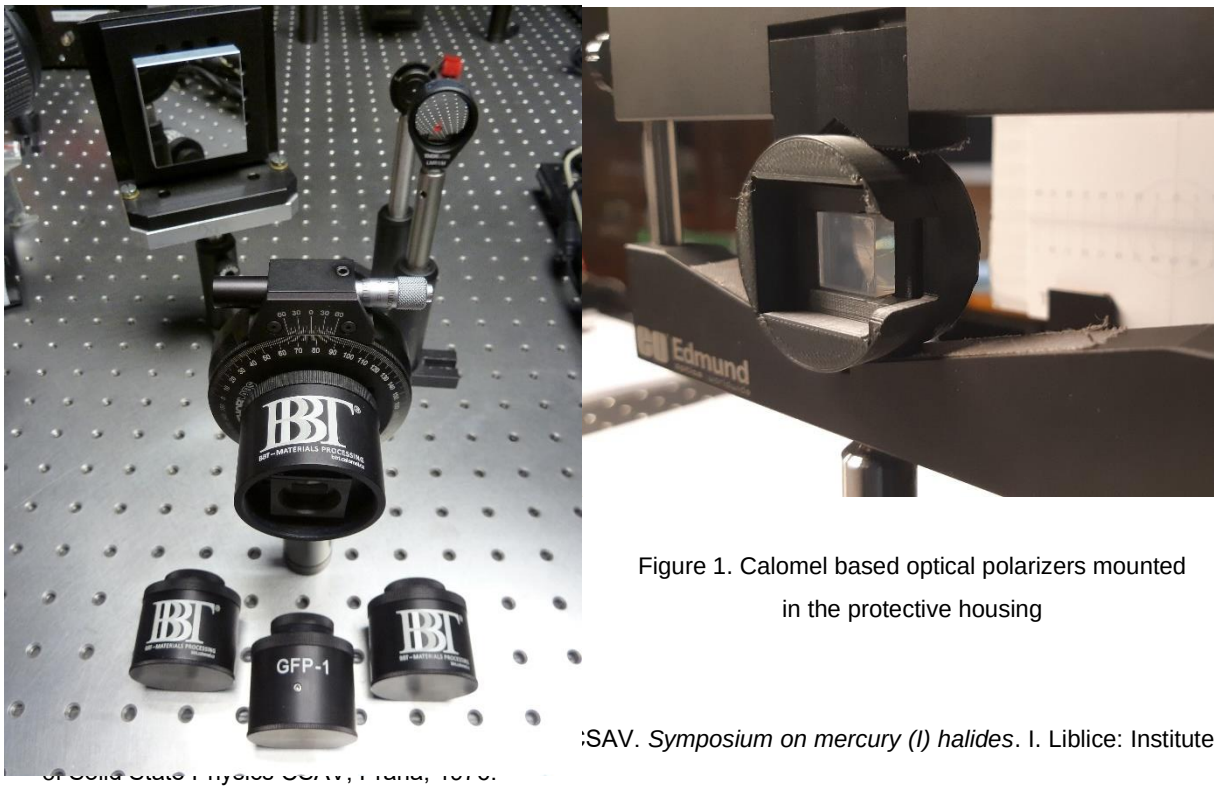

Figure 1. Calomel based optical polarizers mounted in the protective housing

SAV. *Symposium on mercury (I) halides*. I. Liblice: Institute of Solid State Physics CSAV, Praha, 1970.

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:

Products which this exemption will be related to, include calomel based optical components and devices (polarizers, laser and acousto-optic devices, spectroscopes, etc.) and other optical equipment in scope of RoHS. The components will also be used as the custom designed products for scientific applications and general optics and photonics purpose.

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: Besides the above mentioned, our products are involved in electronic devices for scientific, research and development applications such as small spectrometers, interferometers, lasers, or custom made electronic devices.

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:

In addition to chlorine, Mercury (Hg) is the essential part of the mercurous chloride (Calomel – Hg_2Cl_2) molecule. It is bonded in the crystal lattice with

strong covalent bond and form the crystal lattice responsible for the unique optical material properties.

4. Content of substance in homogeneous material (%weight):
   The mercury content in the Calomel compound is 85% (given by the standard atomic weight). The mass content depends on the size of the optical components produced, usually between 5-30 grams, giving 4.25-25.5g of mercury.

5. Amount of substance entering the EU market annually through application for which the exemption is requested:
   Considering a size of the optical market dealing with the infra-red polarization optics, we can expect annual production around 100pcs of polarization components with growth rate around 10% per year plus eventually another 50-100pcs for custom designed products. Our company BBT - Materials Processing is specifically engaged in the production of small optical pieces (approximately 0,5 - 4cm^3 with a weight about 5 - 20 grams per one piece), which means that final output doesn't go beyond 3,5 kilograms per year.

6. Name of material/component: Calomel (mercurous chloride monocrystal)

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?

As stated in the 4.3., mercury is one of the two basic atoms forming the molecule of the Calomel monocrystal (mercurous chloride – Hg_2Cl_2). The crystalline form of the mercurous chloride is the synthetically prepared monocrystal used for different kinds of applications in the optical and photonics industry. The Calomel (solid form) based optical components are used in the field of polarization optics, acousto-optical components and general optical components like prisms, windows, cubes and other standard optics used in laser and photonics industry. All electrical or electronic devices equipped with Calomel are used by professionals in research and development photonics institutes, universities and private companies dealing mainly with infrared part of the electromagnetic spectrum, worldwide.

- **Polarization Optics**

Calomel IR polarization components represent unique devices based on monocrystal of mercurous chloride, showing an exceptionally high extinction ratio (ER) in comparison with the market competitors targeting to MWIR/LWIR[2] spectral band. The current optical market of MWIR/LWIR polarizers is covered only by wire-grid or holographic types of polarizers. These types provide only low, or limited ER values and damage threshold which limit the final application performance of the products. The combination of Calomel's two unique material properties: a high value of birefringence (n_o=1.973, n_e=2,656 @ 589nm) and a wide transparency range makes it a great candidate for infrared polarizers.

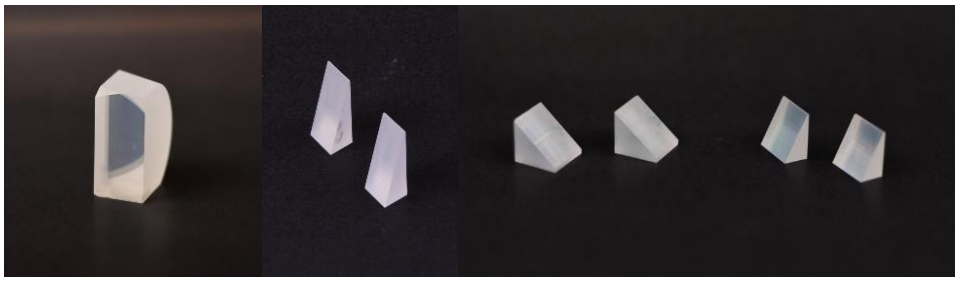

Figure 2. Different types of polarization prisms made from mercurous chloride crystalline material.

In terms of material, we distinguish two main types of optical polarizers: polymer film polarizers / grid polarizers and crystal (prism) polarizers. The film/grid polarizers are the order of magnitude cheaper (especially applies to film polarizers) compared to crystal polarizers but exhibit lower Extinction Ratio (10^2 -10^3) and due to the higher absorption (50-90%), they are not good for high power laser applications. The crystal polarizers (Calomel prism based) exhibit high ER (up to 10^4 – 10^5), transparency (95-98%?) and high optical resistance.

[2] SWIR/MWIR/LWIR/TIR stands for specific wavelength ranges; Short Wavelength Infrared (*SWIR*), Medium Wavelength Infrared (*MWIR*), Long Wavelength Infrared (*LWIR*) and Thermal Infrared (*TIR*)

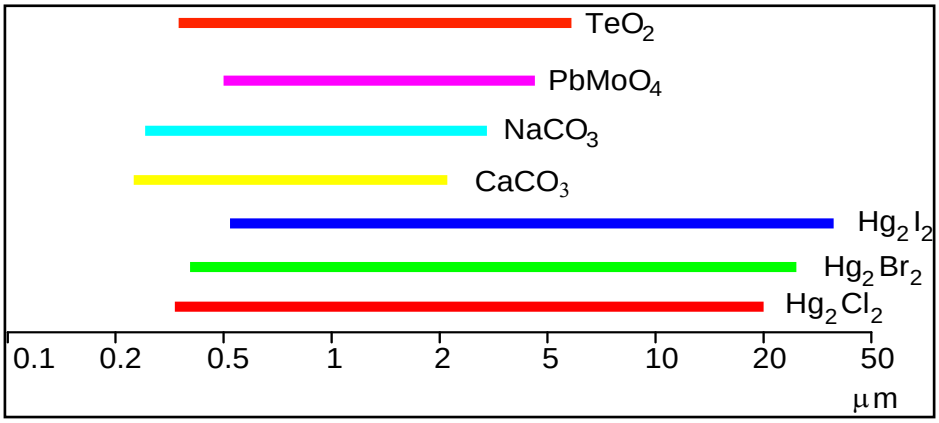

Figure 3. Comparison of optical transmission: Calomel vs. other materials

A typical and traditional representative of crystal polarizers is a Calcite. Calcite is a naturally occurring birefringent crystal with excellent polarization properties including very high extinction ratio and transmission efficiency. Unfortunately, Calcite material exhibits only limited transmission performance from 320 to 2300 nm. Looking at Figure 3, it is clear, that Mercury halides (including Calomel) covers much wider spectral region than in case of other optical materials.

- **Acousto-optics**

Calomel is suitable for the construction of acousto-optical devices such as AO tuneable filters (Fig. 4), AO deflectors, and modulators. In comparison, Calomel's figure of merit is comparable with tellurium dioxide TeO_2 and more than one order better than lead molybdenate $PbMoO_4$. Moreover, the transparency of Calomel (0.38 to 17 µm) enables the use of AO units in a broad spectral range (compared with TeO_2 which is limited only up to 5 µm) covering a part of the thermal IR region where no other materials can be applied. No other tuneable acousto-optical filter for thermal IR region is currently available on the market what represents a significant market advantage for this material.

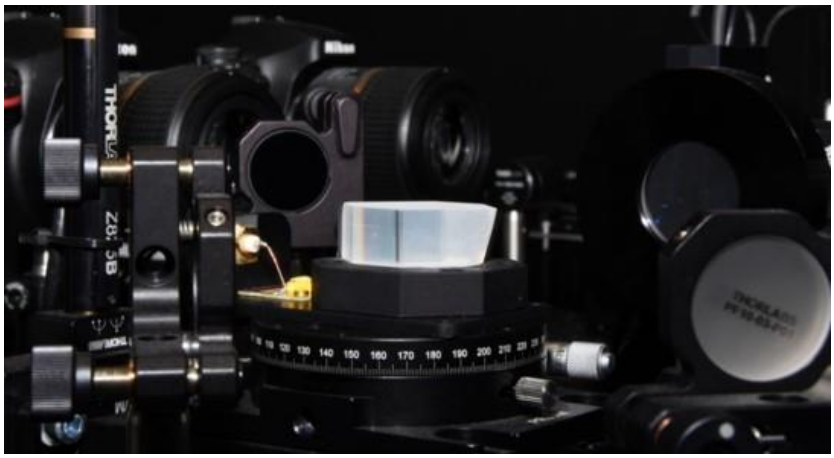

Figure 4. Breadboard of Calomel Acousto-Optical unit

- **Optical Elements**

Optical elements as filters, beam-splitters, prisms, and windows offer a variety of non-polarizing optical elements for operating light sources from the SWIR to TIR spectral regions. Custom made optical components may be supplied in different shapes, angles and configurations, and may be used for a wide range of applications, such as OPD (optical path difference), spectroscopy or sample substrates. It may be also used in IR optical systems, where other IR transparent materials are struggling with low damage threshold or transparency.

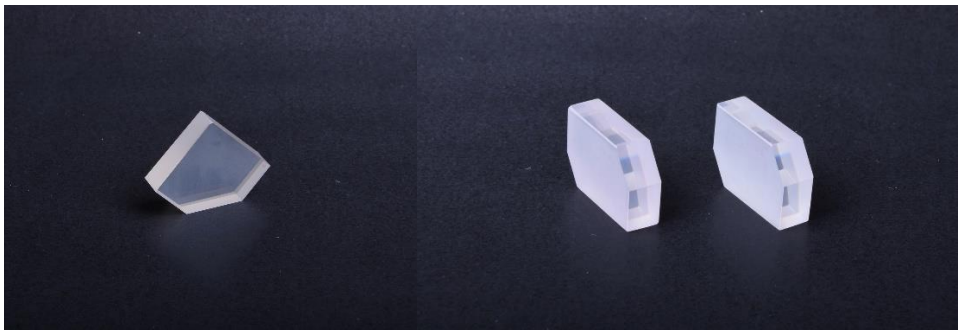

Figure 4. Calomel optical components - custom production

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

The mercury is one of a two essential atoms forming the Hg_2Cl_2 molecule (mercurous chloride) monocrystal. Crystal lattice, formed by the long linear chains of the Cl-Hg-Hg-Cl molecules, is responsible for unique physical properties. This crystalline material has its own extraordinary characteristics, such as:

- Broadband spectral range from the visible spectrum to TIR (0.38-17 μm).
- High value of birefringence (for example four times higher than Calcite, which is nowadays commonly used because of the lack of materials as good as Calomel).
- Very high indices of refraction (n_o = 1.973, n_e = 2.656).
- Extremely low velocity of elastic wave propagation (347 m/s).
- Extremely high values for acousto-optical figures of merit M_2.

---

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.)

Calomel monocrystal is a highly durable and stable compound, with almost endless lifetime cycle. When handling properly, there is zero risk of material decomposition and/or degradation. Naturally occurring crystals of Calomel are present in nature for thousands of years without any change. The only possible way of the product degradation is a mechanical damage by user, or accidental deposition to the UV/X-ray radiation. Our products are designed to be used by photonics specialist or industry engineers for simple application, however, when use is no more possible because of the above mentioned cases, Calomel parts should be dismantled and sent for proper treatment back to the manufacturer. Other parts of electronic devices (that are using Calomel) should be recycled accordingly.

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:

Electronic parts of devices using Calomel crystals may be used as spare parts, but it is beyond our company's authority. Calomel crystals with proper housing are designed for easy removal from electronic devices and thus can be reused and mounted into another device or sent back to the manufacturer in case of damage.

☒ The following parts are subsequently recycled:

At the end of its life cycle, when reuse of optical component is no longer possible because of the insufficient power/optical performance caused by inappropriate handling, Calomel pieces should be sent back to the manufacturer for appropriate ecological waste recycle process. Optical components may be used as a raw material for growing process of the new crystals, so almost zero waste is produced because of a high rate of the recycle efficiency.

☐ 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 — For pieces that are refurbished or reused, the end of their life cycle has been postponed. That stands for about half of annual production (i. e. 2,5 kg of Calomel per year, but we assume that the final figure should be lower).

☒ In articles which are recycled — The rest of the material that cannot be reused should be properly 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

In the second half of the last century, our company began a research trying to find some optically proper replacement for in optics commonly used Calcite crystal. We discovered crystalline form of mercurous halides and its astonishing optical properties, some of them enormously outnumbering above mentioned Calcite ($CaCO_3$) or other known materials. Since that time no other material with similar qualities has been discovered. Because of that, we consider looking for substitutes as ineffective.

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

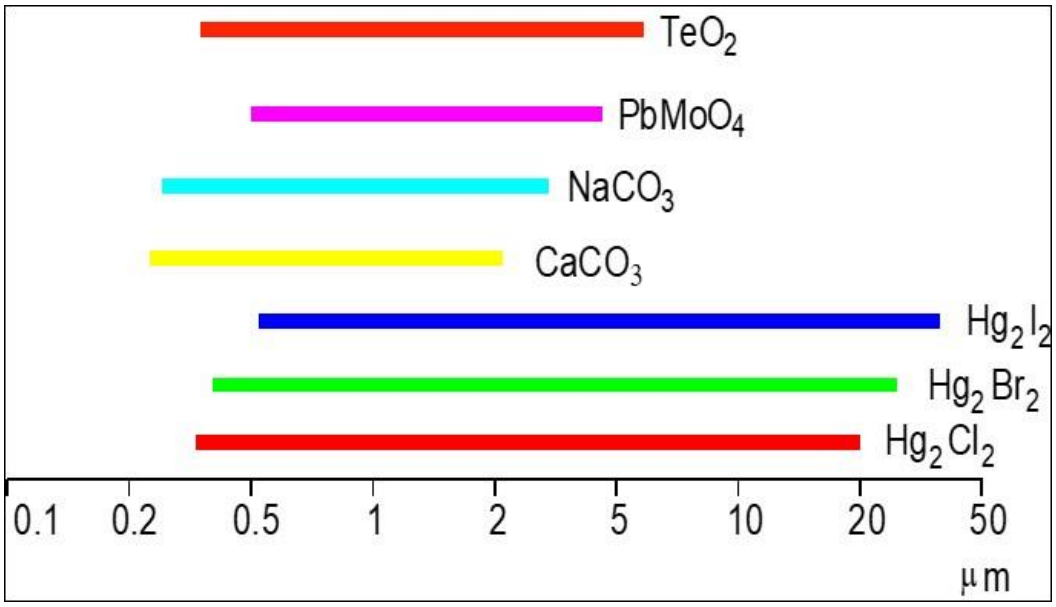

Fig. 3: Illustrative depiction of optical transmissions for different materials. Our long-term research with the participation of leading Czech Universities and European Science Institutes is used as a source. For more details, please visit our website http://www.calomel.cz/.

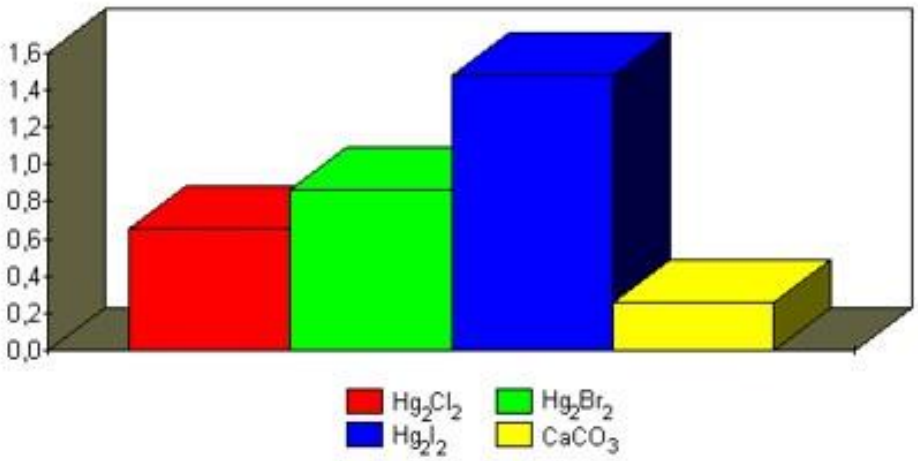

Fig. 4: Chart showing different birefringence values for mercurous halides and for the most common birefringent material – $CaCO_3$.

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.

Any actions towards developing mercury-free alternatives have not been taken, because no suitable alternatives with desired optical properties exist.

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

_____

---

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
  - ☐ Registry of intentions
- ☐ Registration

2) Provide REACH-relevant information received through the supply chain.
Name of document: EC no. 233-307-5

https://echa.europa.eu/cs/substance-information/-/substanceinfo/100.028.278

https://echa.europa.eu/cs/substance-information/-/substanceinfo/100.030.266

(B) Elimination/substitution:

1. Can the substance named under 4.(A)1 be eliminated?
   - ☐ Yes. Consequences? _____
   - ☒ No. Justification: There are no substitutions or suitable replacement on the market or in development.

2. Can the substance named under 4.(A)1 be substituted?
   - ☐ Yes.
     - ☐ Design changes:
     - ☐ Other materials:
     - ☐ Other substance:
   - ☒ No.

     Justification: There is no other optical material combining such optical properties as mercurous chloride .
3. Give details on the reliability of substitutes (technical data + information): Please see Figure 3 and Figure 4. For example, the most common material used for polarization is nowadays the limestone (or the Calcite; $CaCO_3$) with birefringence value almost as good as Calomel, but its transparency, damage threshold and other parameters essential for optical and photonic use are insufficient.
4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts: Any other substances would not provide the necessary parameters.
   2) Health impacts: As mentioned above, any other substances would not provide the necessary parameters.
   3) Consumer safety impacts: The same as mentioned above.

⇨ Do impacts of substitution outweigh benefits thereof?

Please provide third-party verified assessment on this: Not applicable to this exemption.

(C) Availability of substitutes:

a) Describe supply sources for substitutes: Not possible.

b) Have you encountered problems with the availability? Describe: Yes. It does not exist, which means it is not available.

c) Do you consider the price of the substitute to be a problem for the availability?

☐ Yes ☒ No

d) What conditions need to be fulfilled to ensure the availability? Not applicable.

(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

☐ Possible social impacts external to the EU

☐ Other: Progress of scientific research would be reduced in some sectors due to absence of suitable materials for IR polarization, acousto-optics, laser and/or microscopy devices. It would affect exploration both here on Earth and in space, too.

⇨ Provide sufficient evidence (third-party verified) to support your statement: One of the claims supporting our application could be our membership in the Czech Space Alliance. For details please see CSA website: http://www.czechspace.eu/index.php?mnItem=1.

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:

_____
