Consultation Questionnaire Exemption Annex III n. 2(b)(4)-I

Exemption for “Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg [Hg]”

Applicant

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1.- Background – About MSTECH Europe

Founded in 2017, MSTECH Europe develops and manufactures advanced backend equipment for semiconductors and electronic board assembly, including systems for handling, conformal coating, curing, depaneling, and inspection. Our mission is to deliver innovative, efficient, and environmentally sustainable solutions that exceed current technological standards, with a focus on adaptability and total cost of ownership for our clients.

In 2024, MSTECH successfully developed a mercury-free UV curing technology using multifrequency UV LED, within the framework of the MULTISMART project (**PROYECTO:** PID IDI-20230789), co-financed by the CDTI, the European Commission, and the Government of Catalonia. This initiative aimed to provide an industrial-grade alternative to mercury vapor lamps used in microelectronics and electronics manufacturing.

Through this study, a UV LED curing oven capable of curing market-standard chemistries effectively was developed and validated, demonstrating a viable and scalable alternative to mercury UV lamps.

This document outlines the technical characteristics of our multifrequency UV LED technology, and the results of comprehensive testing and comparison with traditional systems.

2.- UV LED Technology: A Modern, Viable Alternative to Mercury Lamps

2.1 Working Principle

UV LEDs are solid-state light sources that generate ultraviolet radiation through electroluminescence, a process in which electrical current passes through a semiconductor material. Electrons recombine with holes, releasing energy as photons. Unlike traditional UV lamps, such as mercury vapor lamps, UV LEDs do not rely on gas discharge or require high-voltage ignition, making them inherently safer, more energy-efficient, and faster to activate. Their compact size and low thermal output also offer significant advantages in system integration and thermal management.

One of the most important features of UV LEDs is their ability to emit light at specific, narrowly defined wavelengths. This spectral precision allows them to be tailored to match the peak absorption range of modern photo initiators, which are the active compounds in UV-curable formulations such as conformal coatings, adhesives, inks, and gels. As a result, UV LED curing systems can achieve highly efficient polymerization with less energy waste, reduced heat exposure, and improved process control—critical factors in advanced manufacturing and electronic assembly.

2.2 MSTECH's Multifrequency UV LED Lamp Development

Since most chemistries require activation at specific wavelengths, such as 395 nm, 365 nm, 275 nm, or 254 nm[1], the broad spectrum emitted by mercury bulbs is unnecessary. Instead, a well-selected combination of single-wavelength UV LEDs can effectively activate the required photo initiators.

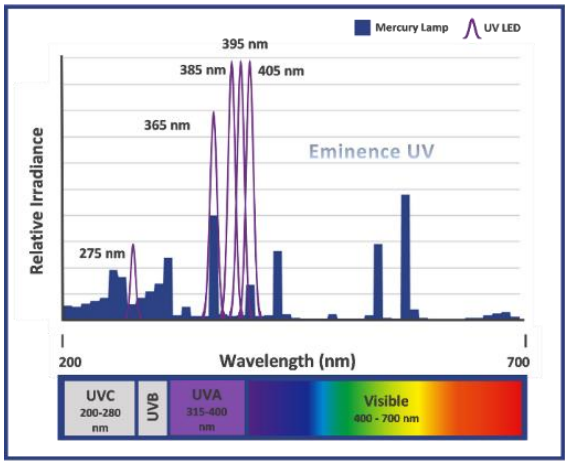

Figure 1.- Figure: Emission spectra of mercury lamp and selected UV LED: targeted LED outputs align with photo initiator activation peaks.

[1] https://www.sigmaaldrich.com/deepweb/assets/sigmaaldrich/marketing/global/documents/233/907/photoinitiators.pdf

Furthermore, there is commercial availability at competitive prices for the required UV LEDs in the market. Thus, as part of the MULTISMART project, MSTECH designed and built two types of multifrequency UV LED lamps using LEDs:

- Lamp A: 395 nm, 365 nm, 274 nm
- Lamp B: 395 nm, 365 nm, 254 nm

These wavelengths were selected based on:

- Data sheets and chemical compatibility from suppliers such as AB Chimie, Delo, Dow, Dymax, Henkel, Humiseal, Peters, and Wacker
- Experimental curing tests
- Alignment with known absorption peaks of widely-used photo-initiators

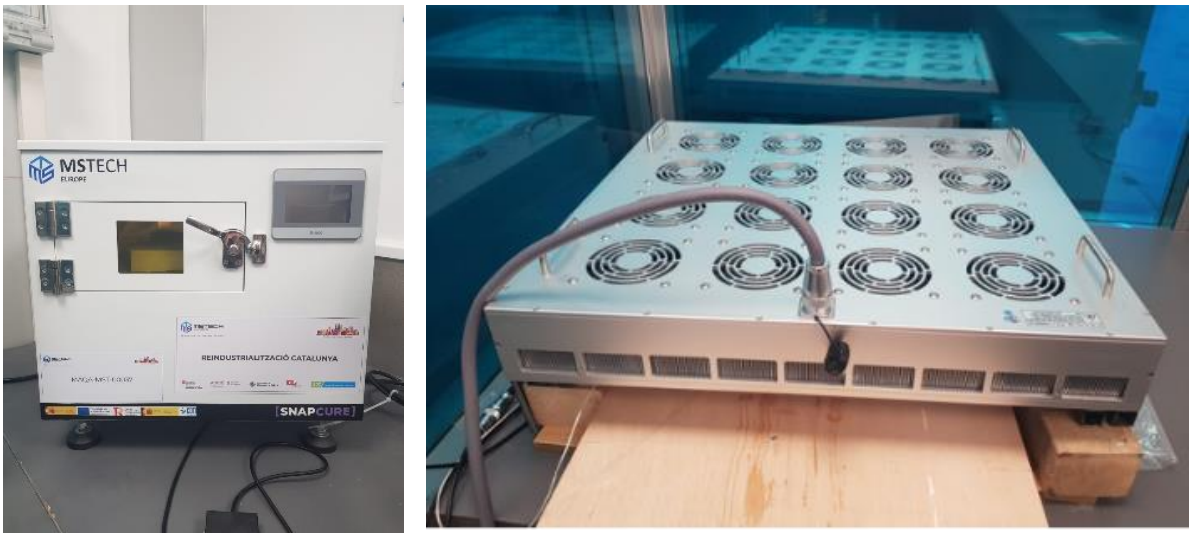

Figure 2.- Proprietary, fully functional MULTISMART UV LED curing oven developed by MSTECH.

2.3 Validation Results

We tested 25 formulations widely used in industry. All showed full curing, evaluated by the Shore D hardness and Tack-free surface qualitative test indicators.

Materials	Comment
AB Chimie 526 UV LED	Cured
AB Chimie 526 UV LED DS55	Cured
AB Chimie 836 UV LED	Cured
AB Chimie 42KUV LED	Cured
Apteklab Uvikote 7503 LM PMF	Cured
DELO GE4931	Cured
DOWSIL™ CC-8033	Cured
DOWSIL™ CC 2530	Cured
Dymax 984 LVUF	Cured
Elantas Bectron PL5621D	Cured
Elantas Bectron PT4600	Cured
Henkel LOCTITE® AA 5884	Cured
Henkel LOCTITE® 5031	Cured
Humiseal UV40led	Cured
Humiseal UV40	Cured
Humiseal UV 80	Cured
Humiseal UV 50	Cured
Humiseal UV 40 GEL	Cured
Humiseal UV 40-250	Cured
Humiseal UV 500	Cured
Peters DSL 1600 E-FLZ/150	Cured
Peters DSL 1600 E-FLZ/75	Cured
Peters 1602 FLZ/400	Cured
Peters 1602 FLZ/75	Cured
Shin-Etsu KJR 9246WS	Cured
Wacker semicosil 942 UV A / B	Cured

Table 1.- List of popular formulations effectively cured by MSTECH with UVLED technology.

To validate the effectiveness of curing with our Multifrequency UV LED oven, a comparison between the infrared (IR) absorption spectra of Humiseal UV40 samples cured using two different light sources was conducted. The spectra were obtained using the Attenuated Total Reflectance (ATR) method. One sample was cured with a traditional mercury lamp, while the other was cured with our UV LED lamp.

The results showed no significant differences in their absorption spectra, indicating similar curing performance between the mercury lamp and the Multifrequency UV LED lamp. The comparative spectra are shown below:

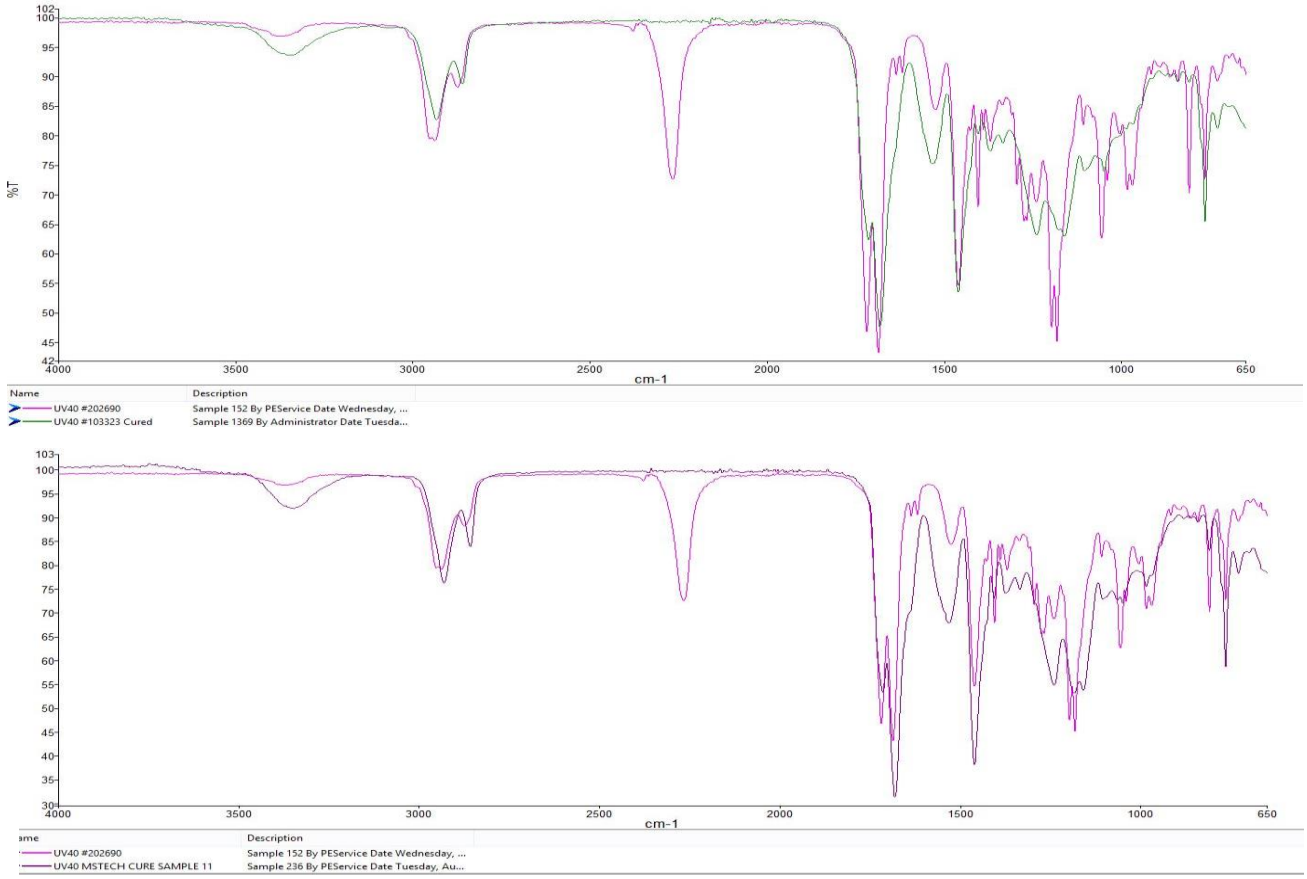

Figure 3.- Comparison of IR absorption spectra of Humiseal UV40 samples cured with a mercury lamp (blue) and a Multifrequency UV LED lamp (red), showing equivalent curing performance.

This study demonstrates that our Multifrequency UV LED lamp is a viable replacement for traditional mercury bulb lamps in curing industry-standard adhesives, gels, and coatings. As of this writing, we continue to test a wide range of chemistries based on customer requests, and our lamp is gaining increasing adoption in the market. Additionally, we have identified further potential applications, including optical bonding processes and ink curing.

3.- Advantages of UV LED over Mercury Lamps

Mercury Lamp	UV LED
Short lifespan (approx. 8,000 hours)	Extended lifespan (~20,000+ hours), equivalent to over 1,000,000 working hours
High energy consumption	5 times lower electric power consumption
High thermal output	Low temperature dissipation, suitable for sensitive components
Long startup time	Instant on/off functionality
Non-targeted spectrum	Precise wavelength emission aligned with photo-initiator absorption peaks
Bulky system design	Reduced machine layout, space saving by 2/3
Higher operational costs and maintenance requirements	Minimal maintenance and lower investment costs
Limited compatibility with new PCB formats	Compatible with next-gen PCB designs, such as large-format powertrain PCBs and large-scale semiconductor manufacturing
Safety and regulatory risks	Safer handling and transport, reduced compliance and health liabilities
High end-of-life costs, complex disposal	Low-cost and simple end-of-life recycling

Furthermore, leading chemical manufacturers are now formulating UV-curable materials with single photo initiators optimized for narrow-band UV LED wavelengths at 365 nm or 395 nm. This shift demonstrates the industry's recognition of the advantages and sustainability of UV LED curing technology.

With both lamp hardware and chemistry now aligned, UV LED systems increasingly represent a viable and scalable alternative to mercury-based curing. This convergence strongly supports the phase-out of mercury lamp exemptions under current environmental regulations and promotes the adoption of cleaner, safer, and more efficient technologies in electronics manufacturing.

4.- Conclusion

The research and testing conducted demonstrate that multifrequency UV LED technology is a technically viable and environmentally sustainable alternative to traditional mercury lamps for curing industry-standard chemical formulations in electronics manufacturing. The lamps developed by MSTECH have shown equivalent curing performance, superior energy efficiency, significantly longer lifespan, and much lower heat emission and environmental impact.

Furthermore, advancements in chemical formulations optimized for specific UV LED wavelengths confirm the maturity of this technology and its growing market adoption. In this context, maintaining the exemption for mercury lamps may no longer be technically justified and poses unnecessary environmental risks.

Therefore, we strongly recommend the progressive withdrawal of the exemption under Annex III 2(b)(4)-I for mercury lamps, encouraging immediate replacement with UV LED systems. This action will support the transition to cleaner, more efficient, and safer technologies, aligning with European environmental goals and enhancing long-term industrial competitiveness.

5.- Questions & Answers

Q: Do you agree with the arguments put forward by the applicants? Are there any additional reasons that support the requested extension of the exemption?
A: • I do not agree with the arguments for the extension.

Q: In your opinion, what reasons oppose the requested extension of the exemption?
A: • There are affordable and effective alternative curing solutions available on the market, including both single- and multi-frequency UV LED technologies.
• Chemical manufacturers have already developed formulations that are fully compatible with UV LED curing systems.

Q: For which specific applications are LED retrofit or conversion lamps already available? Could these applications be grouped together?
A: • Group [3]: curing, polymerisation, and similar industrial processes.
• I am not certain whether further grouping is possible or appropriate.

Q: Does the grouping of applications proposed by the applicants –
[1] colour applications (including decorative applications, photographic darkroom, clean room lighting),
[2] food and horticulture pest management,
[3] curing, polymerisation, etc.,
[4] lamps for explosion-proof luminaires in areas with a higher risk of fire or explosion, special visibility task lighting, and
[5] medical and phototherapy – make sense in your view, or do you have an alternative proposal that could appropriately limit the scope of the existing exemption?
A: • I do not have an alternative grouping proposal. The grouping suggested by the applicants appears reasonable.

Q: How would you rate the availability of LED lamps (both for retrofitting existing installations and for new installations) in the defined groups?
A: •For Group 3 (curing and polymerisation), I would rate LED lamp availability as fully sufficient and commercially mature.

Q: Are there any other aspects that you believe should be considered when assessing this application? Please provide relevant documents and evidence.
A: • No additional aspects at this time.