

Brussels, XXX  
[...] (2023) XXX draft

**COMMISSION DELEGATED DIRECTIVE (EU) .../...**

**of XXX**

**amending Directive 2011/65/EU of the European Parliament and of the Council as regards an exemption for cadmium in downshifting quantum dots directly deposited on LED semiconductor chips**

(Text with EEA relevance)

*This draft has not been adopted or endorsed by the European Commission. Any views expressed are the preliminary views of the Commission services and may not in any circumstances be regarded as stating an official position of the Commission.*

## EXPLANATORY MEMORANDUM

### 1. CONTEXT OF THE DELEGATED ACT

This Commission Delegated Directive amends, for the purpose of adapting to technical and scientific progress, Annex III to Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment ('the RoHS Directive')<sup>1</sup> as regards an exemption for specific applications containing cadmium.

Article 4 of the RoHS Directive restricts the use of certain hazardous substances in electrical and electronic equipment (EEE). Currently, 10 substances are restricted and listed in Annex II to the Directive: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDEs), bis(2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP) and diisobutyl phthalate (DIBP).

Annexes III and IV to the RoHS Directive list the materials and components of EEE for specific applications exempted from the substance restrictions in Article 4(1) of the Directive. Article 5 allows Annexes III and IV to be adapted to scientific and technical progress (on the granting, renewing and revoking of exemptions). Under Article 5(1)(a), exemptions are to be included in Annexes III and IV only if this does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006 ('the REACH Regulation')<sup>2</sup> and if any of the three conditions below are met:

- if the elimination or substitution via design changes or materials and components that do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable;
- if the reliability of substitutes is not ensured;
- if the total negative environmental, health and consumer-safety impacts of substitution are likely to outweigh the total environmental, health and consumer-safety benefits.

Decisions on exemptions, and their duration, must take into account the availability of substitutes and the socio-economic impact of substitution. Decisions on the duration of exemptions must take into account any potential impact on innovation. Life-cycle thinking on the overall impact of the exemption must apply, where relevant.

Article 5(1) of the RoHS Directive allows the Commission to include materials and components of EEE for specific applications in the lists in Annexes III and IV by means of individual delegated acts pursuant to Article 20. Article 5(3) and Annex V lay down the procedure for submitting exemption applications.

The Commission receives many requests from businesses to grant or renew exemptions according to Article 5(3) and Annex V to the RoHS Directive.

In October 2017, by Commission Delegated Directive (EU) 2017/1975, exemption 39(a) replaced the previous exemption 39 in Annex III to the RoHS Directive<sup>3</sup>. Exemption 39(a) concerns the use of

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<sup>1</sup> OJ L 174, 1.7.2011, p. 88.

<sup>2</sup> Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and establishing a European Chemicals Agency (OJ L 396, 30.12.2006, p. 1).

<sup>3</sup> OJ L 281, 31.10.2017, pp. 29-31

cadmium selenide in downshifting cadmium-based semiconductor nanocrystal quantum dots (QDs) for use in display lighting applications. The expiry date was set for 31 October 2019<sup>4</sup>.

In September 2017 and in April 2018, within the timeframe for renewal laid down in Article 5(5) of the RoHS Directive, the Commission received three requests to amend the scope and to prolong the duration of exemption 39(a) in Annex III. According to Article 5(5), the existing exemption remains valid until a decision on the renewal application is taken by the Commission. The exemption requests differed in their applied configuration of QDs as well as in the application area. The three exemption requests concerned respectively:

- (a) the use of cadmium (<1 000 ppm) in luminescent material for on-chip application on light-emitting diode (LED) semiconductor chips for use in lighting applications of a colour rendering index of at least 80 for a validity period of 5 years;
- (b) the use of cadmium in downshifting semiconductor nanocrystal QDs directly deposited on LED chips for use in display and projection applications (< 5µg cadmium per mm<sup>2</sup> of LED chip surface) for a validity period of 5 years;
- (c) limiting the cadmium concentration by amending the existing exemption (<0.1 µg per mm<sup>2</sup> of display screen area) and prolonging it until 31 October 2021.

## 2. CONSULTATIONS PRIOR TO THE ADOPTION OF THE ACT

To evaluate these renewal applications, the Commission launched a study in December 2017<sup>5</sup> to carry out the required technical and scientific assessment. The study, which included an eight-week public consultation, was published in January 2021. Information about the consultation was provided on the project website<sup>6</sup>. Five stakeholders provided comments in the consultation and their contributions were taken into account in the technical assessment report.

The Commission presented the results of the study in a meeting of experts from Member States under the RoHS Directive on 23 February 2021<sup>7</sup>. Some experts expressed their disagreement with the report's conclusions on the criteria set out in Article 5 of the RoHS Directive. In particular, these experts considered that the benefits of granting an exemption would not outweigh the negative impacts consisting of not substituting cadmium in the applications concerned. The assessment results were subsequently reviewed by the Commission considering the comments and open questions. On 6 April 2022, the Commission presented reviewed conclusions and invited comments on these conclusions from the Member State experts. These comments from Member State experts were similar to the previous comments and emphasised that this sector of the market was very dynamic. A follow-up study to update the information on the use of QD applications in displays and lighting was prepared and published in December 2022<sup>8</sup>.

The Commission prepared a draft delegated directive and made it available to the public for 4 weeks. [No contributions were received and no substantial changes to the draft act were required.]

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<sup>4</sup> OJ L 285, 1.11.2017, pp. 32-32.

<sup>5</sup> Final Report of the study (Pack 15 Task 5) is available at <https://op.europa.eu/en/publication-detail/-/publication/afa12b2f-5a0a-11eb-b59f-01aa75ed71a1/language-en/format-PDF/source-187695217>.

<sup>6</sup> Consultation period: 18 March 2019 until 13 May 2019 <https://rohs.exemptions.oeko.info/>.

<sup>7</sup> <https://ec.europa.eu/transparency/expert-groups-register/screen/meetings/consult?lang=en&meetingId=23745&fromExpertGroups=true>.

<sup>8</sup> Study to update the information on the use of cadmium in quantum dot applications for displays and lighting under Directive 2011/65/EU – Final report is available at <https://op.europa.eu/en/publication-detail/-/publication/ac232efe-76ad-11ed-9887-01aa75ed71a1/language-en/format-PDF/source-277797051>.

All necessary steps relating to exemptions from the substance restriction pursuant to Articles 5(3) to 5(7) have been taken<sup>9</sup>. The Council and the European Parliament were notified of all activities.

### Technical evaluation

Cadmium (typically based on cadmium selenide or cadmium sulphide) can be used in materials that convert blue LED light into narrow emission spectra, so-called downconverters. Cadmium-containing downconverters lead to fewer losses in the spectral non-visible infrared range than cadmium-free downconverters. This means that cadmium-containing downconverters can result in light sources with lower waste heat and thus be more energy efficient. Because these converters owe these improved properties to particles of a few nanometres in size, they are also called quantum dots (QDs).

The exemption requests concern cadmium-based QDs in LEDs for **display applications** and **lighting applications** (solid-state lighting). Solid-state lighting applications are not covered by the existing exemption 39(a) in Annex III of the RoHS Directive. The pace of development in new lighting and display applications is very fast, and in recent years many applications were replaced by alternatives which comply with the RoHS Directive.

There are different ways to implement QD technology in display or lighting applications. ‘On-edge technology’ incorporates QDs into a remote component situated in close proximity to the LED chips. In ‘on-surface technology’, the QDs are encapsulated in a film that covers the complete display area. In ‘on-chip technology’, the QDs are placed directly on the LED surface, encapsulated within its LED package.

The on-chip configuration requires the lowest amount of cadmium-based QD material in applications, and therefore uses the lowest amount of cadmium. The on-edge configuration is the next most efficient in its use of cadmium-based QD material, while the on-surface configuration requires the highest amount – relatively – of cadmium-based QD material.

The following three developments must be taken into account.

- i. It is understood that **on-edge applications** have become obsolete on the market.
- ii. The exemption request under (c) covers **on-surface applications** of cadmium QD in displays. Cadmium-free QD alternatives are more developed in on-surface configurations than in on-chip configurations and are already available on the market and sufficiently reliable. In addition, cadmium QD below 100 ppm of cadmium are also available, which is below the threshold value for cadmium in Annex II of the RoHS Directive. The argument previously was that on-surface cadmium QD applications have superior energy efficiencies compared to cadmium-free applications. However, the market availability of similar or better-performing cadmium-free alternatives on the QD level is confirmed. In conclusion, the criteria for an exemption are not met.
- iii. The exemptions requested under applications (a) and (b) can be subsumed under the configuration ‘on-chip’. For **on-chip applications**, the market availability of cadmium QD LED can be distinguished between lighting and display applications, both of which are discussed in the sections below.

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<sup>9</sup> A list of the required administrative steps is available on the [Commission website](#). The current stage of the procedure can be viewed for each draft delegated act in the Interinstitutional Registry of Delegated Acts at <https://webgate.ec.europa.eu/regdel/#/home>.

## Lighting applications

Application (a) covers **lighting applications**, which are not in the scope of the current exemption 39(a). For lighting applications, RoHS-compliant alternatives on the level of colour-conversion material or QD with cadmium below 100 ppm are available on the market and considered reliable. However, for the high-quality light segment in particular, the cadmium QD LED can have higher energy efficiencies than those of RoHS-compliant alternatives. For example, a cadmium QD LED with less than 100 ppm cadmium (RoHS-compliant) has roughly 10% greater energy consumption than cadmium QD LEDs with 400-800 ppm cadmium.

On the question of end-of-life environmental impact, cadmium LED packages within the LED lamp might be disposed of together with fluorescent lamps, other non-fluorescent lamps, or other EEE in which they are incorporated. Parts of cadmium LED packages may also be improperly disposed of in household waste or in other inappropriate ways. The applicant has not provided sufficient information about the fate of the cadmium in the material streams.

It can be concluded that the potential benefits in terms of energy efficiency of granting an exemption would not outweigh the negative impacts of using the restricted substances. This also considers that the whereabouts of the remaining cadmium from waste EEE in the material cycle is precarious, i.e. it might hamper future recycling. In light of the rapid developments in technology in the sector, granting a new exemption for cadmium-containing applications in the market gives the wrong signal for research and development and would run counter to policies aiming at clean material cycles.

## Display applications

For **display applications**, RoHS-compliant alternatives exist on the device and colour-conversion material level for most of the established technologies. For some new technologies, like **micro displays**, no market-ready cadmium-free alternatives or configuration alternatives that are as reliable as cadmium QD on-chip configurations currently exist. The development of such alternatives might take an additional 4-5 years, so alternatives for these specific cadmium QD applications might not be available until the end of 2027.

Technologies that use on-chip configuration require in total much less cadmium per device than technologies using on-surface configuration, which is still covered under the existing exemption 39(a) in Annex III. This means that using less than 100 ppm of cadmium under the on-surface configuration can result in more cadmium per device than using more than 100 ppm under on-chip configurations. Consequently, to avoid unnecessary cadmium in display applications, in particular for **liquid crystal displays** (LCDs), the maximum amount of cadmium per device should be limited under a new exemption. In this way, the positive environmental impact of reducing the total amount of cadmium and the beneficial energy efficiency of the technology outweighs the negative impacts by a total substitution.

It is assumed that cadmium LED packages in LED screens would be mainly disposed of together with the screen or monitor. However, no sufficient data were provided on the end-of-life stage. It is assumed that the end-of-life of the cadmium QD LEDs does not conform to the objectives of the circular economy action plan<sup>10</sup>. One problem is the risk of adverse impacts on the environment and human health from cadmium in QD LEDs when they are not properly disposed of. The other problem is that recyclers do not have established processes that are capable of extracting and recycling cadmium from LED chips. In order to minimise the risk, Commission Regulation (EU)

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<sup>10</sup> COM/2020/98 final.

2019/2021<sup>11</sup> stipulates that electronic displays with a screen panel in which concentration values of cadmium by weight in homogeneous materials exceed 0.01% must be labelled with the ‘Cadmium inside’ logo.

## Conclusions

The technical evaluation study mentioned that granting an exemption for cadmium QD might have positive impacts on innovation, e.g. in the miniaturisation of products. On the other hand, it could also potentially slow down the development of cadmium-free alternatives for lighting and display applications on the market, and for this reason the innovation argument does not favour continued use of cadmium.

The first requirement for granting an exemption is stipulated in Article 5(1)(a) of Directive 2011/65/EU. According to this threshold requirement, the use of cadmium in lighting and displays must not weaken the environmental and health protection afforded by the REACH Regulation, mainly by authorisations and restrictions under that Regulation. An exemption for cadmium in QD for LED applications does not weaken the environmental and health protection afforded by the REACH Regulation.

One of the objectives of the chemicals strategy for sustainability<sup>12</sup> is to minimise the presence of substances of concern in products, in particular in electronics, and to ensure that new materials should be sustainable. Granting an exemption by expanding the scope for a newly developed product (lighting applications in this case) containing a restricted substance would give the wrong signal to industry. Even though the industry is in general making an effort to phase out cadmium applications, no substitution plan was provided for the requested applications.

In conclusion, it is not recommended to expand the scope of the exemption as requested under application (a). Instead, the scope of the exemption should be limited to applications that cannot be replaced by cadmium-free alternatives. Consequently, the lighting applications are not to be included. Application (b) meets the criteria for granting an exemption if the scope is further limited to certain technologies for display applications. Thus, a maximum concentration of cadmium per device (i.e. per display screen) will be laid down.

According to Article 5(5), subparagraph 2 of Directive 2011/65/EU, the existing exemption remains valid until a decision on the renewal application is taken by the Commission.

### 3. LEGAL ELEMENTS OF THE DELEGATED ACT

The act amends an exemption from the substance restrictions in Annex II of Directive 2011/65/EU, to be listed in Annex III, for cadmium-based QDs for use in display applications, by narrowing down its scope. The requested exemption (b) meets the second and third criterion of Article 5(1)(a). The reason is that, for most technologies, substitution and elimination are technically practicable and reliable alternatives exist. The only exception to this is recently developed technologies which cannot be currently replaced with reliable alternatives. By limiting the maximum amount of cadmium per device, some display applications benefit from greater energy efficiency and the total amount of cadmium is reduced, which results in greater environmental benefits that outweigh the negative impacts caused of substitution. Thus, these technologies should be covered by the new exemption, under a new entry 39(b).

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<sup>11</sup> OJ L 315 5.12.2019, p. 241.

<sup>12</sup> COM(2020) 667 final.

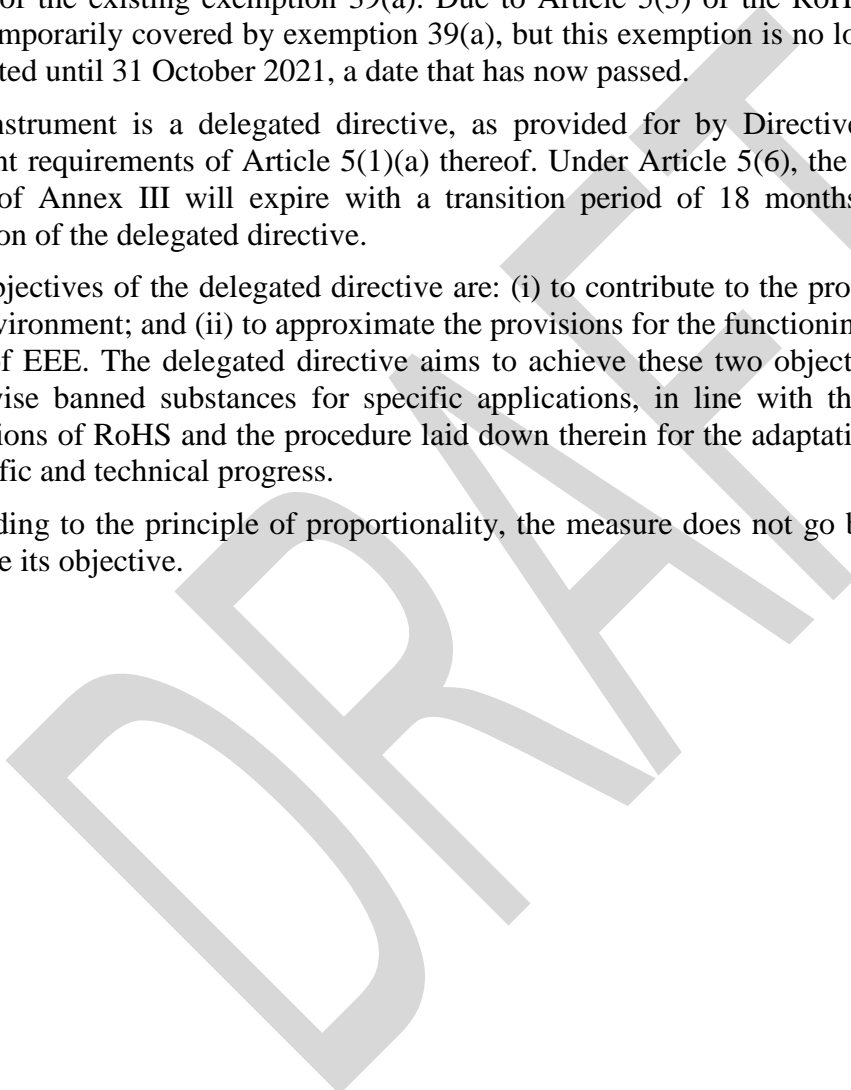
Exemption request (a) for cadmium-based QDs for use in lighting applications is rejected, as none of the conditions for justifying an exemption is met. Consequently, no corresponding entry is added. It is technically and scientifically practicable to manufacture reliable cadmium-free or RoHS-compliant QDs. Even if cadmium QDs in lighting applications might show better energy performance than cadmium-free or RoHS-compliant QDs, it could not be shown that this improved performance is significant. Thus, using cadmium QDs in lighting applications does not outweigh any such negative impacts of substitution. The slightly lower energy performance of compliant alternatives does not justify an exemption from the substance restriction for cadmium.

A decision on exemption request (c) became obsolete. The requested application scope includes the scope of the existing exemption 39(a). Due to Article 5(5) of the RoHS Directive, the application was temporarily covered by exemption 39(a), but this exemption is no longer necessary having been requested until 31 October 2021, a date that has now passed.

The instrument is a delegated directive, as provided for by Directive 2011/65/EU, meeting the relevant requirements of Article 5(1)(a) thereof. Under Article 5(6), the existing exemption in entry 39(a) of Annex III will expire with a transition period of 18 months following the date of the adoption of the delegated directive.

The objectives of the delegated directive are: (i) to contribute to the protection of human health and the environment; and (ii) to approximate the provisions for the functioning of the single market in the field of EEE. The delegated directive aims to achieve these two objectives by allowing the use of otherwise banned substances for specific applications, in line with the provisions and under the conditions of RoHS and the procedure laid down therein for the adaptation of Annexes III and IV to scientific and technical progress.

According to the principle of proportionality, the measure does not go beyond what is necessary to achieve its objective.



COMMISSION DELEGATED DIRECTIVE (EU) .../...

of **XXX**

**amending Directive 2011/65/EU of the European Parliament and of the Council as regards an exemption for cadmium in downshifting quantum dots directly deposited on LED semiconductor chips**

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment<sup>1</sup>, and in particular Article 5(1), point (a), thereof,

Whereas:

- (1) Article 4(1) of Directive 2011/65/EU requires Member States to ensure that electrical and electronic equipment placed on the market does not contain the hazardous substances listed in Annex II to that Directive. That restriction does not apply to certain exempted applications listed in Annex III to that Directive.
- (2) Cadmium is a restricted substance listed in Annex II to Directive 2011/65/EU. The maximum tolerated concentration value is 0,01% by weight of cadmium in homogenous materials.
- (3) By Delegated Directive (EU) 2017/1975<sup>2</sup>, the Commission granted an exemption for the use of cadmium selenide in downshifting semiconductor nanocrystal quantum dots for use in display lighting applications ('the current exemption'), which is listed in entry 39(a) of Annex III to Directive 2011/65/EU. The exemption was to expire on 31 October 2019.
- (4) On 29 September 2017, 29 April 2018 and 30 April 2018, the Commission received applications for amending the current exemption ('the applications'), that is within the time limit laid down in Article 5(5) of Directive 2011/65/EU. In accordance with Article 5(5), second subparagraph, of Directive 2011/65/EU, an exemption remains valid until a decision on the renewal application has been taken.
- (5) The evaluation of the applications, which took into account the availability of substitutes and the socioeconomic impact of substitution, included a technical and scientific assessment study<sup>3</sup> and a follow-up study<sup>4</sup>. The evaluation also included

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<sup>1</sup> OJ L 174, 1.7.2011, p. 88.

<sup>2</sup> Commission Delegated Directive (EU) 2017/1975 of 7 August 2017 amending, for the purposes of adapting to scientific and technical progress, Annex III to Directive 2011/65/EU of the European Parliament and of the Council as regards an exemption for cadmium in colour converting light-emitting diodes (LEDs) for use in display systems (OJ L 281, 31.10.2017, p. 29).

<sup>3</sup> Assessing three exemption requests for the use of cadmium in quantum dot applications in displays and lighting – Study to support the review of the list of restricted substances and to assess a new exemption



stakeholder consultations in accordance with Article 5(7) of Directive 2011/65/EU. The comments received during those consultations were made publicly available on a dedicated website.

- (6) The current exemption does not distinguish between different configurations regarding the way the cadmium-based material is embedded in the quantum dot. The evaluation found that applications with the so-called on-edge and on-surface configurations no longer meet the conditions set out in Article 5(1), point (a), of Directive 2011/65/EU. The so-called on-chip configuration requires the lowest amount of cadmium and shows better performance levels.
- (7) The evaluation further concluded that alternatives to ‘on-chip’ technology applicable in lighting applications are currently available that are reliable and that achieve similar performance levels. For those applications, the evaluation concluded that the benefits of an exemption would not outweigh the negative environmental, health and consumer safety impacts thereof. The conditions set out in Article 5(1), point (a), of Directive 2011/65/EU are therefore not met for the ‘on-chip’ technology applicable in lighting applications.
- (8) The evaluation further concluded that many alternatives to ‘on-chip’ technology applicable in display applications are currently available, however, for some specific technologies, such as micro displays, no reliable alternative currently exists. For those specific display applications, even though substitutes are under development, the condition set out in Article 5(1), point (a), second indent, of Directive 2011/65/EU is met, namely that the reliability of substitutes is not ensured.
- (9) ‘On-chip’ configuration can also result in less cadmium per device, in particular for liquid crystal displays, compared to ‘on-surface’ configurations, which uses less than 0,01 % by weight of cadmium in homogenous material. Due to greater energy efficiency and lower use of total cadmium, the environmental benefits outweigh the total negative environmental, health and consumer safety impacts caused by a substitution of cadmium. The limited scope of the exemption sought in the applications, in the form of a maximum concentration of cadmium per device, would ensure that less cadmium is placed on the market than under the current exemption. The condition set out in Article 5(1), point (a), third indent, of Directive 2011/65/EU is therefore fulfilled. The exemption is consistent with Regulation (EC) No 1907/2006 of the European Parliament and of the Council<sup>5</sup> and does not weaken the environmental and health protection afforded by it.
- (10) It is therefore appropriate to grant the exemption for cadmium in downshifting semiconductor nanocrystal quantum dots directly deposited on LED semiconductor

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request under RoHS (RoHS Pack 15 - Task 5, final), November 2020 <https://op.europa.eu/en/publication-detail/-/publication/afaf12b2f-5a0a-11eb-b59f-01aa75ed71a1/language-en/format-PDF/source-187695217> .

<sup>4</sup> Study to update the information on the use of cadmium in quantum dot applications for displays and lighting under Directive 2011/65/EU Final Report, November 2022 <https://op.europa.eu/en/publication-detail/-/publication/ac232efe-76ad-11ed-9887-01aa75ed71a1/language-en/format-PDF/source-277797051>

<sup>5</sup> Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

chips for use in display and projection applications. It is expected that alternatives for those cadmium quantum dot applications might be available by the end of 2027. Both positive effects on innovations (e.g. miniaturisation) as well as negative effects on innovation (e.g. fewer incentives for the development of cadmium free alternatives) are taken into account here. It is therefore appropriate to limit the duration of the exemption until that date in accordance with Article 5(2) of Directive 2011/65/EU.

(11) An expiry date for the current exemption should be set in accordance with Article 5(6) of Directive 2011/65/EU. In order to allow sufficient time for industry and in view of global supply chains for such products, it is appropriate to set the maximum possible expiry date of 18 months following the decision for the current exemption.

(12) Directive 2011/65/EU should therefore be amended accordingly,

HAS ADOPTED THIS DIRECTIVE:

#### *Article 1*

Annex III to Directive 2011/65/EU is amended as set out in the Annex to this Directive.

#### *Article 2*

1. Member States shall adopt and publish by [OP: please insert the last day of the 6<sup>th</sup> month after the date of entry into force of this Directive] at the latest, the laws, regulations and administrative provisions necessary to comply with this Directive. They shall forthwith communicate to the Commission the text of those provisions.

They shall apply those provisions from [OP: please insert the last day of the 6<sup>th</sup> month after the date of entry into force of this Directive + 1 day].

When Member States adopt those provisions, they shall contain a reference to this Directive or be accompanied by such a reference on the occasion of their official publication. Member States shall determine how such reference is to be made.

2. Member States shall communicate to the Commission the text of the main provisions of national law, which they adopt in the field covered by this Directive.

#### *Article 3*

This Directive shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

#### *Article 4*

This Directive is addressed to the Member States.

Done at Brussels,

*For the Commission*  
*The President*  
*Ursula von der Leyen*