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Do light-emitting diodes (LED) bulbs contain potentially hazardous constituents?

Requested by Local Hazardous Waste Management Program in King County

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Key Findings

- Currently, LEDs are not classified as hazardous waste and are disposed of in regular landfills.
- There are many different designs and colors of LED lights, with an array of different constituents. Without disclosure from manufacturers, it may be very difficult to determine which bulbs may contain hazardous constituents.
- A 2010 study, conducted by the University of California (UC) used standard leachability tests to determine if certain LEDs should be categorized as a hazardous waste under current United States federal and California state regulations. (A second objective of this study was to evaluate hazards and resource depletion of earth metals used in production of LEDs, but this is not discussed further here). The study did find numerous metallic toxicants in crushed samples from different LED light sources (not the entire assembled LED product), and certain bulbs were found to contain metals in concentrations high enough to be categorized as hazardous waste under certain regulatory limits [1].
- Potential human or environmental exposure from constituents of LED bulbs could come from occupational exposure to constituents or blue light and glare, landfill leachate (after bulbs are discarded to landfills), bulb breakage, and potential misuse activities such as a child ingesting a bulb because it looks like a small, colorful piece of candy, or potential stress to the retina from blue-light and glare from LEDs [1,2,3,4].
- No conclusive research was found comparing the potential exposure risk and environmental fate of chemicals released from LED bulbs vs. fluorescents bulbs (containing mercury).

Summary

The market for LED lighting has increased over the past 10 years, and they are being used for numerous applications such as exit signs, traffic lights, decorative lighting, and office or task lighting for small areas. LEDs are advertised as environmentally friendly because they are energy efficient and they offer a mercury-free alternative to fluorescent lamps, in a growing number of uses and applications. Currently, LEDs are not classified as hazardous and are disposed of in regular landfills.

Even though LEDs are free of mercury, they do contain other metals. The principle of LED lighting evolved from semiconductor manufacturing, and LED chips may contain typical semiconductor metals [1] and other metals. The types of metals, in varying quantities, that may be present in the LED chips or circuitry, are primarily arsenic, copper, nickel, lead, iron, gold, silver, gallium, indium, antimony, and aluminum. The metals present in a bulb may be dependent upon the brand or manufacturer, color, and intensity.

The UC study tested nine different commercially available LED bulbs, all 5mm, pin-type LEDs, of differing hues and intensities, using standard leachability tests. Researchers found that the low-intensity red LEDs contained

a high lead content (up to eight times the amount of lead allowed under California law), and in general, high-intensity, brighter bulbs contained more contaminants than lower ones [1].

Under federal standards, the only LED that tested hazardous was a low-intensity red LED, which leached lead at levels exceeding regulatory limits. However, under California regulations, excessive levels of copper, lead, nickel, and silver, were found in all bulbs except low-intensity yellow LEDs.

The concluding remarks of this study suggest establishing benchmark levels of metals to minimize their use in LEDs, improving recycling and recovery for spent bulbs, improving occupational safety associated with manufacture of bulbs, designing products with alternatives, and informing policymakers about waste management needs. One author of the UC study (Ogunseitan) suggests using precaution during cleanup of bulbs that break at a residence or workplace, or in a vehicle accident.

Because of the limited scope of this study, and the fact that subcomponents of LED bulbs were used, and the vast number of different LED bulbs and composition of available bulbs, many suggest carefully reviewing the study details prior to jumping to conclusions that the use or disposal of LEDs present significant hazards [3,4].

At least one red-hue LED is made from aluminum gallium arsenide (AGA), a common material used in semiconductor fabrication. Little information exists about adverse health impacts that workers who are exposed to these particles face, but increased use of AGA has raised concern regarding occupational exposure because it has been scientifically proven to be toxic to animals [5,6].

ANSES, the French Agency for Food, Environmental and Occupational Health & Safety, has published a report (in French), discussing the potential visual health effects of LED lighting. A translation of this article [5] states that the issues of most concern are due to the “toxic effect of blue light and the risk of glare."

The potential for retina or eye harm from an LED, like any other lamp, is determined by the built-in protection of the product, and also the precautions taken by the viewer (proximity, looking into the light, time), and the type and luminance of the lamp. Dr. Roberts, director of Macular Degeneration Support, a nonprofit organization based in Missouri, advises to avoid gazing up close into a light box of blue or white LEDs for longer than 100 seconds and less for those with macular degeneration [7].

Conclusions:

The LED industry is maturing, LED designs are evolving, and LED lighting offers significant advantages in energy efficiency. There are potential concerns with retinal exposure to the light itself, and to constituents in some LED bulbs (containing toxic metals) if they are not handled or managed properly.

No conclusive research was found comparing the potential exposure risk and environmental fate of chemicals released from LED bulbs vs. fluorescents bulbs (containing mercury).

LED lighting systems should be designed as safe as possible and guidelines should be disseminated on the manufacture, use, and disposal of spent or broken LED products.

From a regulatory standpoint, it may be challenging to begin classifying LEDs (as a whole) as hazardous waste because only certain brands or types may contain sufficient concentration to be characterized as hazardous waste.

References:

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Additional Information:

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