International Institute for Sustainable Laboratories®

Technical Bulletin: Expanded Polystyrene Use in Laboratories

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Introduction

This guide proposes strategies to reduce the use of expanded polystyrene (EPS) foam containers and packaging in laboratories and the greater scientific sector due to their negative environmental, social, and public health impacts.

Guide Summary and Purpose

The Laboratory Waste Landfill Diversion Working Group (LDWG) of the International Institute for Sustainable Laboratories (I²SL) exists to create avenues for landfill diversion of laboratory material waste by communicating with suppliers and purchasers of laboratory products. EPS is prolific in laboratory spaces and presents particular challenges to diversion when compared to other products. Due to its recognized adverse impacts, many municipalities have enacted legislation banning EPS (Ivanova, 2019; Martinelli, 2018), but most of these policies focus on food ware and exempt laboratory use. In this document, we argue for reduced use of EPS in laboratories despite these exemptions. We provide an overview of the many issues associated with EPS packaging products, discuss innovative work being done to minimize their use and impact, and provide recommendations, strategies, and tools for both suppliers and purchasers to reduce the use of this material.

Why Focus on EPS?

From disposable coolers used in cold transport shipments to conical tube trays, EPS packaging is ubiquitous in laboratory spaces. While this material does provide some benefits—it is cost effective, lightweight, sturdy and provides reliable insulation—the environmental and health costs greatly overshadow its convenience. Furthermore, laboratory professionals and scientists have consistently indicated that EPS is a challenging waste stream that could benefit from innovation.

A Note about Terminology: EPS Foam and Styrofoam™

EPS foam products are often erroneously referred to by the name "styrofoam." Styrofoam is a trademarked brand of a type of extruded polystyrene foam used as building insulation (DuPont, 2020). Throughout this document, we use the acronym EPS or write out expanded polystyrene with some exceptions. When referencing a program or document that uses the term "styrofoam" to refer to EPS products, we use their terminology.

EPS is a fossil fuel product that is made from the crude oil refinery monomer styrene (Omnexus, n.d.). In addition to the environmental impacts associated with its disposal, like other waste products, EPS is part of a long supply chain that creates greenhouse gas emissions, pollution, waste, and social justice concerns at resource extraction and manufacturing stages (Bekin et al., 2007).

Most polystyrene products are designed to be single use. Although in a laboratory certain EPS items (such as coolers) might be reused a few times, it is a material destined to quickly become a waste product. And, while possible in some markets to be reused and recycled, the logistics can be challenging, as we describe in greater detail in the Challenges With Reuse and Issues with Recycling sections.

Background: EPS Impacts on Environment and Health

Environmental Impacts

In disposal, EPS becomes a pernicious environmental hazard. Because it is light and bulky, EPS is more likely than other forms of waste to blow away and become litter. Once in the natural environment, EPS can be ingested by animals, which can result in adverse health effects and death (Turner, 2020; Wilcox et al., 2016). EPS also makes up a large portion of marine plastic pollution (Gallo et al., 2018; Ocean Conservancy, 2017) and its leachate has been found to be toxic to marine life (Thaysen et al., 2018). When EPS degrades and becomes a microplastic in the environment, it poses a public health risk, the consequences of which are not yet fully understood (Karbalaei et al., 2018).

While technically recyclable, the majority of EPS products in the U.S. end up in landfills (based on the EPS recycling rate and U.S. Environmental Protection Agency (EPA) estimates of plastics landfilled; EPS Industry Alliance, 2013; U.S. EPA, 2019). Landfills are the third largest source of human-related methane emissions in the U.S. (U.S. EPA, 2020), emit carbon dioxide, can pollute groundwater through leachate, and are often disproportionately sited near communities of color and low socioeconomic status (Cannon, 2020; Abiriga et al., 2020). Other waste disposal methods, such as incineration, can also pose a significant environmental and public health problem, particularly when incineration infrastructure is nonexistent or subpar (Tait et al., 2019).

Health Impacts

Exposures during manufacturing, use, and recycling of EPS pose human health risks. Health effects of styrene exposure, which occurs during the manufacturing of EPS and in some types of recycling, include headache, fatigue, confusion, dizziness, and difficulty concentrating (OSHA, n.d.). As with most plastics, bioaccumulation of EPS microparticles can occur in the food chain (van Raamsdonk et al., 2020). Although some researchers have pointed out that styrene may be carcinogenic (Huff & Infante, 2011), the health impacts of polystyrene waste and plastic waste generally are not well-understood (Alabi et al., 2019).

Although research has determined little to no significant risk to consumers or with everyday exposure “under intended use conditions” (Nova Chemicals, n.d.), workers manufacturing EPS products are exposed to over 50 different chemicals, including the hazardous substances pentane, styrene vapors, resin dusts, and hydrogen bromide (CDC, 1994; NJ DOH, 2009; OSHA, n.d.) Hydrogen bromide, for example, can cause severe burns and difficulty breathing when inhaled (WHO INCHEM, 2001). Safety risks have also been described when recycled EPS is used in building materials, particularly due to increased risk of fire (Doroudiani & Omidian, 2010).

As sustainability professionals, scientists, and doctors, we work every day to make the world a better, healthier, and safer place. We recognize that this is a harmful material, and that there is an urgent need to transition away from EPS products. Removing EPS from our laboratory spaces contributes to this vital work by preventing pollution from entering our air, land, and waterways and by keeping unnecessary toxins from entering our communities.

Options: Avoid, Reduce, Reuse, Recycle

Challenges With Reuse

Although EPS products in laboratories can technically be reused as a strategy to temporarily divert this material from landfills, incinerators, and the natural environment, due to the amount of EPS materials entering labs, reuse can be challenging for staff who are dealing with time, space, and logistical constraints.

For example, laboratory spaces that receive coolers are typically not the same areas that would send out cold samples. Reusing EPS foam coolers would require laboratory staff to find space to store them temporarily, when storage space is often already limited and other interests also compete for valuable lab space. Furthermore, laboratory staff may need to identify another staff member in a different part of the laboratory, or even a different building or institutional location, that ships specimens using cold transport, accumulate enough coolers to justify meeting, coordinate with the other staff member, and find a way to transport them. This process has to be repeated continuously, and most likely without incentives or time allowances for anyone involved.

Another option for reuse is to find a local company that is interested in reusing EPS from laboratories. There can be safety, legal, and logistical complications with doing this, requiring consultation with proper environmental health and safety or legal counsel before offering EPS from labs to others. This strategy has worked for some research institutions, usually on a small scale, sometimes in addition to recycling and reduction schemes. For example, any company that uses EPS for shipping products where they would provide secondary containment within the EPS cooler (aquariums, food distribution, etc.) might be an excellent candidate for reusing lab EPS. However, these reuse partnerships are not readily available solutions that are scalable across the global research enterprise and require staff time to solicit, secure, maintain, and standardize for a research lab or institution.

Take-back programs are another type of reuse strategy that rely on the company or manufacturer of some EPS materials, such as coolers, to provide an avenue to take it back (My Green Lab, n.d.). This is an example of extended producer responsibility, which puts the responsibility of managing the post-consumer waste from their products back onto the producer (Dimino & Hesterman, 2020). These programs are not currently ubiquitous in the lab supply industry. In these limited availablility scenarios, space is still required to store the coolers until the pick-up occurs. Laboratory spaces typically are not designed with convenient extra storage areas. Future laboratory designs should consider the waste handling needs for the space. Additionally, shipping back to the manufacturer can result in damage, limiting its potential for reuse. Return also incurs transport emissions, limiting the sustainability of take-back options.

Photo credit: CU Boulder Green Labs Program

Issues With Recycling

The same qualities that make polystyrene useful also make it difficult to recycle—it is bulky, expensive to transport, and does not command a high market price, making it an undesirable material for many recyclers (Kelly, 2012; Rubio, 2018). Its low-density, has relatively low value for its recycled resin, and potential contaminants such as food, labels, or tape exacerbate recycling complications. The University of Wisconsin-Madison Office of Sustainability (UW-M, 2021), for example, only accepts EPS coolers and bulky packing material that is clean and without tape.

Despite the chasing arrows recycling label that can be found on many EPS products, they are not accepted in many recycling systems (Seaver, 2018; Tullo, 2015). The labeling of this material as recyclable can be confusing and lead to contamination of otherwise recyclable loads of material. When contamination rates are too high, materials recovery facilities (MRFs) can reject entire loads, which then get sent to landfills or incinerators (Marshall & Bandhauer, 2017). Pilot studies of secondary MRFs, which can recover more of the low-volume or overlooked materials, have shown promise for polystyrene recovery (Smalley, 2019).

While EPS products designed for laboratory use are clean and therefore more likely to be accepted than other EPS items (e.g., foodservice packages), recycling infrastructure for these items is severely lacking, and most require transport to a collection facility (see the map published by the EPS Industry Alliance, n.d.) showing where EPS recycling facilities do exist and where they are sparse). If no recycling facility is available, the EPS Industry Alliance recommends mailing them to regional recycling facilities (EPS Industry Alliance, 2021), which represents a shipping and logistical cost for laboratories. EPS recycling rates are reported based on a voluntary annual survey of companies by the EPS Industry Alliance (EPS Industry Alliance, 2020), and therefore only represent a minimum weight of EPS that is recycled per year.

One way to encourage programs for EPS recycling is by working with local waste management companies. Landfills are permitted by the cubic yard, yet tipping fees are based on weight. Because EPS is lightweight yet bulky, it occupies a large amount of space without garnering income for the companies that operate landfills. In this way, it is in the self-interest of these organizations to provide alternatives for their customers to divert EPS from their landfill streams. Working with these local waste management institutions is one potential, albeit potentially challenging, solution to expand EPS recycling options.

What Is a CHaRM?

CHaRM is an acronym for Center for Hard to Recycle Materials.

Some institutions that are able to recycle EPS do so by connecting with their local CHaRM, since EPS is not typically included in hauling and recycling contracts along with typically recyclable materials. Many CHaRMs are able to recycle EPS through investment in a densifier and resale to users of densified polystyrene.

In 2017, our working group conducted a survey to better understand the challenges that laboratories face in their diversion efforts. Many respondents cited challenges recycling EPS because no program existed, it had to be kept separate from other waste streams, and it needed to be stored, among other challenges (I^2SL, 2017).

Photo credit: https://livethrive.org/charm/

Even when recycling is locally available, it may require large amounts of space to store materials until enough is collected to justify the cost of hauling to a dedicated EPS recycling facility. For example, to supplement ongoing collection of EPS created through their internal scientific supply chain, Emory University in Atlanta hosts annual public recycling events and collected 15 pounds of EPS at their 2018 Earth Month Recycling Day (Kaufman, 2018).

If storing happens outside or in an environment where the EPS might get dirty due to space constraints, it can also lower its value as a recyclable material. Additionally, some institutions may have to pay for proper disposal or invest in equipment (such as a densifier), which can be cost prohibitive. The University of North Carolina-Wilmington is one example of an institution with an onsite densifier for EPS (Wernicke, 2019).

Identifying partners to transport the EPS to a recycling facility can be challenging, especially in cases where the recycler only offers drop-off service, leaving the burden of identifying, contracting with, and coordinating with the transportation partner of the laboratory or its home institution.

Advanced or "chemical" recycling is another option to process EPS and convert it into a different use material (Bassil et al, 2018, agilyx, n.d.). However, chemical recycling has received criticism from environmental groups because it is energy-intensive, emits carbon dioxide, may release toxins, and does not limit plastic production (Recycling Magazine, 2020).

EPS coolers stored outside. Photo credit: Allen Doyle

Innovations to Reduce and Avoid EPS Use

Sustainable Packaging

There are a growing number of alternatives to EPS in laboratories. For coolers, some companies have recently begun to develop more easily recyclable alternatives, such as Thermo Fisher Scientific's 100% paper cooler (Thermo Fisher Scientific, n.d.) and New England BioLabs' (NEB) cardboard ClimaCell® cooler (New England BioLabs, 2020). Vericool has a biodegradable and recyclable cooler, as well as a social mission (Vericool, n.d.), and Indoor Biotechnologies has been awarded for using this product (GBENN, 2019). Mycelium-based packaging alternatives are also available, which are made from completely compostable materials (Mushroom® Packaging, 2021). For conical tube trays, which typically are made from EPS, Labcon offers non-EPS reusable and recyclable tray materials (Labcon, 2021). Durable non-EPS cold transport options with purchase or rental options are becoming more commonly available as well (Sofrigam, n.d., Reusable Packaging Association, 2021). While the LDWG encourages and applauds these innovations and hopes to see more growth in sustainable alternatives, these relatively new options exist for limited types of laboratory supplies and are not available for all types of cold shipment products or even in all market sectors.

Rethinking the Science of Cold Transport

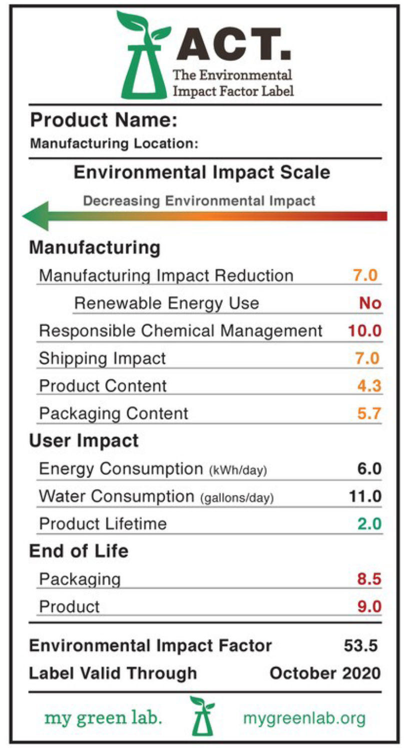
The scientific research industry should evaluate whether or not cold transport is always necessary. For example, Cell Signaling Technology has conducted temperature stability testing on its antibodies and found no changes in performance at room temperature for many of their products (Cell Signaling Technology, 2021). To avoid excess packaging waste, they ship their products that pass these antibody performance tests without coolers. More research is needed to support the reduction of EPS use in cold shipments for whether or not certain types of samples (such as DNA and RNA) can be stored at or shipped at room temperature.

Another method to reduce cold shipments, and therefore use of EPS, would be to make use of onsite stocked vendor freezer programs. NEB, Bio-Rad, and Thermo Fisher Scientific all offer programs by which the customer can purchase a continually stocked freezer that contains commonly used lab reagents, ensuring that EPS is not used for each individual shipment of the designated reagents (NEB, n.d., Bio-Rad, n.d., Thermo Fisher Scientific, n.d.). Such freezers can be housed in an individual laboratory area, a common laboratory area that serves several labs, such as on the same floor or wing of the building, or in a central supply room, depending on the needs and frequency of use. Vendors bring shipments in bulk to restock the freezer and carry the product from the truck to the freezer in reusable coolers. This option supports sustainable laboratory practices of sharing equipment while reducing the need for both EPS and the frequency of cold transport to the lab.

Making the Rules: Ask for What You (Don't) Want

As purchasers of scientific products, we can leverage our buying power and tell our suppliers what products and materials we do not want to support. Leveraging purchase power can also include asking the right questions to potential laboratory vendors. As part of an ambitious zero waste goal, the University of California system implemented a packaging foam ban (UCLA, 2020). Although laboratory and medical products are exempt, the university does use sustainability

Leveraging Purchase Power



The ACT (Accountability, Consistency, Transparency) Label is another tool to use when choosing products. An eco-certification program for laboratory products, the ACT label is a collaboration between My Green Lab, SMS Collaborative, scientists, procurement specialists, sustainability directors, and manufacturers. Based on Environmental Impact Factor (EIF) criteria, ACT labels are intended to help laboratories reduce their environmental impact through smarter purchasing decisions. Currently, EPS foam to transport material is out of scope for the ACT assessment unless it comprises part of packaging for an ACT label manufacturer. In these cases, EPS coolers do impact ACT scores for products shipped in cold storage. If a manufacturer does not offer a nationwide take-back program, the end-of-life score for EPS packaging is 8+ (on a scale from 1 "least impact" to 10 "highest impact").

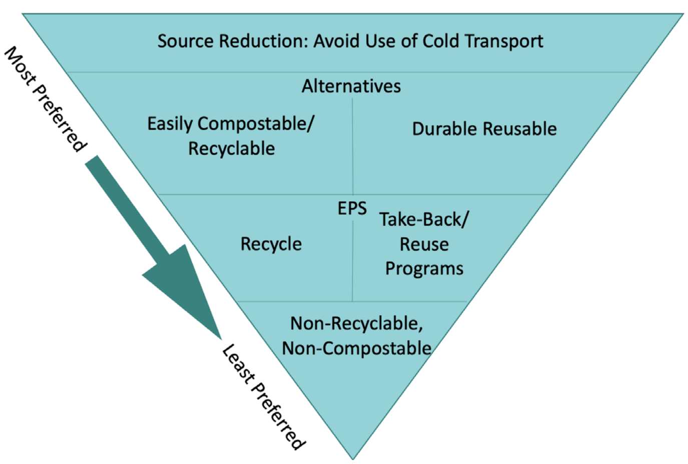
measures to evaluate Requests for Proposals (RFP), which includes questions about packaging and EPS (UCOP, 2019).

Waste Hierarchy: Cold Transport for Labs

In our experience, EPS packaging in labs frequently takes the form of disposable cold shipment coolers. Based on EPA's (US EPA, 2017) and the United Nations Environment Program (UNEP)'s (UNEP, 2010) Waste Management Hierarchies, we have developed the I^{2}SL EPS Cold Transport Waste Hierarchy that ranks strategies from most preferred to least preferred.

Source Reduction

The most preferred strategy to reduce EPS in labs is source reduction. In the section Rethinking the Science of Cold Transport above, we have described several innovative strategies for reducing the volume of EPS coming into laboratories.



Alternatives to EPS

When cold transport is unavoidable, non-EPS alternatives should be considered next. In the section Sustainable Packaging above, we describe innovations around containers that are compostable or recyclable, and durable cold transport containers with take-back or reuse strategies.

EPS Recycling and Take-Back, or Reuse

If EPS is used, recycling and take-back strategies should be utilized, or reuse where feasible. In the Challenges With Reuse and Issues With Recycling sections above, we elaborate on these strategies. This is a departure from typical waste management hierarchies that place reuse above composting and recycling. While some evidence suggests that reusable options have a lower footprint than single-use despite the carbon cost of shipping (Goellner & Sparrow, 2014), EPS cold transport containers take up valuable laboratory space, time, and personnel to coordinate pick-ups. Therefore, for laboratory professionals and scientists, this may be a less preferred option in comparison to containers that could be easily composted or recycled and turned into valuable end materials such as new paper products or soil amendment for growing food. However, for institutions that have storage space and have found return and reuse strategies feasible, it makes sense for reuse to be a higher priority option.

Composting and recycling facilities vary considerably across regions and institutions. Therefore, we urge suppliers to communicate with customer purchasing, recycling, or sustainability experts about what types of materials are actually compostable or recyclable at their institution and not just theoretically if proper facilities were to exist. Communication between suppliers, purchasers, and end users is vital in order for sustainable cold transport to be successful.

Discarding of EPS

Finally, non-compostable, non-recyclable, single-use EPS is the least preferred option. At this point, EPS can be diverted to a combustion technology facility, or it must go to a landfill.

Combustion technologies, commonly called "incineration," are classically associated with production of soot and smoke, measured as PM 2.5, and other toxic byproducts, such as dioxins (National Research Council (US) Committee on Health Effects of Waste Incineration, 2000). Incinerators are often cited as an example of environmental injustice, having a disproportionately deleterious impact on the surrounding, often low-income urban neighborhoods (Earthjustice, 2021).

A modern combustion technology is waste-to-energy (WtE). These facilities are relatively common in Europe due to land scarcity, the need for waste heat in residential heating, strong pollution controls, and electricity generation (CEWEP, n.d.). WtE is becoming more common outside of Europe due to it being a landfill diversion method that avoids associated methane emissions. However, the energy content of EPS per volume is low, and WtE may represent a disincentive for recycling, therefore reducing the amount of recovered materials, while encouraging continued production and consumption. For these reasons, the combustion of EPS should be avoided as a long-term strategy.

The final pathway is putting EPS in the regular trash, destined for a landfill—although not all landfills are equivalent, and ones with greenhouse gas capture technology (EPA, 2021) are preferred.

Strategies for Success

Removing EPS from laboratories altogether is a valuable goal, but increasing waste diversion is a journey. In some circumstances, it may be difficult to find alternatives. In these cases, we have identified several strategies that LDWG members have utilized to overcome challenges with EPS recycling and reuse.

EPS Task Force, University of Virginia

Virginia's Executive Order 77 will eventually ban the buying, selling, or distribution of disposable plastic bags, single-use plastic and polystyrene foodservice containers, plastic straws and cutlery, and single-use plastic water bottles at all executive branch state agencies including state universities (with some exceptions in terms of medical or public health situations). While cold-chain EPS is not currently included on this list, the University of Virginia's Expanded Polystyrene Task Force has long advocated for the use of alternative cold-chain shipping containers being shipped to our campus that would reduce or eliminate languishing EPS in our laboratories. Central Virginia has no infrastructure for recycling these materials, and the task force has determined that introducing EPS processing facilities is not only resource-intensive, but would take our initiative in the opposite direction of our goal, which is to reduce or eliminate the use of EPS in cold-chain shipping for the sciences. Institutions are saddled with this difficult-to-manage material. Manufacturers and state agencies need to make meaningful changes to the contents of our waste streams by supporting innovation and preventing the expansion of EPS use.

—Christine Alencar (MS) LEED Green Associate, Smart Labs Project Associate, Office for Sustainability, University of Virginia

Build Partnerships

It's likely that there are other sustainability-minded, anti-waste advocates at every research institution and company, and building partnerships with important stakeholders is an important part of the process toward finding solutions for EPS landfill diversion. For example, the University of Colorado (CU) Boulder engaged fire marshals and building managers in identifying locations to collect foam coolers. Cleveland Clinic forged a community partnership to provide recycling vocational opportunities for adults with disabilities (I[2]SL Conference, 2016). Similarly, EPS manufacturers want their products to be recycled whenever possible. If there are EPS recyclers or manufacturers in your area, contact them to see if they're willing to collect your foam or provide storage or transport resources (Foam Facts, 2021; EPS Industry Alliance, 2021).

Make It Easy

The most effective recycling and reuse strategies are those with the least amount of friction. If it is easy and straightforward, others will participate. Coordinate EPS pick-ups with other waste streams, make a map of drop-off sites or pick up points at your institution (Emory, 2021), and make sure the program's operation is clear and known by everyone who participates.

Nylon bags used for collection at UC Davis. Photo credit: Allen Doyle

Get Creative

LDWG members at UC Davis overcame collection and transport challenges by using large, "single-use" nylon bags that had an original purpose of shipping sand and rubber chips. Connect with other departments to see if they have a frequent source of incoming bags or boxes that can be repurposed.

Be Flexible

It may not be possible to completely switch to a manufacturer that offers a take-back program or start an institution-wide collection service. If this is the case, consider smaller, more feasible alternatives, like hosting an EPS collection day a few times per year or working with the procurement or purchasing office to identify alternatives with existing vendors. Celebrate these small victories and build upon them.

The Mission-Alignment Case

Many institutions have explicit missions, values, and guiding vision statements that act as guideposts for strategic decisions. EPS recycling, reuse, and product bans can be cumbersome to implement, but are often aligned with the mission or value statement of our institutions. Especially when presenting an EPS reduction strategy to leadership, being prepared to meet them where they are by making this connection can strengthen your case. Framing the issue as something that employees care about can also make the connection to employee engagement.

Replicate Models That Work

We have presented many examples of innovations and ideas for reducing the use of EPS containers and packaging in laboratories, and the research institutions where these strategies have been implemented. Click on the links, explore the different options, connect with colleagues, find which models fit your needs, and implement an EPS reduction strategy that will work for your institution. Be sure to share your strategy so that others can also find success!

European Perspective

European labs commonly suffer from the same challenges as our U.S. counterparts—labs are left with high volumes of EPS (or polystyrene as it's more commonly referred to in the U.K.), with countless examples of excess packaging. We work with staff and students to highlight the available take-back schemes, but these are not all available around the European continent, with some countries having no available options. In the U.K., NEB is currently the only known company which offers a take-back scheme that leads to reuse, whilst Promega will take them back for compacting. These require updated training, engagement with our stores, and space for storage. Apart from consolidating orders and attempting to reuse polystyrene wherever feasible, it remains a common challenge. We look forward to suppliers providing sustainable options in the future! And don't get us started on ice-packs.

—Martin Farley, Sustainable Lab Advisor, UCL/ Sustainable Research Manager, King's College London

Conclusion

The scientific community has increasing options for reducing the use of EPS containers and packaging. The known environmental and health impacts, along with the consistent inclination for laboratory professionals and researchers to decrease the EPS burden in their labs, has led to innovative solutions on the part of both manufacturers and suppliers of laboratory products and sustainability professionals, scientists, doctors, and others working in laboratories. Understanding options to avoid, reduce, reuse, and recycle EPS, rethinking the waste hierarchy related to cold-transport, and identifying strategies for success are foundational for decreasing EPS burden in laboratories.

References

All references last accessed: June 2021.

Abbreviations: n.d., no date; I^{2}SL, International Institute for Sustainable Laboratories; CDC, Centers for Disease Control and Prevention; OSHA, Occupational Safety and Health Administration; NIOSH, National Institute for Occupational Safety and Health; WHO, World Health Organization; INCHEM, Internationally Peer Reviewed Chemical Safety Information; NJ DOH, New Jersey Department of Health; US EPA, United States Environmental Protection Agency; CEWEP, Confederation of European Waste-to-Energy Plants; GBENN, Green Business Engagement National Network; UCLA, University of California Los Angeles; UCOP, University of California Office of the President.

About Our Working Group

The Laboratory Waste Landfill Diversion Working Group is coordinated by sustainability professionals and researchers at the Cleveland Clinic and Emory University under the International Institute for Sustainable Laboratories. Our group works to address barriers and share best practices related to laboratory waste diversion with a particular focus on reducing waste from the supply chain by bridging the communication gaps between purchasers and suppliers and manufacturers. To learn more about this working group or to get involved, visit https://www.i2sl.org/working/labwaste.html.

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