Use of Adjuvants for Roadside Vegetation Control

Requested by
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July 7, 2017

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Background

Adjuvants, also known as additives or carriers, are substances added to herbicides to enhance their delivery, penetration or stability. Adjuvants are also added to herbicide formulations to decrease their drift and dispersion during application and to minimize transport to nontarget plants. California regulates adjuvants as a pesticide and requires that adjuvants be registered with the California Department of Pesticide Regulation. The U.S. Environmental Protection Agency (EPA) does not require adjuvants to be registered.

Recently, Caltrans has received feedback from citizens and the agency's field maintenance staff about the adjuvants used as part of the Caltrans vegetation management program. Some of this feedback is related to the labels used for various classifications of chemicals on the Occupational Safety and Health Administration (OSHA)–required Safety Data Sheets (SDS). Caltrans would like to know more about the use of adjuvants by other state departments of transportation (DOTs) and the availability of federal guidance and related research that considers the toxicity of adjuvants used in herbicide formulations for roadside vegetation control.

To assist Caltrans in this information-gathering effort, CTC & Associates contacted representatives of the state DOTs that also require registration of adjuvants, and examined related research that addresses adjuvant use and potential toxicity when used for roadside vegetation control.

Summary of Findings

As a prelude to reviewing the practices of states that regulate adjuvants as a pesticide, we provided a brief overview of the federal chemical labeling requirements associated with OSHA's new hazardous chemical labeling requirements. These requirements were associated with the 2012 revision of the agency's Hazard Communication Standard.

Selected State Practices

We surveyed representatives from the eight states (in addition to California) that require registration of adjuvants to learn how the DOTs or other state agencies manage adjuvant use in a roadside vegetation control program. The states surveyed were Arkansas, Idaho, Kentucky, Mississippi, Tennessee, Utah, Washington and Wyoming. Five of these states—Arkansas, Idaho, Tennessee, Utah and Washington—responded to our eight-question email survey that addressed adjuvant labeling, documented state practices, communication with staff and the public, and research associated with adjuvant toxicity.

Labeling and Registration

Several respondents noted that no further labeling for adjuvants is provided other than the manufacturer's label provided with the product. None of the respondents indicated that their state requires the use of any signal words and/or pictograms to accompany the required labels for adjuvants. None of the states reported challenges associated with revising adjuvant labeling to comply with the relatively new OSHA standard. To supplement survey responses, we provided links to state statutes, administrative codes and other guidance describing the registration and labeling requirements for the five states responding to the survey.

Documented State Practices and Training

Only Washington State DOT provided a response when asked about documented state practices with regard to the management and use of adjuvants in a vegetation control program. The agency includes adjuvant specifications in its roadside vegetation management plans for all applications as part of documented best management practices. These plans are refined annually with the goal of updating all area plans to include specific adjuvant product specifications and rates.

None of the respondents conduct training or offer outreach specific to adjuvants. In Utah and Washington, training is conducted as needed. For example, when research uncovers issues related to Washington State DOT's vegetation control program, such as the aquatic toxicity of a product, the agency includes that information in employee training.

Adjuvant Research

None of the respondents are aware of research specific to the toxicity of adjuvants. The Washington State DOT respondent indicated that most of the agency's research efforts have been focused on the chemistry of the active ingredients in herbicides.

Related Resources

This section of the report cites publications that describe the registration and labeling requirements for the three states—Kentucky, Mississippi and Wyoming—that require registration of adjuvants but did not respond to our survey. Also highlighted is Oklahoma DOT's vegetation management guidance, which describes compatibility testing for adjuvants using a standard jar test method. We also include a compendium of herbicide adjuvants that contains more than 779 entries from 38 companies, and selected journal articles that examine adjuvant toxicity.

Gaps in Findings

The survey conducted for this project netted relatively few details of current state practices. Three of the eight states registering adjuvants as pesticides did not respond to the survey, and the depth and breadth of responses from the five states that did respond varied widely. In some states, agencies outside the DOT are responsible for adjuvant registration and labeling. Follow-up contacts to individuals in these agencies may prove helpful. We also found little research addressing the toxicity of adjuvants used in a roadside vegetation control program.

Next Steps

Moving forward, Caltrans could consider:

- Consulting with the Washington State DOT respondent to learn more about the state's policies and practices within the DOT and in other state agencies.
- Following up with contacts in Kentucky, Mississippi and Wyoming to attempt to gather information about these states' adjuvant-related activities.
- Contacting governing boards or other state agencies (for example, the Arkansas State Plant Board and the Washington State Department of Agriculture) to learn more about practices for registering and labeling adjuvants.

Detailed Findings

Background

Adjuvants, also known as additives or carriers, are substances added to herbicides to enhance their delivery, penetration or stability. Adjuvants are also added to herbicide formulations to decrease their drift and dispersion during application and to minimize transport to nontarget plants.

While the U.S. Environmental Protection Agency (EPA) does not consider adjuvants to have pesticidal properties and therefore does not require their registration, nine states (Arkansas, California, Idaho, Kentucky, Mississippi, Tennessee, Utah, Washington and Wyoming) regulate adjuvants as a pesticide and require that adjuvants be registered. Associated with this registration are labeling requirements specified in state statute or administrative code, or established by the Occupational Safety and Health Administration (OSHA).

State-specific labeling guidance appears in the **Selected State Practices** and **Related Resources** sections of this Preliminary Investigation in the form of survey responses and citations for state statutes and other guidance documents. Below is a brief summary of the federal chemical labeling requirements.

In 2012, OSHA adopted new hazardous chemical labeling requirements as a part of the revision of the Hazard Communication Standard (HCS); see 29 CFR 1910.1200, Hazard Communication, available at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099. The new rule became effective May 25, 2012.

OSHA's Hazard Communication page, available at https://www.osha.gov/dsg/hazcom/index.html, provides this background on why the standard was revised and the impact of the changes:

> The Hazard Communication Standard (HCS) is now aligned with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). This update to the Hazard Communication Standard (HCS) will provide a common and coherent approach to classifying chemicals and communicating hazard information on labels and safety data sheets. This update will also help reduce trade barriers and result in productivity improvements for American businesses that regularly handle, store, and use hazardous chemicals while providing cost savings for American businesses that periodically update safety data sheets and labels for chemicals covered under the hazard communication standard.
>
> Hazard Communication Standard
>
> In order to ensure chemical safety in the workplace, information about the identities and hazards of the chemicals must be available and understandable to workers. OSHA's Hazard Communication Standard (HCS) requires the development and dissemination of such information:
>
> - Chemical manufacturers and importers are required to evaluate the hazards of the chemicals they produce or import, and prepare labels and safety data sheets to convey the hazard information to their downstream customers;

- All employers with hazardous chemicals in their workplaces must have labels and safety data sheets for their exposed workers, and train them to handle the chemicals appropriately.

Major changes to the Hazard Communication Standard

- **Hazard classification**: Provides specific criteria for classification of health and physical hazards, as well as classification of mixtures.
- **Labels**: Chemical manufacturers and importers will be required to provide a label that includes a harmonized signal word, pictogram, and hazard statement for each hazard class and category. Precautionary statements must also be provided.
- **Safety Data Sheets**: Will now have a specified 16-section format.
- **Information and training**: Employers are required to train workers by December 1, 2013 on the new labels' elements and safety data sheets format to facilitate recognition and understanding.

Selected State Practices

Survey Approach

We surveyed representatives from the eight states, in addition to California, that require registration of adjuvants to learn how the departments of transportation (DOTs) or other state agencies manage adjuvant use in a vegetation control program. The states surveyed were:

- Arkansas.
- Idaho.
- Kentucky.
- Mississippi.
- Tennessee.
- Utah.
- Washington.
- Wyoming.

Representatives from these states responded to the following questions by email:

1. What is the extent of your state's labeling requirements for adjuvants?
2. What standards or measures do you use to determine how an adjuvant is labeled?
3. Does your state require the use of any signal words and/or pictograms to accompany the required labels? If so, please describe the accompanying signal words or pictograms.
4. Do you have any documented state practices (for example, a state plan) related to the management and use of adjuvants in a vegetation control program? If so, please provide links to this documentation or email any files not available online.

5. Has your state provided any communication to your field maintenance staff and/or the general public related to the safety of adjuvants? If so, please describe this communication and provide specific examples, if available.
6. Has your state conducted or sponsored research that examines the toxicity of adjuvants used in herbicide formulations for roadside vegetation control purposes? If so, please describe this research.
7. Have the registrants in your state experienced any difficulties in revising the labeling of the Safety Data Sheets to comply with OSHA's new Hazard Communication Standard? If so, how has this been addressed?
8. Are you planning to make any changes to current practices for the management and use of adjuvants in your vegetation control program? If so, please describe these changes.

Summary of Survey Results

Five of the eight states (Arkansas, Idaho, Tennessee, Utah and Washington) responded to our request for information. Most respondents, with the exception of the Washington State DOT respondent, offered limited details in their responses. Below is a summary of survey responses in these topic areas:

- Labeling and registration.
- Documented state practices.
- Communicating with staff and the public.
- Adjuvant research.

Note: References to Material Safety Data Sheets, or MSDS, appear in the summary of survey results below and the related resources that follow. OSHA's recent revision of the Hazard Communication Standard includes new hazardous chemical labeling requirements, and MSDS are now known as Safety Data Sheets, or SDS.

Labeling and Registration

Several respondents noted that no further labeling for adjuvants is provided other than the manufacturer's label provided with the product. None of the respondents indicated that their state requires the use of any signal words and/or pictograms to accompany the required labels for adjuvants. None of the states reported challenges associated with revising adjuvant labeling to comply with the relatively new OSHA standard.

The following summarizes the survey responses that addressed adjuvant labeling and registration:

- Arkansas State Highway and Transportation Department does not require any specific labeling beyond what the manufacturer provides. Adjuvant containers are labeled in a manner similar to pesticides with active and inert ingredients—with the manufacturer's information on the label along with directions for use.

  An agency web site providing direction to registrants seeking to register pesticide products in Arkansas indicates that "[t]he Arkansas State Plant Board does not require

Material Safety Data Sheets, EPA Stamped Accepted Labels, or Confidential Statements of Formula unless specifically requested."

- Idaho DOT's adjuvant labels include:
    - Name of pesticide.
    - Name and address of manufacturer.
    - Name and address of registrant.
    - Net contents.
    - Name and type of up to three functioning agents.
    - Total percentage of constituents ineffective as spray adjuvants.
    - Directions for use.

  The state requires registration of adjuvants and payment of an annual fee, but does not require that MSDS information be provided with the registration.

- In Utah, the DOT uses the label provided with the product and includes any special use or other labeling that might be issued by the Utah Department of Agriculture.

- The Washington State Department of Agriculture approves all adjuvant labels for use within the state. Operators are required to carry these labels with them in the field along with MSDS, and are required to follow all directions included on labels for any adjuvants used in conjunction with herbicide applications. The respondent noted that in general, when labeling adjuvants the agency considers "the same environmental and human health risks/potential exposure levels as are considered for labeling pesticides."

Related Resources

Below we highlight the state statutes, administrative codes and other guidance describing the registration and labeling requirements of the five states responding to our inquiries for this Preliminary Investigation.

Arkansas

Pesticide Registration, Arkansas Agriculture Department, 2017.
http://www.aad.arkansas.gov/registration
This web site describes Arkansas' registration program for pesticides, which are defined by the Arkansas Pesticide Control Act as:

- Any substance or mixture of substance intended for preventing, destroying, repelling or mitigating any pest.
- Any substance or mixture of substance intended for use as a plant regulator, defoliant or desiccant.
- Any substance or mixture of substance intended to be used as a spray adjuvant.

Pesticides must be registered with the State Plant Board before they are distributed, sold or offered for sale in Arkansas.

Idaho

Idaho Code Ann. § 22-3402, Registration; Labels; Information required; Fees, 2017.
https://legislature.idaho.gov/statutesrules/idstat/Title22/T22CH34/SECT22-3402/
From the statute:

(3)(b) all labels for spray adjuvants shall contain but are not limited to:

1. The name of the pesticide; and
2. the name and address of the manufacturer. An unqualified name and address listed on the label shall be considered the manufacturer's name and address; and
3. the registrant's name and address. If the registrant's name appears on the label and the registrant is not the manufacturer, it must be qualified by appropriate wording such as "packaged for or distributed by"; and
4. the net contents; and
5. the name and type of functioning agents. If more than three (3) agents are present, only the three (3) principal agents need be named; and
6. the total percentage of constituents ineffective as a spray adjuvant; and
7. directions for use.

Tennessee

Tennessee Code Ann. § 43-8-104, Registration of products; Annual renewal; Labeling; Statement filed by registrant; Registration of brand or grade; License to sell registered brands; Refusal or cancellation of registration, 2015.
http://law.justia.com/codes/tennessee/2015/title-43/chapter-8/part-1/section-43-8-104
From the statute:

(4) In the case of adjuvants, surfactants, emulsifiers, wetting agents, and other materials included as adjuvants that have nonionic surfactants as the principal agent, the ingredient statement on the label must show the percentage of the active adjuvant at least by the generic chemical name and, further, that the specific chemical name identifying the hydrophobic and hydrophilic portions of the molecule and the ratio of the same must be given on a data sheet that shall accompany the label when application for registration is made, the latter being necessary in order that the chemical content may be determined by the department of agriculture, division of technical services, for regulatory purposes. In the case of products having cationic and anionic surfactants as the principal agent, the chemical names of those materials must be used in the ingredient statement on the label together with the percentage contents of the principal surfactants. In the case of products not involving hydrophobic and hydrophilic portions of the molecule such as in the case of most synergists and other nonsurfactant adjuvants, the chemical name of the material must be used in the ingredient statement on the label.

Utah

Utah Code § 4-14-104, Labeling requirement for pesticides specified, Utah Agricultural Code, effective July 1, 2017.
https://le.utah.gov/xcode/Title4/Chapter14/4-14-S104.html?v=C4-14-S104_2017050920170701
This state statute describes the standard labeling required for pesticides and adjuvants in Utah and includes this requirement:

(3) If the pesticide is highly toxic the label shall, in addition to the other label requirements, display:

(a) the skull and crossbones;

(b) the word "POISON" in red prominently displayed on a background of distinctly contrasting color; and

(c) a statement of a practical treatment, first aid or otherwise, in case of poisoning by the pesticide.

Washington

Washington Rev. Code Ann. § 16-228-1400, What are the requirements for pesticide labels?, General Pesticide Rules, Washington Administrative Code, effective June 9, 2017.
http://apps.leg.wa.gov/WAC/default.aspx?cite=16-228-1400
This administrative code provides the requirements for spray adjuvant labeling.

WSDA Guidance on Globally Harmonized System (GHS) Implementation for Spray Adjuvants and 25(b) Minimum Risk Pesticides, Pesticide Management Division, Washington State Department of Agriculture, undated.
https://agr.wa.gov/fp/pubs/docs/391-WSDAGuidanceOnGHSforSprayAdjuvants.pdf
From the document:

> In Washington, registration of spray adjuvants and 25(b) minimum risk pesticides are required. In order to insure that the label directions and precautionary statements are adequate to protect the people and environment of Washington, the Washington State Department of Agriculture (WSDA) has developed guidance for spray adjuvants and 25(b) minimum risk pesticides, including label requirements. In general, the label requirements for signal words and precautionary statements were based on the EPA Label Review Manual.

Guidance for Registration and Labeling of Spray Adjuvants, Pesticide Management Division, Washington State Department of Agriculture, undated.
https://agr.wa.gov/PestFert/Pesticides/docs/AdjuvRegGuide4335.pdf
This guide describes required label elements for adjuvants and provides a sample label and sample statement of formula.

Pesticide Registration, Washington State Department of Agriculture, August 2015.
http://agr.wa.gov/fp/forms/pm/pesticideregistration_websummary.aspx
This web site describes the requirements for registering pesticide products that will be sold in Washington, including the form that must be completed and submitted with a letter of authorization from the company.

Related Resource:

Supplemental Information for Spray Adjuvant Registration, Pesticide Management Division, Washington State Department of Agriculture, undated.
https://agr.wa.gov/PestFert/Pesticides/docs/PestRegSuppInfo4119.pdf
This form completed in connection with adjuvant registration in Washington asks for studies showing the efficacy of the product and information on toxicity (phytotoxicity (if the adjuvant will be applied to desirable plants), mammal acute toxicity and aquatic acute toxicity).

Hazard Communication and the Globally Harmonized System (GHS), Washington State Department of Labor and Industries, undated.
http://www.lni.wa.gov/Safety/Topics/AtoZ/ghs/
This web site offers information about Washington State's Hazard Communication (GHS) Rule, Chapter 296-901, which became effective April 15, 2013. As the site notes, this rule "is substantially identical to OSHA's rule. As a result, labels on containers of chemicals and Safety Data Sheets (SDSs) are now required to follow GHS specifications. Other requirements such as training for employees on the GHS label and SDS changes also apply."

Pesticide Information Center Online (PICOL) Databases, Washington State University, 2017.
http://cru66.cahe.wsu.edu/LabelTolerance.html
From the web site:

> Welcome to Washington State University's label databases. These databases are operated by WSU with funding from the Washington State Department of Agriculture, the Oregon Department of Agriculture, Oregon State University, and WSU. The databases are updated daily.
>
> **Registered Labels**
> The label database can be searched by using selected information from pesticide products registered in Oregon and/or Washington. Washington data includes Section 3, Section 24c, Section 18 and federal supplemental labels. It does not include EUPs [experimental use pesticides]. Oregon data includes Section 3, Section 24c and federal supplemental labels. It does not include EUPs. Electronic copies (i.e., PDFs) of Washington labels are uploaded as we receive them from WSDA.
>
> Note: These web labels are for informational purposes only. This database is not a substitute for obtaining and reading pesticide labels. PICOL information has no legal status, whereas the label is a legal document.
>
> **Section 24c**
> This site contains nine SLN [Special Local Need] Quick Search Lists for Washington and Oregon. Users may also access the full PICOL database via the Registered Labels button above to perform more detailed searches for SLNs.
>
> Maintenance of the PICOL tolerance database has been discontinued. We sincerely apologize for any inconvenience. In its place we recommend users access the USEPA Tolerance Database or the USDA Foreign Agriculture Service Maximum Residue Limit Database.

Documented State Practices

Only Washington State DOT provided a response when asked about documented state practices with regard to the management and use of adjuvants in a vegetation control program.

The agency includes adjuvant specifications in its roadside vegetation management plans for all applications as part of its documented best management practices. These plans are refined annually with the goal of updating all area plans to include specific adjuvant product specifications and rates. See the Eastern Region, Area 2: Integrated Roadside Vegetation Management Plan, available at http://www.wsdot.wa.gov/NR/rdonlyres/0EA2DD94-FB66-49DA-8D51-3F9579E8E107/0/spokaneplan.pdf, for an example of how adjuvants are referenced in the agency's roadside vegetation management plans.

Communicating with Staff and the Public

None of the respondents conduct training specific to adjuvants. In Arkansas, all employees applying pesticides or herbicides receive training through the University of Arkansas Extension. The Arkansas State Plant Board licenses and certifies employees applying herbicides, pesticides and adjuvants through an exam for noncommercial agricultural pesticide applications on rights of way every three years. Utah DOT conducts training on herbicides and adjuvants as needed. Washington State DOT uses a similar approach: When research uncovers issues related to Washington State DOT's vegetation control program (for example, the aquatic toxicity of a product), the agency includes that information in employee training.

Adjuvant Research

None of the respondents are aware of research specific to the toxicity of adjuvants. The Washington State DOT respondent indicated that most of the agency's research efforts have been focused on the chemistry of the active ingredients in herbicides. As the respondent noted, "WSDOT has invested in detailed risk assessment research of all herbicide products used on our roadsides." If the agency becomes aware of new information indicating potential environmental or human health impacts from adjuvants, treatment prescriptions are revised as necessary.

Related Resources

The citations in this section are organized in three sections:

- Other State Practices.
- Guidance for Adjuvant Use.
- Adjuvant Toxicity.

Other State Practices

The citations below provide details of the registration and labeling requirements for the three states—Kentucky, Mississippi and Wyoming—that require registration of adjuvants but did not respond to our survey. Also highlighted is Oklahoma DOT's vegetation management guidance, which describes compatibility testing for adjuvants using a standard jar test method.

Kentucky

Pesticide Product Registration, Kentucky Department of Agriculture, 2017.
http://www.kyagr.com/consumer/product-registration.html
From the web site:

> According to KRS 217.544(31), "Spray Adjuvant" means any wetting agent, spreading agent, sticker, deposit builder, adhesive, emulsifying agent, deflocculating agent, water modifier, or similar agent intended to be used with any other pesticide as an aid to the application or to the effect thereof, and which is in a package or container separate from that of the other pesticide with which it is to be used. Spray adjuvants shall be registered to comply with KRS 217.544(31).

Kentucky Rev. Stat. Ann. § 217.570, Registration of pesticides; Annual inspection fee; Renewal, effective July 15, 2010.
http://www.lrc.ky.gov/Statutes/statute.aspx?id=9388
This portion of the state statute relates to registering an adjuvant.

Mississippi

Regulations, Subpart 3: Bureau of Plant Industry; Chapter 08-Pesticide Law, Subchapter 01, Regulations Governing Registration of Pesticides and Pesticide Products, Mississippi Department of Agriculture and Commerce, 2014.
http://www.mdac.ms.gov/wp-content/uploads/08-Pesticide-Law.pdf
From the document:

> Requirements For Adjuvants
> 108.01 In the case of adjuvants, surfactants, emulsifiers, wetting agents, and other materials included as adjuvants which have nonionic surfactants as the principal agent, the ingredient statement on the label must show the percentage of the active adjuvant at least by the generic chemical name and, further, that the specific chemical name identifying the hydrophobic and hydrophillic portions of the molecule and the ratio of same must be given on a data sheet that shall accompany the label when application for registration is made, the later being necessary in order that the chemical content may be determined by the State Chemist for regulatory purposes. In the case of products having cationic and anionic surfactants as the principal agent the chemical names of such materials must be stated in

the ingredient statement on the labels along with the percentage contents of the principal surfactants.

Oklahoma

Oklahoma Roadside Vegetation Management Guidelines, 4th Edition, Douglas P. Montgomery, Dennis L. Martin and Craig C. Evans, Oklahoma Department of Transportation, January 2010.
http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-3158/Roadside+Vegetation.pdf
From the abstract:

> A fourth edition of the Oklahoma Roadside Vegetation Management Guidelines was developed. The guidelines serve as a training and reference manual for Oklahoma Department of Transportation (ODOT) employees that are responsible for herbicide application as a part of maintaining roadside vegetation in Oklahoma. The guidelines were developed as a cooperative project between the Oklahoma State University Roadside Vegetation Management Program and the ODOT. The guidelines provide a comprehensive review necessary for understanding and implementing an integrated roadside vegetation management program that is compliant with ODOT, Oklahoma State and Federal policies, rules and regulations.
>
> ….
>
> Where applicable, biological weed control agents are discussed. Herbicide product classification, pesticide fate, environmental protection, applicator personal protective equipment, proper equipment calibration and operation are discussed. Pesticide rules and regulations pertinent to Oklahoma are addressed. Use of the ODOT Approved Herbicide and Adjuvant List is also discussed.

See Chapter 6, Herbicide Adjuvants, on page 131 of the PDF. This chapter provides "information on spray adjuvants, their proper use, and compatibility with herbicides. These products will have met the ODOT Approved Herbicide and Adjuvant List (AHAL) Program criteria (refer to Chapter 14 for AHAL information)."

Related Resource:

> **Attachment C: Approved Herbicide & Adjuvant List (AHAL)**, Oklahoma Department of Transportation, December 2015.
> www.bidnet.com/bneattachments?/384816222.docx
> This bid attachment is the 2015 version of Oklahoma DOT's list of approved herbicides and adjuvants.

Wyoming

New Product Registration Application, Wyoming Department of Agriculture, undated.
http://wyagric.state.wy.us/images/stories/pdf/techserv/newproductsapp3.pdf
This application form to register products provides labeling requirements for pesticides.

Guidance for Adjuvant Use

Compendium of Herbicide Adjuvants, 13th Edition, Bryan G. Young, Joseph L. Matthews and Fred Whitford, Purdue Extension and Southern Illinois University, 2016.
https://ppp.purdue.edu/wp-content/uploads/2016/11/PPP-115.pdf
From the document:

> This 2016 *Compendium of Herbicide Adjuvants* is the 13th edition of the biennial publication and contains 779 entries from 38 companies. The first edition of the *Compendium* was assembled in 1992 and contained 76 entries from 22 companies. What accounts for such growth in the adjuvant products we list? There are a combination of factors. First, foliar herbicide applications continue to be important. Second, growers need to optimize herbicide efficacy to discourage herbicide resistance. Third, there have been great advancements and innovations in herbicide adjuvant chemistry. Fourth, many adjuvants combine multiple adjuvant groups blended into a single product for greater functionality. Finally, growers are better informed about adjuvants and the value they provide. While the *Compendium of Herbicide Adjuvants* is published every two years, the associated website is updated more frequently. This *Compendium* organizes adjuvant products by type (such as nonionic surfactants, crop oil concentrates, etc.). And each listing includes the product name, manufacturer/distributor, principal functioning agents, use rates, and comments. Most listings do not include percent "active ingredient" since an industry-wide standard has not been established for the composition of these materials. However, the Council of Producers & Distributors of Agrotechnology (CPDA) has developed a voluntary certification program that requires adjuvant products to meet 17 separate benchmarks for adjuvant composition. For more information about CPDA and a list of certified products, see page 63.

Adjuvant Toxicity

"Toxicological Risks of Agrochemical Spray Adjuvants: Organosilicone Surfactants May Not Be Safe," Christopher A. Mullin, Julia D. Fine, Ryan D. Reynolds and Maryann T. Frazier, *Frontiers in Public Health*, Vol. 4, 2016.
Citation at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4862968/
Excerpt from the abstract:

> Adjuvants generally enhance the pesticidal efficacy and inadvertently the non-target effects of the active ingredient. Spray adjuvants are largely assumed to be biologically inert and are not registered by the USA EPA, leaving their regulation and monitoring to individual states. Organosilicone surfactants are the most potent adjuvants and super-penetrants available to growers. Based on the data for agrochemical applications to almonds from California Department of Pesticide Regulation, there has been increasing use of adjuvants, particularly organosilicone surfactants, during bloom when two-thirds of USA honey bee colonies are present. Increased tank mixing of these with ergosterol biosynthesis inhibitors and other fungicides and with insect growth regulator insecticides may be associated with recent USA honey bee declines. This database archives every application of a spray tank adjuvant with detail that is unprecedented globally. Organosilicone surfactants are good stand alone pesticides, toxic to bees, and are also present in drug and personal care products, particularly shampoos, and thus represent an important component of the chemical landscape to which pollinators and humans are exposed. This mini review is the first to possibly link spray adjuvant use with declining health of honey bee populations.

"Ethoxylated Adjuvants of Glyphosate-Based Herbicides are Active Principles of Human Cell Toxicity," R. Mesnage, B. Bernay and G.-E. Séralini, *Toxicology,* Vol. 313, No. 2-3, pages 122-128, November 2013.
http://www.gmoseralini.org/wp-content/uploads/2012/11/2012.-Mesnage-et-al.-Ethoxylated-adjuvants-of-glyphosate-based-herbicides-are-active-principles-of-human-cell-toxicity.pdf
From the abstract:

> Pesticides are always used in formulations as mixtures of an active principle with adjuvants. Glyphosate, the active ingredient of the major pesticide in the world, is an herbicide supposed to be specific on plant metabolism. Its adjuvants are generally considered as inert diluents. Since side effects for all these compounds have been claimed, we studied potential active principles for toxicity on human cells for 9 glyphosate-based formulations. For this we detailed their compositions and toxicities, and as controls we used a major adjuvant (the polyethoxylated tallowamine POE-15), glyphosate alone, and a total formulation without glyphosate. This was performed after 24 h exposures on hepatic (HepG2), embryonic (HEK293) and placental (JEG3) cell lines. We measured mitochondrial activities, membrane degradations, and caspases 3/7 activities. The compositions in adjuvants were analyzed by mass spectrometry. Here we demonstrate that all formulations are more toxic than glyphosate, and we separated experimentally three groups of formulations differentially toxic according to their concentrations in ethoxylated adjuvants. Among them, POE-15 clearly appears to be the most toxic principle against human cells, even if others are not excluded. It begins to be active with negative dose-dependent effects on cellular respiration and membrane integrity between 1 and 3ppm, at environmental/occupational doses. We demonstrate in addition that POE-15 induces necrosis when its first micellization process occurs, by contrast to glyphosate which is known to promote endocrine disrupting effects after entering cells. Altogether, these results challenge the establishment of guidance values such as the acceptable daily intake of glyphosate, when these are mostly based on a long term in vivo test of glyphosate alone. Since pesticides are always used with adjuvants that could change their toxicity, the necessity to assess their whole formulations as mixtures becomes obvious. This challenges the concept of active principle of pesticides for non-target species.

Analysis of Issues Surrounding the Use of Spray Adjuvants with Herbicides, David Bakke, U.S. Forest Service, U.S. Department of Agriculture, revised January 2007.
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_045552.pdf
As the introduction indicates, "[t]his paper is intended to serve as a source document for basic information concerning adjuvants commonly used with herbicides." It is not intended as a risk assessment though it does provide some hazard information. The fourth section of this paper describes hazards by adjuvant, including two tables that list the results of standard acute toxicity testing in mammals and aquatic species.

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CTC contacted the individuals below to gather information for this investigation.

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