Group Interview
Developing Agrochemical Formulations
- New Challenges, Solutions and Trends

Stepan Company
Structured Surfactants as Rheology Modifiers in Agricultural Product Formulations
Discover the advantages of selecting LignoTech co-formulants

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Europe:
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NO-1701 Sarpsborg,
Norway
Tel: +47 69 11 80 00

America:
LignoTech USA, Inc.
100 Grand Avenue
Rotschild,
WI 54474, USA
Tel: +1 715 359 6344

Asia:
Borregaard S.E.A. Pte. Ltd. (S)
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Singapore 068530
Telephone +65 6778 0008
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Disclaimer: If some advertisements and product profiles in this issue contain references to active ingredients still under patent protection in certain countries, such content are deemed inapplicable to those countries.
About Stepan Agricultural Solutions

To help meet ever-changing market dynamics, Stepan Agricultural Solutions offers a robust pipeline of innovative products and actively seeks to be the strategic supplier of choice for your agricultural chemical needs. Our global research network and geographic footprint is such that we can effectively meet the needs of our customers around the globe. In addition, our industry-leading, in-house formulation expertise in emulsifiable concentrates, microemulsions, suspension concentrates and dry products provides a value-added service to help solve customers’ most difficult challenges.

phone: 800.745.7837
email: techserv@stepan.com
web: www.stepan.com

Stepan
Agricultural Solutions
Today's increased global demand for food, feed, fibers and biorenewable fuels, coupled with climate change and the need to conserve natural resources, presents complex challenges for the agricultural industry. The industry's response has been to focus on technology enhancements in three critical, interdependent areas — biology, chemistry and sustainability — and to enhance productivity through the use of agricultural chemicals.

**Major Technologies and Products**
Stepan Agricultural Solutions leverages the company's core technologies of sulfonation, alkoxylation, amidation, oxidation, quaternization, and polymerization to deliver a complete line of products that meet our customers' needs.

Stepan offers a broad product portfolio including, but not limited to, dispersants, emulsifiers, solvents, and specialty blends:

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<td></td>
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Stepan Company is committed to innovation and new product development in partnership with our customers. In listening closely to our customer's needs, Stepan is focused on the continued development of environmentally-sustainable solvents, improved adjuvant technologies, and our novel polymeric dispersant technology.

**Digital Tool Box**
We know immediate access to information and ease of use is important when making product selection. Rely on Stepan Company to offer you the right tools. Our most recent development, the Online Product Attribute Library (OPAL), is a customized private portal that is ideal for formulators looking for a more comprehensive technical data set, which includes chemical structure, fundamental surfactant properties, and advanced performance properties.

**Agricultural Solutions Manufacturing and R&D Sites**

![Map of Stepan's manufacturing and R&D sites around the world](image)
History of structured liquids

Surfactants in the bulk aqueous phase self-assemble into various aggregate forms, such as lamellar, hexagonal or multi-lamellar vesicles (figure 1). This phenomenon is largely driven by the surfactant concentration and chemistry. These various phases impart unique physical properties to the surfactant solution, particularly at high concentrations where shear-thinning suspensive systems can be obtained.

First appearing more than 30 years ago, examples harnessing the self-assembly of surfactants are numerous across many disciplines. In 1985, multi-lamellar vesicles were used in laundry liquid to suspend sodium tripolyphosphate crystals, allowing higher loading of the builder than previously attainable. Although these systems can be employed by using high surfactant loadings, it was discovered that various additives, such as salts or oils, can force the conformation of surfactants into multi-lamellar vesicles at much lower concentrations. While additives improve practicality and cost by reducing the surfactant load, they limit the scope of formulations where this technology can be used.

Structured liquids in agrochemical formulations

Herein, Stepan Company presents a novel method for preparing suspensive systems by using a combination of high and low HLB surfactants, thereby eliminating the need for additional additives. We apply this technology to agrochemicals, allowing us to develop formulations not achievable through conventional methods.

An optimized ratio of a low HLB surfactant to high HLB surfactant, in the presence of water, forms vesicles that measure approximately 100 nanometers in size, resulting in a translucent liquid. These packed vesicles create a thick fluid with high yield stress, capable of suspending a range of materials, from solid pesticides to oil adjuvants. These fluids are also shear-thinning, non-thixotropic and have high elasticity.

The conventional rheology aids found in agricultural formulations have many limitations. For example, some pesticide actives are incompatible with xanthan gum and fail to solvate regardless of how much or how long shear was applied. Xanthan gum and other rheology aids can also present incompatibilities when electrolytes are built into a formulation concentrate or when diluted into liquid fertilizers. Additionally, low pH systems can cause issues with xanthan gum, even when an acid-stable grade is used. To evaluate a structured surfactant system in low pH, a carbaryl suspension concentrate (SC) was developed and evaluated for stability against xanthan gum controls at varying pH levels. All samples containing xanthan gum showed significant separation and hard packing, while the structured surfactant formulations remained stable at an elevated temperature.
**Identifying structuring components**

To identify the optimum ratio of low HLB to high HLB surfactant, the formulation liquids are first evaluated without any component suspended. Several samples should be prepared varying the ratio of surfactants and visually inspected for stability. High shear energy is not necessary to incorporate the structured surfactants, unlike with xanthan gum and other rheology aids.

After some mixing, air would have been incorporated, and the presence of suspended air bubbles over time gives an early indication of the suspensive system. Promising samples are then placed for temperature stability testing at 54°C and for freeze thaw evaluations at -15°C. An example of sample preparation with ratios and stability observations can be seen in figure 2.

Once a ratio is identified for a structured system, the formulation can be prepared with solid pesticide particles or the liquid oil adjuvant suspended. With a suspended component, small adjustments to the HLB ratio may be necessary for an optimized formulation. The type of surfactant chosen for the low and high HLB structurants can also be selected to perform more than one function, such as a dispersant or wetting agent, for example.

**Rheological properties of structured liquids**

To determine if a strong suspensive system was developed, we can characterize the rheological profile of the formulation. A four-pound per gallon atrazine SC was developed with structured surfactant technology and evaluated against a control formulation containing xanthan gum. An oscillation stress sweep of these two formulations reveals a more robust system and stronger structure at rest. Additional rheological methods were performed on the structured surfactant system, including a thixotropic loop, to show rapid recovery of the internal structure and temperature ramp to illustrate similar viscosities over a range of temperatures, compared to xanthan gum control.

**Structuring in the presence of electrolytes or oil**

Formulations can also be structured in the presence of electrolytes. It is important to start evaluating HLB ratios with the electrolyte present at the targeted level to determine which ratio will work best. A combination potassium and isopropylamine (KIPA) glyphosate salt was structured and evaluated for stability without any additional component suspended. That same structured formulation was then used to suspend atrazine particles for a combination KIPA glyphosate and atrazine formulation. The structured glyphosate-atrazine formulation showed superior dilution performance, compared to a generic KIPA glyphosate formulation tank mixed with a generic atrazine SC at the same active levels. The tank mixed material flocculated immediately upon dilution and after one hour had 7.5% separation, while the structured combination dilution had trace levels of cream sedimentation (As shown in figure 3).

An oil adjuvant can also be suspended through structured surfactant technology. Similar to structured KIPA glyphosate with suspended atrazine, rapeseed oil was suspended in KIPA glyphosate. When a generic rapeseed oil crop oil concentrate and a generic KIPA glyphosate formulation were combined without structured technology, the formulations separated, demonstrating that additional surfactant would be necessary or the materials would require tank mixing instead. In addition, both oil and

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*Figure 2. Surfactant Ratio Evaluations*

*Figure 3. One Hour Dilution Stability of Structured vs. Tank Mixed Glyphosate and Atrazine*
pesticide particles can be suspended together in one formulation concentrate, as seen in the rapeseed oil and suspended atrazine combination that was developed.

Field trial data

Stepan conducted field trials with two different structured Atrazine SC formulations, a neutral pH and low pH chassis, along with a commercial standard and xanthan control formulation. The results showed similar or improved performance in three weed varieties, using a 10-ounce per acre use rate, while comparing seven days of control against 28 days of control (As shown in figure 4).

The future work with structured surfactants will continue to focus on unique combination formulations and identification of advantages over existing conventional technology.

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3. Tai Ho Tan, Build Liquid Detergent Compositions, EP0074134, 1984
We do not only give solutions, we make tailor made suits

SURFACTANTS

- Manufacture of a wide line of surfactants.
- Solutions for Formulation.
- R & D: Know-how and Ability to develop biodegradable and sustainable surfactants.
- Special blends in surfactants to simplify the formulation of A.I. and Adjuvants.

ADJUVANTS

- Innovative Technology.
- Development for specific markets.
- Development of countertypes.
- Products that exceed commercial standards.

Francisco Albo / mail@polakgrupo.com / +52 (55) 19460500 Ext. 1566 / Mobile. +52 (55) 18005964
Developing Agrochemical Formulations - New Challenges, Solutions and Trends

Q1. What are the new challenges facing agrochemical formulation development, potential solutions and future trends?

**Syngenta:** Resistance of pathogens or pests to chemical agents is not a new issue facing the agrochemical industry but it is one that remains a key challenge for agrochemical formulation development. With resistance comes the continued need for identification of new active ingredients and subsequently the need to formulate them into usable products. All the simple molecules have been discovered, so the pipeline of new compounds is trending to be increasingly complex — higher molecular weight, more diverse chemical functionality and multiple chiral centers are not uncommon. This subsequently imparts additional complexity on both manufacture of the active ingredient and in producing formulations that exhibit the desirable biology, application and shelf-life characteristics.

In my opinion, the fundamental solutions haven’t and won’t change. It’s about application of sound scientific know-how to work around the challenge. Through industry leading formulation science, Syngenta is able to offer some of the best and yet most complex products in the marketplace. Formulations containing five, six and even seven active components in a single premix are common in Syngenta’s product portfolio. These products provide the convenience and dose accuracy of a single premix with multiple modes of action, providing broad-spectrum control of pests. The technical hurdles of physically and chemically compatibilizing multiple active ingredients are done during formulation development, to mitigate these issues occurring in the mix tank at application.

The responsibility to produce new products that meet and exceed stewardship performance standards is an additional formulation challenge, whether it be reducing spray drift for aerial or ground spray application, dust reduction for seed treatments or improved operator safety. As formulation chemists, we’re looking to utilize innovative surfactant and coating technology to build in or tank mix additives that benefit or sustain biological activity, whilst addressing environment challenges and the safe use of pesticides.

**BASF Crop Protection:** Challenges in formulation development should be discussed in the context of product development and how customers experience our products.

What makes a good product? From a farmer’s perspective, a product should be robust, flexible to use, efficient and performing, cost competitive, convenient, safe and without residue concerns.

Developing robustness and flexibility in various weather conditions, such as rain, sun and wind, remain challenging for formulation development. To address these challenges, we focus on improvements in wash off, uptake, UV decomposition and off-target movements of active ingredients. Chemists develop polymeric stickers, surfactants, UV absorbers or drift reducing agents through proper formulation technology.
These improvements not only help a farmer run his operations profitably, but are also a crucial part of BASF’s sustainability strategy.

Other formulation trends are spurred by application constraints, such as low water volume or water quality, and from new application technologies, such as drones. Consequently, products must often be refined and adjusted so that inherent properties of the active ingredient, e.g. solubility and mixing compatibility, are managed effectively.

Arysta LifeScience: Modern agrochemical formulation development has faced significant challenges not only from a technical perspective, but also regulatory and market demands. The main challenges are:

- The increasing demand for formulation quality, including the compatibility of multiple active ingredients in a single formulation and the controlled crystal growth of active ingredients.
- The increasing regulatory pressures. Most regulatory authorities demand formulations that have minimal impact on the environment, which requires favorable ecotoxicity profiles with biodegradable additives, reduced use rate, and minimal pesticide residues on crops after spraying.
- The cost-effectiveness of new formulations.
- While it is costly to develop new pesticides, formulation innovation has become a means to address the above challenges. For future trends, formulation innovation should not be separated from the improvement in application technologies. Instead, application technologies, such as precision agriculture, will also play a key role in reducing chemical drift and using pesticides effectively.

Q2. What are the key factors in agrochemical formulation technology innovation?

What initiatives did your company take to drive its innovation?

Syngenta: Customer experience is a primary focus for development of any Syngenta product. To a large extent, this and responsible environmental stewardship is what drives our formulation technology innovation. Biological efficacy, application behavior and shelf-life stability are obviously core product performance attributes. Stewardship features associated with toxicological endpoints, such as residues, runoff and acute toxicity, are equally important to advance our understanding, and, subsequently, to continue to develop technology solutions to support the safe use of pesticides.

Within Formulation Development at Syngenta we look to leverage knowledge and external interactions across the organization. By partnering with our commercial teams, we’re able to coordinate visits of our development scientists with channel partners, retailers and growers to see and hear firsthand how products perform. With this, we gain further insight in understanding the challenges and performance improvement needs to enhance their experience and agronomic practices. Additionally, our development scientists work closely with product stewardship and regulatory teams to ensure foresight on regulatory and environmental concerns. This subsequently defines our technology innovation to provide step-change improvements for items like reducing dust-off for seed treatment or reducing spray drift through formulation or application technology enhancement.

BASF Crop Protection: Innovations in formulation technology are derived from novel physicochemical presentations of active ingredients. Combining agrochemical formulation know-how with technologies from other disciplines drives this innovation approach. At BASF, central research units such as Advanced Materials & Systems Research, Bioscience Research and Process Research & Chemical Engineering offer a variety of technologies, which we systematically link to crop protection formulation research and innovation projects. Using these resources, we derive new encapsulation concepts or polymeric solubility...
promoters for active ingredients. Our colleagues from Bioscience Research closely collaborate with formulation labs on biological crop protection projects to develop novel product solutions.

We also foster partnerships with universities and research companies to combine their expertise with our formulation capabilities.

Digital technologies are becoming an integral part of R&D, resulting in quick access to clean data and new imaging methods. These tools will speed up processes and enable new pathways for formulation innovation.

**Arysta LifeScience:** Formulation technology innovation should address the current and future technical challenges generated by technology, regulatory authorities and the market. An advanced delivery system and the adjuvant technology will be the key areas in formulation innovation through integration with precision agriculture technology.

Arysta LifeScience R&D has global footprints, including in North America, Latin America, Europe, Africa and Asia Pacific. Our in-depth expertise covers agrochemical and biosolution formulations, seed treatment, and analytical capability to deliver customized solutions. The R&D teams are highly motivated and actively work on formulation innovations that meet increasingly stringent regulations and provide green and integrated solutions for growers.

Arysta LifeScience R&D actively works on formulation technology innovation that includes but is not limited to:

- Improved formulation quality with broad-spectrum control
- Enhanced biological efficacy by combining with application technology to improve grower yields
- Combatting herbicide-resistant biotypes with multiple modes of action (MoA) contained in a stable, fully optimized and user-friendly formulation
- Environment-friendly inerts with favorable ecotoxicity profiles to deliver high-performing and cost-effective formulations

**Q3. What do you think of the important role of adjuvants for formulation technology innovation? How can adjuvants drive its innovation?**

**Syngenta:** Formulating active ingredients involves balancing several competing factors such as physicochemical stability, regulatory profile and biological efficacy. Adjuvants can play an important role in this by boosting bio-performance and improving the environmental profile of a product. In turn, adjuvants help to realize the maximum potential of our active ingredients.

Traditionally, adjuvants have been used as uptake enhancers, but by carefully studying aspects of product delivery we now know that uptake is only one of a number of loss mechanisms that contribute to product performance. As such, we now utilize adjuvants to fulfill a range of roles including use as retention aids, spreading enhancers, rain-fastness aids and drift-reducing agents.

Innovation in adjuvant technology will continue to play an important role in addressing targeted delivery of pesticides to maximize crop capture and potentially further improve the environmental profile of products.

**BASF Crop Protection:** Adjuvants are the “salt in the soup” of any good formulation and are needed to manage inherent physical active ingredient properties and associated aspects.

Moreover, they play an important role in designing and tuning of product properties, for example, retention, spreading and uptake.

In addition to physicochemical formulation aspects and biological efficacy-improving features, adjuvants provide a means to influence mobility of crop protection products. Mobility control, in terms of reduced wash off, leaching and drift, is important to optimize the use rate and influence the e-fate of products.

Progress in adjuvant technology will probably not be a game changer in formulation innovation, but it is vital to new improvements in crop protection products.

**Arysta LifeScience:** Adjuvants are a key component in formulation technology innovation. Ideally, adjuvant technology should enhance the effectiveness of agrochemical formulations by improving their biological efficacy. Key research activities for formulation chemists are:

- Improving foliar performance of pesticidal formulations
- Reducing the formulation waste that is caused by either bouncing off from leaves during spraying or drifting from targeted crops

To this end, Drift Reduction Technology (DRT) has become increasingly interesting with a focus on developing effective drift retarders and enhancing spray quality control.

Arysta LifeScience has implemented short-term and long-term plans to develop internal application technologies and initiate the investigation of adjuvants in formulation development. The application technology will assist formulators in screening adjuvants to improve pesticide uptake through leaf cuticles. This new capability will enable chemists to reduce the number of testing prototypes required in field efficacy trials.

Arysta LifeScience will also explore new collaboration opportunities and work with external solution providers to further enhance adjuvant technology.

**Q4. Which agrochemical formulations will see the best growth prospects? Which will face significant competition from other formulations or technology?**

**Syngenta:** Biocontrol products are based on naturally occurring compounds: minerals, microorganisms or plant extracts. They are used for biotic stress management in controlling fungal and
bacterial diseases, arthropod pests, nematodes and weeds. Biocontrols can offer new modes of actions and high specificity for target organisms. In light of resistance and regulatory challenges, there is great potential for this segment of agrochemistry, and, subsequently, it’s an area of intensive research and product development activity. The synergistic use of biocontrols alongside chemical products may help manage the onset of resistance.

The challenge for the formulation chemist is that the active components tend to be produced commercially via fermentation processes. Consequently, the technical-grade active material typically contains large amounts of fermentation excipients, e.g., proteins and carbohydrates. These excipients can impact the product storage or application performance characteristics, necessitating additional formulation science insights in order to meet the performance standards of chemical products.

It’s unlikely in the short term that biocontrols will comprehensively exclude the need to supplement agronomic practice with conventional chemical products. At this moment in time, there just aren’t enough biocontrols developed that provide comparable efficacy or spectrum control to chemical products. But the investment in research and development is rapidly advancing this technology space.

**BASF Crop Protection:** The leading formulation technology by volume is SL (Soluble Concentrate) technology used in non-selective herbicides, followed by EC (Emulsifiable Concentrate) technology and SC (Suspension Concentrate) technology used in a broader range of indications. These liquid technologies account for roughly three quarters of total market volume. Growth of these formulation types depends mainly on regional market development and crop and corresponding technology preferences, and less on the specific technology.

Other technologies such as OD (Oil Dispersion) and CS (Capsule Suspension) formulations are garnering more interest. Both technologies are used if more prominent techniques fail or if special tactics are needed to manage active ingredient properties.

**Arysta LifeScience:** An agrochemical formulation consists of single or multiple active ingredients with other inert additives to form a chemically and physically stable mixture. When a formulation is developed, the type of formulation is determined by the physchem properties of the active ingredients. To determine a type of formulation, a formulator should also consider market facts, such as regulatory recognition and end-users’ preferences for specific regions.

The current trend is focused on the development of sustainable premix formulations, which include multiple active ingredients for a broad spectrum of control and ease of use. This leads to the increasing complexity of new formulations and technical challenges in improving compatibility. Generally speaking, agriculture technology should not be isolated from advanced technology in other industries. Advanced delivery systems are a key technology innovation and will contribute to resolving the challenges. Advanced delivery systems should be leveraged and integrated with the technologies that have been developed in other industries, such as pharmaceutical, cosmetics and materials science, with cost-effectiveness.

Environment-friendly formulations have also received increasing attention. The current focus for the agriculture industry is to utilize co-formulants with favorable ecotoxicity profiles; remove inerts from formulations that are banned and restricted by regulatory authorities; use environment-friendly solvents to develop EC (Emulsion Concentrate), OD (Oil Dispersion) and SE (Suspo-emulsion) formulations; as well as integrate biodegradable additives.
Q5. What innovation formulation technologies/products have been launched by your company? What are the agriculture concerns solved by them?

**Syngenta:** Syngenta is continuing to expand its biocontrols portfolio. In 2013, we launched Clariva® Pn nematicide, a biocontrol based on *pasteuria nishizawae* for control of soybean cyst nematode (SCN). This has been successfully launched in the U.S. and will launch in Brazil in 2018. We took this product one step further in 2017 with the launch of Clariva® Elite Beans, a 5-way chemical and biocontrol premix formulation, combining Clariva® Pn with our market leading soybean premix CruiserMaxx® Vibrance® Beans. Clariva® Elite Beans provides broad spectrum control against SCN, in addition to early-season insects and diseases.

Polymer microencapsulation technology has been used in the agrochemical industry for decades but remains a core formulation technology, one which Syngenta has adapted across our product lines for multiple benefits. In weed control, this technology has been exploited to enhance product-application performance and achieve premix compatibility of complex mixtures of active ingredients (Acuron®, Lumax EZ® and Halex GT®). For insect and vector control, microencapsulated products have been developed that improve operator safety and exploit controlled release technology for enhanced bioefficacy (Karate Zeon®, Icon® and Actellic®).

Syngenta has a healthy portfolio of new SDHI chemistries that have been successfully commercialized in recent years. SOLATENOL™ is a potent SDHI active ingredient in a number of products, including the family of ELATUS™ products. These products provide an effective solution for treating the most important and damaging diseases of cereals, including Septoria and Rust. They provide particularly long-lasting control, compared to competitor products. SEDAXANE™ is an active ingredient that was developed specifically for seed treatment. Marketed under the umbrella brand Vibrance™, SEDAXANE™ is formulated to boost a crop’s RootingPower™, by delivering enhanced disease protection that leads to stronger and more robust root systems, which increase moisture and nutrient uptake. ADEPIDYN™ is our new broad-spectrum fungicide, marketed under the umbrella brand name MIRAVIS™. It delivers a step change in leaf spot control (such as Cercospora, Alternaria and Venturia) and excellent control of powdery mildew in many crops. ADEPIDYN™ is also highly effective against difficult-to-control diseases, such as Fusarium Head Blight, Botrytis, Sclerotinia and Corynespora, which cause severe damage on key crops.

**BASF Crop Protection:** We have a broad range of products in our pipeline with innovative formulations, such as:

- **Seltima®**
  Seltima® is a highly innovative encapsulated formulation (Capsule Suspension), specifically developed for F500® in rice. The product has a completely different behavior when reaching the leaf surface or the paddy water. On the leaf surface, where the applied spray broth is drying, the encapsulated F500® is quickly released for an optimal biological performance. The adjuvant already included in the capsule formulation ensures optimal uptake and retention. In the paddy water, the capsules will stay intact and sink to the sediment. F500® released over time will bind to the sediment and will degrade. This behavior ensures necessary safety for aquatic organisms in the paddy water.

- **Engenia™**
  Engenia™ herbicide is a next-generation formulation, representing another significant step in dicamba innovation. With a heavier molecular weight and a stronger chemical bond, Engenia™ herbicide is formulated to provide maximum flexibility with the lowest use rate of all dicamba products currently available in the market, reducing the number of trips to fields and sprayer loading time. With a lower use rate, growers can stock less product and save more space.

- **Revsol®**
  Beginning at the earliest discovery stages, this new fungicide was designed to meet both the highest level of regulatory standards and outstanding biological performance. Extensive research has shown its outstanding biological performance against a range of difficult-to-control pathogens, such as Septoria tritici and rust in cereals, in a multitude of crops. Beyond benefits for row and specialty crop growers, Revsol fungicide will also provide a new option for turf management and seed treatment markets. Pending regulatory approval, first market introductions of customized formulations are expected for the 2019/2020-use season.

**Arysta LifeScience:** Arysta LifeScience has launched a new integrated solutions program, ProNutiva®. ProNutiva® is an exclusive program that integrates biosolutions with conventional active ingredients to deliver crop solutions that meet the real-world needs of growers. This integrated technology has resulted in enhanced interaction and improved compatibility between biosolutions and agrochemical — for either premixes or tank-mixes — that go beyond current benefits expected by most growers.

To deliver innovative solutions, Arysta LifeScience R&D actively looks for technology innovation to improve formulation compatibility and bio-efficacy. The challenge of compatibility can be caused by high ionic strength media or extreme pH conditions or other factors.

Arysta LifeScience also works on advanced delivery systems through innovation, to develop value-added and differentiated products.
In a tough market, **confidence** is a rare commodity. 
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**WuXi JingFung Technology Co., Ltd**

- [www.jingfung.com](http://www.jingfung.com)
- andy.zhang@jingfung.com
- Cell: +86-13812193721 +86-510-85169316

**The Best Surfactant Supplier for SC You Want to Find!**

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<thead>
<tr>
<th>Surfactant Description</th>
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</tbody>
</table>

We did a lot of experiments for these recipes, we did the adaptation verification for each recipe with the TC from different factory and different purity. In addition to the national standard, we have also did several cycles of freeze–thaw stability experiments, stability at least 3 months in normal temperature storage, finally singled out the best surfactant and recipes.

**Dispersant advantages:**

☑️ Effectively control particle size growth, prevent creaming
☑️ Prepare high concentration and low viscosity formulation
☑️ Resistance to heat storage, long time stability
☑️ Suitable for low melting point, and low purity TC
Crop protection has become one of the key concerns in meeting the never-ending demand for food across the globe. Based on the data from 2007 to 2013, the Weed Science Society of America (WSSA) estimated the annual potential loss in the value of crops, such as corn and soybean due to weeds and pests, at $27 billion and $16 billion, respectively. In the past, such cases resulted in the loss of approximately 20% to 40% of agricultural productivity.

Identifying this increasing demand for crop/plant safety, companies have come up with agricultural adjuvants, which assist in maximizing the quality, productivity and sustainability of the agricultural production systems, disease vector management in the public health systems, and in other industrial and residential areas. These do not directly kill pests, instead, these modify certain properties of the spray solution, which improves the ability of the pesticide to penetrate, target or protect the target organism.

The concept of “green crop protection” is spreading rapidly across the globe, and it may be the future of the agricultural sector. This is driving the demand for agricultural adjuvants, as these are important to manage the increasing concern over pesticide residues on food and the problem of pest resistance. Many countries are following the trend of lowering the level of Maximum Residue Limit (MRL), and this is expected to continue in the future. Companies in the agricultural adjuvants market across the globe have launched a wide range of products that provide sustainability, crop quality and harvest flexibility benefits. By 2020, it is expected that a significant number of traditional agrochemical companies will enter this market, which will further consolidate the resource.
The agricultural adjuvants market encompasses a wide array of product types, such as activators, utility modifiers and others, including thickening agents, spreaders and stickers. The activator modifiers dominated the global agricultural adjuvants market in 2017, with a market share of more than 50% in value and more than 40% in volume. This type of adjuvant is also expected to see the best growth prospects by 2022 due to its application on a large-scale to increase the efficiency of crop protection products. These modifiers work to improve the biological performance of pesticides by altering their characteristics: be it the particle size, thickness of the spray or herbicide solubility in the spray solution. Though comparatively less utilized, spray modifiers change the physicochemical characteristics of the spray solution.

Primarily, these agricultural adjuvants are mixed with herbicides and fungicides, to be sprayed over various crop, such as fruits, vegetables, cereal and oilseeds, among others. Utilization of these adjuvants in insecticides has been comparatively less until now. These adjuvants reach the crops/farms through various methods of propagation for crop protection. More than 40% of the times, the foliar spray method is used for propagation. Currently, North America is at the forefront in the agricultural adjuvants market, with high market penetration in countries such as the United States (U.S.), Canada and Mexico, due to the growing consumption rate of adjuvants in these countries.

The American Society for Testing and Materials International (ASTM) and Council of Producers and Distributors of Agro technology (CPDA) are regulating adjuvant products in the U.S., whereas in Canada, particularly for pesticides, Health Canada regulates their usage under the Pest Control Products Act (PCPA), which makes it mandatory to register the pesticide before it can be used in Canada. Agricultural adjuvants in the country are regulated by the Pest Management Regulatory Agency (PMRA) section of Health Canada.

Stringent regulatory norms regarding the Maximum Residue Limit (MRL) in the North American and European regions are expected to guide the adjuvants demand in the Asia-Pacific region, especially in China, Japan and India, in the coming years (as shown in figure 1). The Asia-Pacific region is anticipated to show the highest growth rate over the next five years because of the increased number of initiatives and investments.

The growth of the agricultural adjuvants market as a whole is being driven by certain factors such as the increasing consumption of agrochemicals (for both crop and non-crop use), awareness regarding the hazards of using chemical pesticides, and the development of Integrated Pest Management (IPM) techniques, among others.

Agrochemicals and agricultural adjuvants go hand-in-hand, wherein the high consumption of agrochemicals will support the growth of adjuvants (as shown in figure 2). Thus, agrochemicals can be said to have promoted the development of this industry. However, there are certain challenges that are inhibiting the overall growth of the agricultural adjuvants market (as shown in figure 3). To reduce the environmental effects, consumers are increasingly using methods such as manual removal, application of heat, covering of the weed with plastic using taps and lures, and other similar techniques. Some authorities have put a hold on or banned certain kinds of ingredients used for making these adjuvants. Talking about the opportunities that exist in the market, there is an increasing demand for oil-based pesticides due to their ability to stay in the crop/plant for a longer duration. Also, the demand for bio-based adjuvants has witnessed a sharp rise, primarily due to the general perception that bio-based adjuvants are safer and more environment friendly than traditional adjuvants.
A highly fragmented one, the market currently involves several small and large players from the agrochemical industry. AkzoNobel N.V., Brandt Consolidated Inc., Croda International PLC, Evonik Industries Ag, Helena Chemical Company, Huntsman International LLC, Nufarm Limited, Solvay and The DOW Chemical Company are some of the prominent players in the agricultural adjuvants market. The market is widely considered as an emerging market by governments of various countries and players operating in the market. Significant efforts are being made by them, primarily in the form of business expansion strategies and product launches, to explore the potential opportunities that exist in this market and compete with the other players (as shown in figure 4).

Brandt Consolidated Inc. (U.S.) constructed a new 2,000-square-foot formulations laboratory in Illinois, U.S., in February 2018 to carry out development and testing. Croda International Plc (U.K.) opened their Centre of Innovation for Formulation Science at the University of Liverpool’s new Materials Innovation Factory (MIF) in November 2017 to utilise state-of-the-art automated technologies to enhance their capabilities. Earlier, in October 2017, the company opened a new plant in New Castle, Delaware, which can produce renewable and bio-based non-ionic surfactants. Aqua-Yield, a company based out of the U.S., introduced a new herbicide adjuvant “Nano-Pro” in November 2017. Each 2.5-gallon container of Nano-Pro will be able to service 80 acres of farmland for weed control. The NutriAg Group launched a spray adjuvant “BB5 Platinum” in February 2016. This adjuvant minimizes water pH, water hardness, water conductivity, leaf surface pH and surface tension.

According to BIS Research report, the agricultural adjuvants market is expected to reach $3,594.1 million and 312.8 kilotons by 2021 at a compound annual growth rate (CAGR) of 5.5% and 7.1%, respectively, from 2016 to 2021. This growth is attributed to the increasing demand for IPM techniques and the adoption of green crop protection concepts globally. Moreover, with the growing adoption of precision farming techniques, the use of agricultural adjuvants is also expected to increase, as precision farming techniques use adjuvants for the appropriate agrochemical application.

Though agricultural adjuvants have been available for a couple of decades now, there remains wide scope for innovations and technological advancements in the field. From the global perspective, these adjuvants have been successful to a large extent in enhancing the quality and quantity of agricultural produce. The key focus now should be on the pre-determined dosage of the adjuvants and their applications on farms and crops.
Brief Introduction

Jiangsu Sevencontinent Green Chemical Co., Ltd. is a national high-tech ISO9001 and ISO14001/EMAS OHSAS 18001 accredited factory major in producing and exporting pesticides & their formulations.

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- Flutriafol
- Epoxiconazole
- Difenoconazole
- Cyproconazole
- Hexaconazole
- Triadimenol
- Triadimenol
- Penconazole
- Diniconazole
- Azoxystrobin

HERBICIDES
- Metribuzin
- Clethodim
- Glufosinate ammonium

PLANT GROWTH REGULATORS
- Paclobutrazol
- Uniconazole

INSECTICIDES
- Buprofezin
- Etofenprox

Add: North Area of Dongsha Chem-Zone, Zhangjiagang, Jiangsu, 215600, China
Tel: +86-512-58678398 58918566
Website: www.sevencontinent.com
E-mail: info@sevencontinent.com
Nortox: Change and Challenge in Agrochemical Formulation Development in Brazil

Formulation professionals are increasingly facing big challenges in the development of new products containing a mixture of multisite active ingredients. In Brazil, where the climate is hot and humid for most of the year, conditions are perfect for the emergence of pests, which daily grow more resistant to the formulations available in the market. To keep a check on application dosages to reduce costs and waste, and damage to the environment, there is growing demand for the development of products that contain a mix of compounds with complementary biological activities for effective crop protection.

This is a challenge for developers, as often the active ingredients are incompatible. Some proposed mixes are hard to formulate. At this moment, the formulator must search for compatibility solutions within the portfolio of ingredients available through the suppliers of surfactants. Nowadays, we have at our disposal a wide range of materials approved by national regulators that can be used in the development of agrochemical formulations. When faced with perplexing cases, it is necessary to test compositions containing different chemical dispersants, solvents, emulsifiers, wetting and rheology agents. In addition, sometimes it is necessary to try some unusual blends to solve a given problem.

In fact, there is no ready recipe for the compatibilization of active ingredients in a formulation, because compounds of different chemical natures also require surfactants of distinct natures. And in some cases, it is not possible to achieve the perfect balance just by choosing the “suitable” surfactants. At this moment, the formulator has an even bigger challenge—to choose a less conventional type of formulation instead of the most traditional ones.

A survey done by our regulatory affairs team presents clearly how reluctant we still are to use the less common formulation types. There are approximately 1,948 agrochemical formulations registered up to 2018 in Brazil. Of them, 1,561 (i.e. 80%) are part of the big five formulation types: Suspension concentrate (SC), emulsifiable concentrate (EC), soluble concentrate (SL), wettable dispersible granules (WG) and wettable powders (WP). The other 387 (i.e. 20%) are spread among 34 minor types of formulations. The circle chart presented below summarizes the distribution of the registered products by formulation types (As shown in figure 1).
Although less explored, some types of formulations in this minor group have interesting properties, which can be the technological solution for challenging mixtures. In theory, it is possible to keep each of the compounds in different chemical environments in one pot, so there is no direct interaction between the active compounds at the same phase, resulting in a bipartite system, each one with the suitable surfactant chemistry. For example, in suspo-emulsions (only 7 formulations registered in Brazil; 0.36% of total), an active ingredient co-exists as a suspension in an aqueous phase with another liquid water-insoluble active compound as an EW emulsion, or even an active dissolved in a water-immiscible solvent (also as an EW emulsion). This is a great strategy to reconcile liquid-insoluble compounds with insoluble solids in an aqueous-based formulation. The problem with complex formulations is the fact that the projects involve a much longer development period in the search for stability (shelf life), process and fine-tuning set of components.

Taking advantage of the less explored formulation types and the concept of "in can" adjuvancy towards performance improvement, the oil dispersions (OD, 13 registered in Brazil; 0.67% of total) are formulations with great potential. As the carrier oil (aromatic, paraffinic, vegetable oils and methyl esters of vegetable oils) often acts as an adjuvant, it aids in a better spray retention, spreading and foliar uptake. This feature opens up the possibility of using smaller concentrations of the active ingredient to perform, as well as the traditional suspension concentrates (SCs) of higher concentrations. All this reflects in lower cost of the final product by replacing expensive active compounds with a cheaper set of solvents and surfactants.

Once a mix of active compounds becomes a really robust and physically and chemically stable formulation, we began a new journey that goes through a few more bottlenecks prior to registration. These bottlenecks are intrinsic to the development process and part of the praxis of a formulator chemist in order to achieve an approved formulation. One of the most important parameters to be achieved deals with the ecotoxicological profile of formulated products, which must meet a series of guidelines and suitable values to get the registration approved. We will not go into details about the ecotoxicological tests because it is beyond the scope of this article. However, there are general concerns that formulators keep in mind about the choice and combination of ingredients to ensure a lower ecotoxicological profile of the final product. Therefore, we are always looking for ingredients with good biodegradability and less danger to the environment. Ingredients with a renewable and eco-friendly profile are always welcome as candidates to introduce into new formulas. Nonetheless, being green is not enough. These greener alternatives must have equivalent performance, market availability and feasible cost. This is the only way to have a final product, which is more sustainable but can still compete with products obtained from traditionally applied surfactants and raw materials. This is what we observe in the efforts made by the chemical specialties supplier companies, which are always releasing newer and modern materials trends.

Finally, it is evident that there are available tools and strategies to be adopted by formulation chemists in the search for solutions to complex mixtures of active ingredients. Choice of suitable components, use of underrated and sometimes forgotten formulation types, and partnership with suppliers of formulation ingredients are essential to meet the demands of the market and contribute to increased crop yield and productivity.

2. Special acknowledgment to the agronomist engineer Jéssica Guizeline (regulatory affairs specialist) for the data survey.
Borregaard LignoTech: How Lignin-based Solutions Can Help with Formulation Challenges

By Stig Are Gundersen, Ph.D., Technical Application Manager, Specialty Agriculture at Borregaard LignoTech

Formulation technology has a vital part to play in the development of efficacious and economical crop-protection products. This includes identifying regulatory-favorable and supply-secure co-formulants that can deliver performance through a wide-range of solid and liquid product types. Also important are strong environmental drivers for more sustainable and safer co-formulants that pose inherently lower risk for producers and end-users.

Lignosulfonate is a randomly-branched, chemically multifunctional biopolymer, produced as a value-added co-product of cellulose production. It is derived from biomass, most often wood/timber, as a chemical derivative of lignin. The focus in this article is lignosulfonate produced by sulfite processing, where the product is based on Scandinavian softwood (spruce) and liberated from the raw material (lignocellulose) as a sulfonated water-soluble polymer. The monomeric building blocks of lignin, as well as the sulfonated backbone of a generalized lignosulfonate structure, are depicted in figure 1.

It should be recognized that lignosulfonate is established as a non-toxic, sustainable and regulatory-favorable (e.g. REACH-exempt, EPA-approved) performance-chemical that is used in many commercial products and applications. These applications include: plasticizer for concrete; crystal growth inhibitor in lead-acid batteries; dispersant and colloidal stabilizer for dyestuffs; binder for animal feed; and (of main importance in this article) binder, dispersant, complexing agent and crystal growth inhibitor for agricultural formulated products. The common denominator in these applications is lignosulfonate’s capability to absorb at interfaces, thus imparting one or more of a dispersing, binding, complexing and crystal-growth modifying activity into the final product.

We now present some examples to demonstrate lignosulfonate’s value addition in various crop protection formulations.

Wettable Powders (WPs)

A wettable powder (WP) is a comparatively simple formulation supplied as a powder blend of active ingredient(s) with co-formulants such as dispersant(s), wetting agent(s), and filler(s). Lignosulfonate’s main function here is as a dispersant, where it facilitates dispersion of the active ingredient into an aqueous phase prior to spraying. Due to safety concerns, mainly due to their dustiness, WPs are being phased out by the more complex water dispersible granules (WGs) and suspension concentrates (SCs). Despite this, WPs still represent a significant proportion by value of the crop protection formulation market, and lignosulfonate is often the best available option due its excellent dispersing and colloidal stabilizing characteristics for a wide range of active ingredients.

Borresperse NA imparts superior suspensibility for many active ingredients and tank mix scenarios. In the case of more challenging situations, perhaps involving multiple active compositions or difficult tank mix scenarios, a more refined lignosulfonate product will usually work well. Ufoxane 3A, Ultrazine NA, and Greensperse S9 produced by Borregaard are examples of such products.
Water Dispersible Granules: Multi-Active formulations by extrusion

Water dispersible granules (WGs) formulated with multiple active ingredients are now the rule rather than the exception in the agrochemical industry, due to challenges with pesticide resistance, as well as the desire to incorporate different mode-of-action pesticides within the same product. Lignosulfonate is often the best option for spray-dried and extruded WG products containing multiple actives; this is due to its dual functionality as a binder for the dried product and a dispersing/suspending agent for the spray suspension.

A successful WGs should effectively bind the active particles together in a matrix that is strong enough to allow storage, handling and transportation of the product, but weak enough so the granules disperse easily in an aqueous tank-mix. This balance between granule strength and dispersibility is controlled through judicious selection of parameters, including the lignosulfonate type/concentration, wetting agent type/concentration, fillers present, and the granule processing route/conditions. For a product that contains multiple actives with disparate physical properties, a refined lignosulfonate such as Ufoxane 3A (low sulfonation, high hydrophobicity) usually provides high suspensibility in standard hard water without compromising the dispersibility. This is illustrated in table 1 for three actives compositions of varying nature (*2 weeks at 54 °C).

Improving WG Disintegration with Greensperse S9

In some cases, it is challenging to disperse a WG, particularly an extruded WG routinely dispersed in fertilizers or comparatively hard water. A series of functionalized lignosulfonates have been designed to offer solutions in such scenarios. The Greensperse S range contains a comparatively high number of sulfonic acid groups reacted into a lignosulfonate polymer, thus increasing its ionic composition. The following examples (table 2) illustrate, for thifensulfuron-methyl and copper oxychloride extruded granules, the power of using Greensperse S9 for this application effect. Greensperse S9 adds value over and beyond Ufoxane 3A under such challenging tank mix situations.

Suspension Concentrates (SCs) and Suspoemulsions (SEs)

Many active ingredients are formulated as liquid suspension concentrates (SC), and to a lesser extent, suspoemulsions (SE) and oil-in-water emulsions (EW). Lignosulfonate is utilized in these formulation types due to its ability to act as a stabilizer for one or more phases present in the product. In the case of an SC, lignosulfonate functions as a milling aid through its interfacial action; it also acts as a colloidal stabilizer and/or crystal growth inhibitor for the bulk product.

Choosing the optimal lignosulfonate for an SC formulation will depend mainly on the physicochemical properties of the active ingredient(s). A melting point versus solubility graph is a convenient way to position products (figure 2). In general, the lower the melting point, the more susceptible the formulation is to melting points and solubilities of different products. When selecting a stabilizer, one must consider the melting point-solubility space of each product in the formulation. This information is typically provided by the active ingredient supplier. Read the entire page to understand the significance of these properties.

---

Table 1. Suspensibility and dispersibility of extruded granules formulated with Ufoxane 3A

<table>
<thead>
<tr>
<th>FORMULATIONS</th>
<th>Suspensibility (%)</th>
<th>Dispersibility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Stored*</td>
<td>Initial Stored*</td>
</tr>
<tr>
<td>60% Mancozeb + 10% Azoxystrabin 10% Ufoxane 3A</td>
<td>90 82</td>
<td>93 90</td>
</tr>
<tr>
<td>60% Mancozeb + 5% Azoxystrabin 5% Tebuconazole 10% Ufoxane 3A</td>
<td>91 92</td>
<td>96 94</td>
</tr>
<tr>
<td>57% Metribuzin + 15% Flumioxazin + 5.2% Chlorimuron-ethyl 12% Ufoxane 3A</td>
<td>96 98</td>
<td>95 96</td>
</tr>
</tbody>
</table>

Table 2. Dispersibility of extruded granules in different electrolyte solutions. Comparison between Greensperse S9, Ufoxane 3A and a naphthalene sulfonate condensate.

<table>
<thead>
<tr>
<th>FORMULATIONS</th>
<th>Dispersibility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75% Thifensulfuron-methyl 20g/L MgSO4</td>
</tr>
<tr>
<td>6% Greensperse S9</td>
<td>77 97 81 92</td>
</tr>
<tr>
<td>6% Ufoxane 3A</td>
<td>55 82 65 96</td>
</tr>
<tr>
<td>6% Naphthalene Sulfonate Condensate</td>
<td>35 69 57 85</td>
</tr>
<tr>
<td>80% Copper Oxychloride</td>
<td>Deonised Water 2.5g/L MgSO4 5g/L MgSO4 12.5g/L MgSO4</td>
</tr>
<tr>
<td>10% Greensperse S9</td>
<td>91 92 85 76</td>
</tr>
<tr>
<td>10% Ufoxane 3A</td>
<td>90 81 84 60</td>
</tr>
<tr>
<td>10% Naphthalene Sulfonate Condensate</td>
<td>84 81 74 61</td>
</tr>
</tbody>
</table>

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point, the more challenging it is to control against crystal growth in the bulk product. For low melting actives, a special product, such as Vanisperse CB, is required to stabilize the suspension. This is demonstrated in the change in particle size data for linuron and propanil SCs before and after accelerated storage testing (table 3). For higher melting actives, Borresperse NA or Ultrazine NA is usually sufficient for providing crystal growth inhibition, rheological control and good dispersing behaviour.

Table 3. Examples of crystal growth stability of some suspension concentrates stabilized with Borresperse NA or Vanisperse CB (*sulfonated naphthalene-formaldehyde condensate, **2 weeks at 54 °C followed by two freeze-thaw cycles.

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Lignosulfonate</th>
<th>Wetting Agent (g/L)*</th>
<th>Initial d50 (μm)</th>
<th>Initial d90 (μm)</th>
<th>After Storage d50 (μm)</th>
<th>After Storage d90 (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin (450 g/L)</td>
<td>Borresperse NA</td>
<td>5</td>
<td>2.3</td>
<td>5.7</td>
<td>2.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Tebuconazole (450 g/L)</td>
<td>Borresperse NA</td>
<td>2</td>
<td>3.1</td>
<td>6.8</td>
<td>3.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Metamitron (450 g/L)</td>
<td>Borresperse NA</td>
<td>5</td>
<td>1.2</td>
<td>4.3</td>
<td>1.3</td>
<td>5.4</td>
</tr>
<tr>
<td>Imidaclopid (450 g/L)</td>
<td>Borresperse NA</td>
<td>0</td>
<td>1.1</td>
<td>6.2</td>
<td>1.1</td>
<td>6.2</td>
</tr>
<tr>
<td>Propanil (450 g/L)</td>
<td>Borresperse NA</td>
<td>2</td>
<td>2.8</td>
<td>7.5</td>
<td>&gt;20</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Propanil (450 g/L)</td>
<td>Vanisperse CB</td>
<td>2</td>
<td>2.8</td>
<td>7.4</td>
<td>2.8</td>
<td>7.6</td>
</tr>
<tr>
<td>Linuron (160 g/L)</td>
<td>Borresperse NA</td>
<td>5</td>
<td>1.6</td>
<td>6.5</td>
<td>&gt;50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Linuron (160 g/L)</td>
<td>Vanisperse CB</td>
<td>5</td>
<td>1.5</td>
<td>5.3</td>
<td>3.4</td>
<td>8.5</td>
</tr>
<tr>
<td>Napropamide (220 g/L)</td>
<td>Vanisperse CB</td>
<td>5</td>
<td>1.2</td>
<td>3.2</td>
<td>1.3</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Future Technologies – Biopesticides

The biopesticide market is rapidly expanding and represents a substantial opportunity for lignosulfonate products as co-formulants. Similar to the conventional synthetic pesticide platform, lignosulfonate can function effectively as a dual binder and dispersant in biological products; its aromatic structure also provides UV protection, which is a key requirement for many biocals. Vanisperse CB and Ultrazine NA are products that should be tested in biological formulations owing to their excellent UV-protective attributes and dispersive characteristics.

Summary

- Lignosulfonate has rich history as a co-formulant for agricultural applications, including both pesticide and nutrient products.
- It continues to enjoy success in solid crop protection products, highlighted by Ufoxane 3A’s role as a superior co-formulant for multi-active WGs.
- New product development activity has been directed towards new lignosulfonate products that have specialized characteristics. Bome out of this effort has come Greensperse S9, which aids WG dispersion in hard water and typical fertilizer salts.
- Whilst lignosulfonate is often associated with solid formulations, it can also be successfully employed as a high functioning, cost-competitive co-formulant for aqueous-based liquid formulations.
- With the rise in biopesticide development, lignosulfonate is well-aligned to help solve challenges associated with the chemical and physical stability of such formulations.
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  - Malathion
  - Diflubenzuron
  - Hexachloruron

- **Pyridine Compound:**
  - Pure Pyridine
  - α-Picoline
  - β-Picoline
  - 3,5-Lutidine
  - 2,3-Lutidine

- **Chloropyridine:**
  - 2,3,5,6-Tetrachloropyridine
  - 2,3,4,5,6-Pentachloropyridine
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The crop protection market is constantly changing due to increased regulations, the growing demand for higher yields to feed the world’s expanding population, and the resistance plants have continued to build over the years to certain chemical ingredients. However, the introduction of new active ingredients for crop protection products is decreasing due to the high costs of development and registration.

To solve these challenges, the market is trending toward combining active ingredients and sustainable inert components. These formulations ultimately increase transportation efficiency and reduce costs. While alternative technologies such as bio-pesticides and bio-stimulants offer future promise, they secure only a small share of the crop protection options for growers today.

Pine chemistry-based products are a growing category of sustainable inerts that combine well with active ingredients and effectively provide crop nutrition and protection for growers. Among the crop nutrition and protection products currently available, suspension concentrate (SC) and extruded water-dispersible granule (WDG) formulations provide major advantages to growers.

Combining two mechanisms of suspension through polymeric dispersion

SC formulations are easy-to-use, water-based liquids with reduced environmental and human exposure, compared with solvent or powder formulation types. These formulations present additional challenges to chemists as higher solids and combinations of active ingredients become more desired. There are many surfactants and dispersants that perform well at lower solid concentrations, but fail as the solids increase. As the water is reduced, the particles can more easily agglomerate, causing poor suspension stability, and thus, decreased shelf life. Polymeric dispersants are an alternative that offer excellent suspension stability and can often be used to achieve the desired results.

Kraft lignosulfonates with high molecular weights are an ideal polymeric dispersant option. Thanks to the high molecular-weight nature of kraft lignosulfonates, they can provide steric stabilization in SC formulations, which is the dominating stabilization mechanism in concentrated suspensions. The long polymeric chains of kraft lignosulfonates form a physical barrier between particles. In addition, kraft lignosulfonates can interact with active ingredient particles via hydrogen bonding or π-π stacking. The optimal products are also relatively hydrophobic. High molecular weight and hydrophobicity can also create problems during the milling step, as they contribute to higher solution viscosities. As the viscosity increases, milling efficiency (or the time to reach small particle sizes) also increases. This extends the overall processing time, resulting in higher manufacturing costs. Additionally, increased processing time can cause undesirable foaming and chemical degradation of the active ingredients if they are sensitive to temperature.

One way to avoid increased processing time is to combine two kraft lignosulfonate dispersants in a ratio that gives good suspension stability, while maintaining lower viscosities. By using a combination of Reax® 907, a high molecular weight hydrophobic dispersant manufactured by Ingevity, and Kraftsperse® 25M, a hydrophobic dispersant with a low molecular weight also made by Ingevity, improved milling efficiency can be achieved (As shown in figure 1). The ratio of Reax 907 to Kraftsperse 25M should be 4:1 for optimal performance.

One of the most important components influencing the quality and stability of SC is the dispersant. With a low degree of sulfonation, kraft lignin adsorbs strongly to the active-ingredient surface and the high molecular weight offers the best steric stabilization.
Providing quicker dissolution with pallet integrity

Extruded WDGs is another rapidly growing formulation type that provides quicker dissolution, while maintaining pallet integrity. These formulations have a high loading of active ingredients, which reduce transportation costs. WDGs offer less exposure to the grower than powders, are generally easier to handle, and are a lower-cost manufacturing process compared to other granulation options. Formulation chemists are presented with challenges in achieving the desired performance properties of high-suspension stability with rapid disintegration of the granules. These two properties are diametrically opposed, making the selection of a dispersant difficult.

To achieve rapid disintegration, hydrophilic dispersants with low molecular weights are good choices but have poor suspension stability. Combining two dispersants can often be the best option. Reax® 88B, a hydrophilic low molecular-weight kraft lignosulfonate, can be used with a small amount of a hydrophobic high molecular weight dispersant, such as Ingevity’s Kraftsperse® 8828, to balance the suspension stability and disintegration of extruded WDGs (As shown in table 1).

The ratio of high sulfonation to low sulfonation of approximately 5:1 is important to balance the disintegration as measured by the number of inversions, as well as the suspension stability. The total dispersant required will vary with the active ingredients and other components but will generally be between 6 to 12% of the total formula. WDGs with 80% active ingredients can be achieved using this combination approach.

Another interesting approach to formulations of extruded WDGs is to combine two polymeric dispersants with vastly different chemistries. Kraft lignosulfonates do not effectively lower surface tension, as they are true dispersants. A class of polymeric dispersants with better wetting properties is naphthalene sulfonate condensates. Both are available as powders and are used in dry- and water-based crop protection products.

Ingevity’s Kraftsperse® DD-8 is a product that combines a kraft lignosulfonate and naphthalene sulfonate condensate using a spray-dry process. This gives different properties than if the two were either dry mixed or dry milled together. One measurable property difference can be seen in the wetting times in an atrazine 80% wettable powder. The wetting time is significantly reduced by the co-spray dried Kraftsperse DD-8, compared with the dry blend of the two dispersants (As shown in table 2).

This also aids in the suspension stability and disintegration of extruded WDGs. Enhanced wetting times often lead to better disintegration. In a chlorothalonil 80% WDG, the disintegration and suspension stability are improved with the co-spray dried Kraftsperse DD-8 (As shown in table 3).
AkzoNobel: Adsee™ ST4, A Polymeric Binder for Seed Treatment - A Sustainable Solution

By Dennis Selse, Sr Research Chemist, Agro Applications at AkzoNobel Specialty Chemicals

Seed treatment has been used for centuries, and in the beginning, the treatment often included inorganic chemicals.

During the latter part of the 20th century, both non-systemic and systemic organic fungicides and insecticides were developed for seed treatment. This has been an efficient way to protect valuable seeds from soil borne diseases and insects.

It is also more sustainable compared to foliar treatment; when the pesticide is targeted directly onto the object, it is going to protect instead of using a surplus of pesticides spread over a bigger area used to get the same effect. But the treatment has some risks and dust-off is something that has to be addressed due to the mechanical stress that the seeds are exposed to after the treatment until the planting of seeds. This is an exposure risk for workers who are handling the treated seeds and also contamination of surrounding fields when sowing the seeds.

Developing more sustainable products for the future is an integral part of AkzoNobel’s long-term strategy for growth as a responsible global company. Within months of AkzoNobel and Imperial Chemical Industries joining in 2008, a new, combined technical team was already moving towards the development of a new hybrid polymer technology for different applications.

The impetus behind this effort was to enable users of common synthetic, petrochemical-based polymers to meet corporate sustainability goals with a technology that would reduce the amount of petrochemical materials—synthetic monomers—significantly, and replace them with renewable, plant-based materials.

These would be selected polysaccharides, especially lightly modified starches based on corn, or other common starch-bearing crops.

There are a lot of synthetic binders used today as dust reducing agents in seed treatment formulations, but there are not too many good natural derived binders with a more sustainable profile. A sustainable or green product needs to have a significant natural content. Akzo Nobel’s research center in Chattanooga, USA, has invented hybrid copolymerization technology.

These hybrid copolymers are a combination of polysaccharides with synthetic monomers. The design of the polymer is very flexible and there are multiple ways of creating variations by the choice of:

- Type of polysaccharide (corn, potato etc.)
- Molecular weight of the polysaccharide
- Substitutions on the polysaccharide
- Ratio of polysaccharide to synthetic monomer(s)
- Polymer architecture-number of side chains, length of the side chains, spacing between the side chains

Akzo Nobel’s objective was to develop a more sustainable binder polymer, where at least >50% of the polymer was from renewable resources. Our legacy as part of National Starch and Chemical led us to use starch as the polysaccharide. The polymers were made by free radical polymerization. The polysaccharide moieties have repeat glucose units where the hydroxyl groups act as chain transfer agents during the polymerization. New polymers were developed by optimizing the molecular weight of the polysaccharide, synthetic monomers, ratio of the synthetic/polysaccharide monomers and other parameters. This enabled our scientists to tune polymer properties such as hydrophobicity/hydrophilicity, Tg, molecular weight etc.

The screening of polymers was done by measuring the dust-off in Heubach Dustmeter. The result was benchmarked against polyvinylalcohol/ polyvinylpyrrolidone (PVA/PVP) copolymer, which is a synthetic binder that is often used as a binder in seed treatment.

The dust-off was tested on different actives (e.g. Imidacloprid, Thiomethaxam, Azoxytrobioin, Flutriafol), which had been formulated into flowable concentrate (FS) and tested on various seeds (e.g. corn, wheat, oats, sunflower, rapeseeds). See figure 1 and figure 2.

Adsee™ ST4 is the polymer that gave the best dust reduction. Beside the dust-off characteristics, it’s also important that the binder does not affect the flowability of the seeds and make the logistics of the seeds troublesome. Another important characteristic is the germination of the treated seeds, and it should not have a negative impact on the germination. And of course, the efficiency of the active ingredient should not be negatively affected.

A flowability test was performed on treated seeds of different species and where the time for 400g of seeds to pass a funnel opening with a diameter of 12mm was measured. No detrimental effect on the flowability of the seeds was seen when FSs with and without Adsee™ ST4 were compared. The germination test of oat seeds treated with 600 g/L Imidacloprid FS showed to be unaffected as can be seen in the table 1.
Adsee™ ST4 has been designed to not affect the rheology, which makes it possible to formulate high concentrations of the product in FS. See figure 3.

Adsee™ ST4 is a non-ionic polymer and is not expected to have any detrimental effect on active ingredients as the adhesion is dipol-dipol and hydrogen bounding and not chemical bounding. To evaluate the compatibility of Adsee ST4 in an FS formulation, an accelerated heat storage test was done with 600 g/L Imidacloprid FS. The stored sample did not show any separation and the viscosity and particle size distribution didn’t show any significant changes, as shown in the tables below.

### Table 1. Germination test according to ISTA method performed by Eurofins Food & Feed Testing (Seed Lidköping, Sweden).

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Function</th>
<th>Dosage [g/L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imidacloprid</td>
<td>Active ingredient</td>
<td>600</td>
</tr>
<tr>
<td>Morwet D-425</td>
<td>Dispersing agent</td>
<td>27</td>
</tr>
<tr>
<td>Ethylan NS-500LQ</td>
<td>Stabilizer</td>
<td>12</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>Anti freeze</td>
<td>60</td>
</tr>
<tr>
<td>Adsee ST4</td>
<td>Binder</td>
<td>45</td>
</tr>
<tr>
<td>Xanthan gum</td>
<td>Rheology modifier</td>
<td>1.2</td>
</tr>
<tr>
<td>Rhodorsil 426R</td>
<td>Defoamer</td>
<td>2.2</td>
</tr>
<tr>
<td>Nelikaan Brilliant Blue</td>
<td>Colourant</td>
<td>60</td>
</tr>
<tr>
<td>Water</td>
<td>Solvent</td>
<td>Up to 1L</td>
</tr>
</tbody>
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**Conclusions**

Adsee™ ST4 has proven to be a new sustainable binder solution for the seed treatment application based on innovative, nonionic hybrid polymer technology.

Adsee™ ST4 is/has:
- A Maltodextrin/VP copolymer with high binding capacity for FS formulation to the seeds
- A natural derived copolymer containing >50% renewable content
- Proven in lab tests to reduce the dust-off from coated seeds for several actives in the form of FS, and performance has been better or equal to the control (PVP/PVA copolymer)
- Compatible with FS formulations and is suitable for both Tank-mix and In-can formulations
- A low viscous product with good handling properties
- No risk labeling and is NOT classified as dangerous goods
Rainfall is a common and serious factor causing the loss of pesticides, especially in tropical areas that typically have intense precipitation. The development of rain fastness adjuvants is of great significance to avoid pesticide loss caused by rainfall and enhances its efficacy, thus reducing the pesticide usage amount.

The so-called rain fastness is the ability of the chemicals to resist removal or wash-off due to rainfall. Currently, popular mechanisms for rain fastness include “spreader” concept and “sticker” concept. “Spreader” is aimed at increasing the coverage of pesticides on the foliar surface, and then bringing pesticide quick uptake. “Sticker” could enhance the pesticide retention via a formed polymer film or net-like structure. Dow Chemical has a wide portfolio of technology in terms of wetter and polymer film former. It is a great opportunity to provide high quality products with superior performance to the market.

Herein, the sticker concept is used for pesticide retention enhancement in Figure 1. The incorporated polymer sticker with a specially designed structure and dosage will generate lots of domains on the plant leaf, which are formed by the polymer chains and pesticide particles. The polymer chain provides strong interaction with the plant leaf and pesticide particles, thus fixing the pesticide onto the plant surface strongly to resist rainfall wash-off. The properly added dosage ensures the pesticide particles are not coated by polymer film, maintaining the contact action for some pesticides, such as a fungicide.

In order to explore high performance adjuvants, Dow Industrial Solution Asia Pacific team managed to build up the rain fastness testing method in the lab, and then validate testing method reproducibility and repeatability, which could support quick adjuvant performance evaluation in a facile way. It is found that a lot of factors should be considered during testing procedure set-up, such as substance to mimic leaf surface, equal simulated rainfall to each sample etc; the testing parameters are confirmed after several rounds of trials and equipment debugging.

Through the testing procedure, lots of “stickers” are screened on their rain fastness performance. POWERBLOX™ ADJ-35 and POWERBLOX™ ADJ-65 are two outstanding products, showing excellent performance. Taking 430g/L mancozeb SC as a starting material, lab-testing results were shown in Figure 2. The obvious difference can be seen before (Figure 2a) and after (Figure 2b) rainfall. The adjuvant introduction into the pesticide system helps dramatically for active ingredient retention on the substance.

Adjuvants rain fastness performance to various tested pesticide formulations are summarized in Table 1. The incorporating of...
adjuvant indeed endows pesticides with stronger rainfall resistance, to make them retained for a larger amount. Moreover, the highlighted feature of both products is that they are under U.S. EPA registration, having a good regulation profile.

The practical application effect is critical to reflect adjuvant performance. Third-party capability was utilized to conduct field-testing on weed control effect. Some 18% Glufosinate SL was used as a herbicide and eleusine indica was the weed target. After herbicide dilution was sprayed for 30 minutes, an equal amount of tap water to simulate rainfall was sprayed to each testing zone. Some 15 days later, the weed effect was shown in Figure 3. Compared to CK sample without herbicide, the other two samples exhibited excellent weed control effect. When it came to the comparison between no adjuvant sample and adjuvant added sample, less green tint could be found when POWERBLOX™ ADJ-35 was incorporated. It is demonstrated that the introduction of POWERBLOX™ ADJ-35 can offer excellent rainfall resistance for pesticides, thus providing higher efficacy.

As it is known, field-testing results is statistic data. Actually, four testing zones were kept for each sample, and the weed effect was calculated by three typical plants for each zone. From the average result in Figure 4, it can be seen that the adding of POWERBLOX™ ADJ-35 will improve the efficacy 15-20% for each plant weed effect and aerial parts fresh weight and improve around 50% on underground parts fresh weight.

### Table 1. Pesticide rain fastness performance with and without adjuvant

<table>
<thead>
<tr>
<th>Adjuvant</th>
<th>Mancozeb (Retention/%)</th>
<th>Pyraclostrobin (Retention/%)</th>
<th>Difenoconazole (Retention/%)</th>
<th>EPA Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Adjuvant</td>
<td>8</td>
<td>67</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>POWERBLOX™ ADJ-35</td>
<td>85</td>
<td>90</td>
<td>99</td>
<td>Non-food use only</td>
</tr>
<tr>
<td>POWERBLOX™ ADJ-65</td>
<td>46</td>
<td>84</td>
<td>97</td>
<td>Under 40 CFR 180.920</td>
</tr>
</tbody>
</table>

In a word, POWERBLOX™ ADJ series efficacy enhancers with excellent rain fastness and an eco-friendly profile are recommended for use in water-borne formulations, as in-can additive with dosages around 6wt%, and in solvent-borne formulations as tank mix additive with dosage around 20wt%.

![Figure 3. Weed control after 15 days](image)

![Figure 4. Weed control statistic result](image)
Agrovista: UK Spray Application Technology Expands Into European Markets

UK-based agronomy company Agrovista is stepping up the marketing of its Discovery range of spray application aids across Europe, after rolling out a successful development program across its home territory.

The move follows a comprehensive series of trials across continental Europe that have demonstrated the value of Discovery products in enhancing the efficacy of plant protection products across a range of crops and climates.

This has reinforced findings from up to two decades of research work and commercial use in the UK, and more recently, in northwest Europe.

Many leading UK growers now use Discovery products as a matter of course to maximize the potential of their agrochemical applications. This market alone is understood to be worth several millions of pounds to Agrovista.

Peter McDonald, Agrovista’s head of commercial strategy and Discovery Europe, believes there is considerable market potential to be tapped in the target countries, which include Central Europe, Russia, Ukraine and Turkey.

“Discovery products are an increasingly important and growing part of Agrovista’s business, and the brand has the potential to become very significant indeed,” McDonald says.

He adds, “We have had a presence for some 10 years in north-west Europe, and two to five years in the target countries—all at different stages. We estimate European revenues have the capacity to be five times that of the UK, perhaps more in the longer term.”

A breakthrough currently looks as achievable at any time in the recent past. “We believe growers in these countries will be just as receptive as the UK, perhaps more so, given that commodity prices in continental Europe are currently under a lot of pressure,” McDonald says.

“They can see what we have achieved in the UK, and that’s pretty impressive. By enhancing the effects of agrochemical products, our Discovery range can deliver significant increases in yield for a relatively modest outlay, valuable at any time and particularly when returns are being squeezed,” he adds.

In addition, proven spray application aids, such as Discovery products, are set to play a more important role in growers’ spray programs. “Several active ingredients are under pressure, both from the legislators and pathogen resistance,” McDonald says.

“Some will disappear, others will be subjected to tighter dose restrictions. We need to ensure we can extract
maximum performance from the chemistry that remains. We know that pesticide efficacy is affected by poor water quality, and reduced by poor application and inadequate coverage, retention and uptake on the target surface. Discovery products overcome these challenges, improving the level of control and increasing yields," he adds.

Agrovista has selected three products to spearhead the European campaign. Companion Gold, which claims the largest market share of any adjuvant in the UK, is a multi-functional adjuvant and pod sealant most often used with glyphosate. Remix is an additive that improves the performance of residual herbicides and Velocity is designed to improve the coverage and uptake of fungicides (see panel for further details).

"Each Discovery product undergoes a rigorous pan-European research and development program prior to launch," McDonald says. "We put great emphasis on conducting quality trials with our distribution partners and respected research organizations in each country we market. This way we can ensure consistent performance and efficacy."

Discovery products are manufactured by Agrovista UK. The company’s roots were firmly established over 60 years ago, yet it still maintains its traditional values of professionalism, cutting edge technology, and customer service, he says.

"As an adjuvant and fertiliser manufacturer, as well as a major crop protection distributor, we are uniquely placed in our understanding of the agrochemical market. We recognize that the face of agriculture is changing rapidly and are equipped to respond to these changes before they happen – not when it is too late," he adds.

The business is part of Agrovista BV, a leading European organization in the field, itself part of the international Marubeni Corporation, which has representative offices and is well known in all of the countries where Agrovista is looking to expand.

"We work very closely with Marubeni in these new markets," he says. "Most people won’t have heard of Agrovista, but being part of Marubeni, prospective clients will know we are a reliable and trusted partner they will be comfortable doing business with."

**Discovery R&D**

Each Discovery product has completed a multi-year pan-European R&D screen to ensure efficacy.

This includes laboratory studies and high-quality trials conducted across a range of sites throughout Europe, from Turkey to Lithuania and from France to Russia, including Agrovista’s 30ha site at Stoughton and a large-scale herbicide site at Maidwell in the East Midlands region of the UK.

This geographical spread encompasses a wide range of soil types, climatic conditions and crops, including cereals, maize, oilseeds, pulses, sugar beet and potatoes, ensuring Discovery products have been tested to perform in all market locations.

To ensure maximum performance, Agrovista has designed and developed its own self-propelled sprayers (Figure 1), enabling researchers to test products and methodology under replicated farm conditions.

Research is carried out and evaluated by Agrovista’s own trials team, universities, government research institutes, and leading contract trials organizations.

In addition, Agrovista works in conjunction with the world-renowned NIAB-TAG Silsoe Spray Applications Unit to optimize practical spray advice.

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Figure 1. Agrovista’s self-propelled sprayers
Discovery range

- Spray application aids
- Tank-mixed spray additives and adjuvants
- Designed to enhance plant protection product efficacy
- Targeted formulations, focused by pesticide requirement
- Improved spray application
- Supported by pan-European R&D program
- Comprehensive efficacy data to support use

Key Discovery products

Companion Gold is the perfect partner for glyphosate and can also be used as a pod sealant in oilseed rape and legumes.

This multi-function adjuvant is a tallow-amine-free formulation containing a blend of drift-reducing polyacrylamide polymers, pH buffers, water conditioners, antifoam agents and humectants.

Companion Gold has been proven over many years to significantly enhance the performance of glyphosate (Figure 2). More recent trials suggest those benefits could be even greater when using the new tallow-amine-free glyphosate formulations, which Agrovista trials suggest may be less effective at controlling grass weeds under challenging timings.

Remix is designed specifically to enhance the performance of residual herbicides. It contains a unique blend of highly refined paraffinic oil, hexahydric alcohol ethoxylates and long-chain fatty acids.

The product reduces spray drift, ensures even deposition of the spray over the soil surface and increases adsorption to soil particles, reducing crop effects, while increasing residual weed control.

Figure 2. Companion Gold has been proven to significantly enhance the performance of glyphosate.

Over the past 10 years, the addition of Remix to a residual herbicide stack has improved black-grass control by 11% in Agrovista trials.

Velocity is designed to enhance fungicide application and efficacy in a range of crops. It reduces spray drift, ensuring accurate spray deposition over the target surface.

Organosilicone surfactants ensure complete coverage, while humectants slow droplet drying. Fatty acid methyl esters improve penetration though the outer waxy layers of the leaves.

Results from eight fully replicated trials across Europe over a four-year period using the label dose have shown that adding Velocity can reduce fusarium levels by half, compared with straight fungicide when applied at the key early flowering spray timing.

Adding Velocity also allows spray volumes to be halved in certain situations without any loss of efficacy.

* For further details on Agrovista’s Discovery range, please go to www.discovery-eu.com
Spray application aids
Adjuvants & spray additives

Improve the performance of your plant protection products

Made in Britain and supported by a pan-European R&D programme, our targeted adjuvant and additive formulations improve efficacy and increase yields.

The Discovery range
- **Roller** - Provides even coverage and excellent crop safety
- **Velocity** - Improve disease control and increase yields
- **Remix** - Reduce drift & enhance deposition of residual herbicides
- **Companion Gold** - 6 way mode of action adjuvant and pod sealant
- **KryptoN** - Advanced foliar nutrition
- **Nelson** - For use with Sulfonylurea and fop and dim herbicides
- **Stingray** - pH buffer and water conditioner

For more info: Tel: +44 (0) 115 939 0202 Email: peter.mcdonald@agrovista.co.uk www.discovery-eu.com
GarrCo Products Inc: Spray Drift and the Role of Adjuvants and Formulations

Spray drift is currently the big thing with adjuvants and formulations. Today, more people live in rural areas and often put pressure on government regulators to make sure pesticide drift never happens. Nobody wants spray drift. One of the main applicator goals is always no unwanted effects or contamination of non-target organisms (NTOs).

The most common way that drift occurs is when the wind blows small droplets away from the target. Pesticide labels often forbid application when winds are above a certain speed, such as 16 or 20 kph (10 to 12 mph), but a strong wind is not always the culprit. Pesticide labels also prohibit application when wind speeds are less than 4.8 kph (5 mph). If there is no wind to mix the air, a temperature inversion can occur that suspends spray droplets and moves them unpredictably.

Historically, spray drift has been a problem for herbicides, where a thimble full of certain herbicides diluted in a spray load can injure a non-target crop. Pesticide labels often forbid application when winds are above a certain speed, such as 16 or 20 kph (10 to 12 mph), but a strong wind is not always the culprit. Pesticide labels also prohibit application when wind speeds are less than 4.8 kph (5 mph). If there is no wind to mix the air, a temperature inversion can occur that suspends spray droplets and moves them unpredictably.

Commercial spray nozzles produce a range of droplet sizes. Since droplets are spherical or nearly spherical, their diameter is used to measure their size. The Volume Median Diameter (VMD) is the most common droplet measurement and defines the droplet diameter in microns where half of the spray volume contains smaller droplets, and half contains larger ones. A more important measurement for the smaller driftable droplets is the VD (0.1), which defines the droplet diameter where 10% of the spray volume contains smaller droplets, and 90% contains larger ones. The higher the VD (0.1), the lower the chance for drift.

The perpetual question when applying pesticides is what is the ideal droplet size. Of course, the question really should be the droplet spectrum and not a single droplet size. Experts cannot simply answer because the ideal spectrum depends on many factors, including the pesticide mode-of-action, spray mixture, targeted pests, crop, risk of drift, environmental conditions, application method, as well as application parameters and goals. However, all agree that applying larger droplets will reduce drift (Table 1).

### Table 1. The bigger they are, the harder they fall

<table>
<thead>
<tr>
<th>Droplet Diameter (microns)</th>
<th>Droplet Class</th>
<th>Time to Fall 3.05 Meters</th>
<th>Lateral Movement in 4.83 kph Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Very fine</td>
<td>252 seconds</td>
<td>335</td>
</tr>
<tr>
<td>100</td>
<td>Fine</td>
<td>10 seconds</td>
<td>13.4</td>
</tr>
<tr>
<td>240</td>
<td>Medium</td>
<td>6 seconds</td>
<td>8.5</td>
</tr>
<tr>
<td>400</td>
<td>Coarse</td>
<td>2 seconds</td>
<td>2.6</td>
</tr>
<tr>
<td>1,000</td>
<td>Extra Coarse</td>
<td>1 second</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Source: Modified from Akesson and Yates.

One of the myths about drift is that nozzles alone are the best way to manage off-target movement. That myth would be more valid if nozzles performed the same way in commercial field applications as they do with water sprays in wind tunnels. The industry needs to look at what happens after the droplet leaves the nozzle. The title of a recent article was “Think outside the tip.” Nozzles, nozzle orientation, and spray pressure cannot do everything. One limitation of nozzles is that they cannot control the properties of the spray water that often changes with concentrated spray mixtures. For example, commonly used surfactants, oils, formulation ingredients, and even fertilizers added to spray mixtures can change the properties of spray water and decrease droplet size. Adding an effective DRA can help control the properties of spray water.
**Drift reduction adjuvants**

A drift mitigation or drift reduction adjuvant (DRA) is a material used in liquid spray mixtures to reduce spray drift. The driftable fraction of the spray is the small droplets, often characterized as 150 μm in diameter or less. The primary function of a DRA is to reduce the driftable fraction, but most have other benefits, such as increased retention and reduced evaporation. The general rule is that the larger the droplet, the less drift and more deposition on the target.

The first widely used DRAs were polyacrylamide polymers, sometimes referred to as polyvinyl polymers. Polyacrylamide DRAs are commonly sold in dilute 1 to 2% formulations or as emulsions in 20-fold higher concentrations. The most common alternative to polyacrylamides is guar gum and its derivatives. Both of these polymer types are effective and mix well when formulated properly. Polymers increase the viscosity of the spray water from breaking into smaller droplets as it exits the nozzle, and counteract the negative effect that some tank-mixtures have on droplet size. The higher viscosity increases retention by reducing droplet rebound off the leaf surface. Polymers also act as humectants and keep the spray deposit moist longer.

Commercial DRAs often use the terms drift reduction and deposition interchangeably. A deposition aid is a material that improves the ability of agrichemical sprays to deposit on targeted surfaces, essentially the more on the target, the less drift off-target. Recently, experts have started to group DRAs into two broad categories: rheology modifiers that delay spray fan break-up and increase droplet resistance to shattering, and water-immiscible droplet technologies such as emulsified oils and specialized surfactants that accelerate spray fan break-up (Table 2). Paradoxically, breaking the spray fan more slowly and more rapidly can result in less driftable fine droplets.

**Table 2. Main types of commercial drift reduction adjuvants**

<table>
<thead>
<tr>
<th>Rheology modifiers</th>
<th>Water-immiscible droplets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycrylamide polymers</td>
<td>Emulsified vegetable oils</td>
</tr>
<tr>
<td>Starch-based (guar gum)</td>
<td>Emulsified petroleum oils</td>
</tr>
<tr>
<td>Cellulose-based polymers</td>
<td>Specific surfactants</td>
</tr>
</tbody>
</table>

**Formulation solutions**

The most important new weed management technologies are the new herbicide-tolerant crops that allow for new uses of auxin herbicides with long histories of drift problems. To address this issue, BASF and Monsanto registered new formulations of dicamba, with claims of lower volatility and less spray drift when applicators follow label directions. The Monsanto formulations use the diglycolamine salt of dicamba and acetic acid, or its salt, as a proton scavenger to reduce volatility. Monsanto uses the monoethanolamine salt of glyphosate in combination with dicamba. BASF formulations use the BAPMA (N, N-Bis-(3-aminopropyl) methylamine) salt of dicamba. BASF has sold dicamba for over 50 years, and according to our count, this is their sixth new dicamba formulation. Dow registered a unique formulation that contains the choline salt of 2,4-D alone and the dimethylamine salt of glyphosate. These new salts and formulations have greatly increased the value of these old auxin herbicides over existing formulations and generic alternatives.

The new product formulations also rely on an array of extensive and somewhat complicated application directions that include nozzle type and orientation, spray pressure, boom height, droplet size, wind speed, ground speed, air temperature, buffer zones, and approved DRAs and other tank-mixtures posted on an associated website.

**Fine droplets are not always fine**

The bottom line is that fine spray droplets are not fine. The applicator should always have the spray system set up correctly, use best application practices, follow label directions, and use low drift formulations, if available. Using an effective DRA is also very important and will reduce the production of driftable fine spray droplets and drift complaints.
Rayonier Advanced Materials: •ARBO® AGRO - Advanced Materials for Innovative Formulations

By Guillaume Roubault
Sales & Technical Services, Lignosulfonates at Rayonier Advanced Materials
guillaume.roubault@rayonieram.com

Lignocellulosic Matrix Is New Black

Innovative, optimized, safe:
Simply put, today’s crop protection formulations face the challenges of maintaining optimal efficiency, precision and safety. This must be achieved while respecting the earth and its inhabitants, and working with the latest scientific discoveries and standards. One of the major challenges lies in feeding the world’s ever-increasing population. To help address this serious problem, we’ve exploited petroleum, which, once refined, offers effective solutions. It took nature millions of years to produce it, a basic material of finite quantity. Why not focus on another complex blend, one that is renewable and eco-friendly? Why should we wait for the current industry standard to jeopardize the future of our crops? Why not look for new environmental alternatives, such as wood-based chemistry?

The Forest Is Our Future

Sustainable equals responsible:
At Rayonier AM, we strongly believe that nature can offer answers to some current problems; we actually believe it is the future. In our world-class bio-refineries, we separate the constitutive elements of wood to provide our customers with highly pure bio-sourced polymers. We manage our forests, and our raw materials in responsible and renewable ways to ensure a thriving ecosystem. The entire tree is transformed into useful compounds and green power. Softwood sourced locally from countries such as Canada and France guarantees consistent and superior raw material, ensuring outstanding finished products.

One Highly Functional Additive - Infinite Applications

An additive’s innovation lies in its functionality and efficiency, and the best adjuvants offer several intrinsic functional features, besides demonstrating exceptional performance.

Figure 1. •ARBO® AGRO lignosulfonates can be used both as a binder and a dispersant.
For this reason, we produce *ARBO® AGRO* lignosulfonates from lignin in our state-of-the-art biorefineries. *ARBO® AGRO* adjuvants result from advanced depolymerization of the lignocellulosic matrix.

**As a binder:**

Within the tree, cellulose and hemicelulose are strongly bound together by lignin. Because of its high molecular weight, *ARBO® AGRO* lignosulfonates can be used as a binder; a natural glue (as shown in figure 1).

As such, the use of *ARBO® AGRO* is a good example of biomimicry and is particularly suitable for WG/WP formulations, because it re-dissolves easily in water, maintains uniform dispersion and is thus cleverly used as a dispersant and a binding agent.

**As a dispersant:**

Lignin is hydrophobic by nature. To extract it from wood pulp (cellulose), we employ a sulfonation process to render the lignin hydrophilic. Once sulfonated (addition of -SO3-) on reactive sites, the lignin becomes completely water-soluble and possesses surfactant properties (as shown in figure 1). Combined with its high chemical and thermal stability, *ARBO® AGRO*’s harmless nature logically makes it compatible with crop nutrition and protection. Our high sulfonation rate produces an economically viable, performing and sustainable bio-based surfactant.

**As a solution:**

Deficiencies of micronutrients such as iron, zinc and manganese are widespread in many crops. These deficiencies are not always visible. Our inability to detect and treat them drastically affects productivity and yields. *ARBO® AGRO* ammonium lignosulfonates allow for numerous complexation sites such as carbonyls, carboxyls and sulfonic acids to be made easily accessible to oligo-elements (as shown in figure 2).

**Do more:**

Preventing chemical waste during production is the primary principle of green chemistry. Ammonium lignosulfonates possess the significant advantage of recycling, recovering or reusing the ammonia in NPK production. Smartly adding doped *ARBO® AGRO* lignosulfonates with micronutrients such as zinc, manganese, copper and iron to fertilizer formulations can help reduce toxic co-formulants and prevent deficiencies.

Contrary to EDTA, *ARBO® AGRO* is able to carry both useful cations and provide binding-dispersing properties, as well as tolerate a wide range of pH levels (as shown in figure 3A).

*ARBO® AGRO* complex active fractions penetrate superficial tissues (cuticles) at a much higher rate than other complex-forming agents, even synthetic ones. This serves to ensure increased micronutrient bioavailability. Acting as true vectors, lignosulfonates deliver micronutrients to the right place without harming the plant or its environment.

In addition to its dispersing, binding and complexing additive physicochemical properties, lignosulfonates are known to possess an agronomic interest (as shown in figure 3B). In each nutrition formulation, they are beneficial for the majority of crops. Lignin, the second most abundant renewable biopolymer on the earth, consists of phenolic building blocks that can alter oxidation mechanisms, such as competitive inhibition of peroxidases. Lignosulfonates play a significant role in two key mechanisms of plant physiology — rhizogenesis and flowering.

*ARBO® AGRO*. From And With Nature: Biocontrol Is Our Best Fit

**Biofriendly:**

The effectiveness and success of live active compounds are
well established. Although they present certain issues, they are fundamentally subject to the same challenges as more traditional formulations. Additives derived from living systems remain the best choice for formulating coherent biocontrol solutions. Scientific and technical literature have emphasized the excellent compatibility of lignosulfonates in biocontrol solutions. Therefore, lignosulfonates are excellent candidates that allow effective optimization and improvement without inhibiting the properties of microorganisms. Like many biocontrol active ingredients, powders are obtained by spray-drying. Thus, the spray-drying step could be combined to reduce final costs on powder-based biocontrol solutions.

One of the benefits of working with lignosulfonates is that it does not induce phytotoxicity. Specifically, this means foliar spray can be applied without yellowing or burning the leaves. Lignin is an organic polymer chemically close to humic substances, which is why it affects the soil quality in a positive way. Since soil is the farmer’s most valuable asset, it is imperative that the innovative formulations preserve and enhance it.

**ARBO® AGRO** Advanced Materials: An Innovative Choice With Rayonier AM

**Collaborating with partners:**

Lignin’s exact structure remains a mystery to chemists, leaving much room for innovation. We’re not simply looking for customers, we want to build partnerships with those who share our vision of innovation. Innovation means thinking outside the box, envisioning solutions that no one else has thought of before. Innovation means using materials with leading-edge properties. Innovation means testing and solving. At a time when crude oil prices continue to rise at an alarming rate (100% in two years), we must work together to come up with viable and sustainable alternatives. Only together can we progress effectively and find answers that will help us develop more responsible, yet, effective agricultural methods.

To achieve this, we are constantly improving our processes and practices to ensure that our lignosulfonates maintain an excellent level of quality. We also work closely with our clients and keep abreast of the latest trends in the agrochemical industry. The advanced performance of our lignosulfonates lies mainly in our ability to extract the highest lignin content possible.

With **ARBO® AGRO** now available in various salts: ammonium, ammonium calcium, sodium and potassium, it’s time to discover advanced materials to innovate your formulations.
LIGNIN IS THE WORLD’S SECOND MOST ABUNDANT AND RENEWABLE NATURAL POLYMER PRODUCED IN WOOD.

- Bio-sourced & sustainable adjuvants for bio-stimulation, nutrition and crop protection formulations.
- Alternate and flexible global sourcing solution.

Our lignosulfonates are co-produced with specialty cellulose and sourced from sustainable forests in Canada and France. These softwood forests ensure an eco-friendly source of renewable wood.
The modern pesticide formulator faces many challenges. Sometimes customer needs and desires conflict with government regulation, formulation of company policies, and the chemical behavior of increasingly complex pesticide blends.

A limited number of stable formulation types are available for any given active ingredient. For each acceptable formulation type, only a limited panel of inert ingredients are available. The selection of inert ingredients is further restricted by customer preferences for products already in use in their plants.

Beyond issues related to the manufacture of pesticide products, additional constraints influence formulation decisions. Public pressure, applicator requirements, as well as issues of cost, perception, safety, and legislation, all influence formulation parameters. Increasingly, manufacturers are seeing the need for higher active loading in formulations to deliver added value to customers, accompanied by a minimal increase in inert formulation ingredients to keep the costs low.

Safety concerns related to both product handling and environmental impacts are increasingly important considerations in selecting formulation type and inert ingredients. Wherever possible, hazardous ingredients should be minimized to reduce the personal protective equipment (PPE) requirements for individuals handling pesticides during the manufacture and application. Moreover, ingredients that may not threaten human handlers, but those that pose an environmental threat, are being phased out of formulations.

Classic workhorse surfactants like tallow amine alkoxylate derivatives, alkylphenol alkoxylate derivatives, and tristyrylphenol alkoxylate derivatives are under scrutiny due to the growing body of data demonstrating their toxicity to aquatic life and other small animals.

Formulators must consider the competing pressures when developing a new pesticide product, besides customer demands, safety and efficacy at each step of the process. The first decision a formulator must make is the type of formulation to be created. In general, the type of formulation is dictated by the solubility of each active ingredient in a solvent, with water being preferred over oils and other organic solvents that possess odors and may be somewhat toxic. If a formulation contains a water-insoluble solid active, then formulators typically turn to suspension concentrates (SC) or suspoemulsions (SE).

While chemistry and customer preference play the largest role in determining the formulation type, subsequent decisions on how to create a formulation are based on other considerations too. Each formulation type demands particular inert functions, but within the broad realm of each function, for example, wetting agents or dispersants, the available products are limited by regulatory lists. A final formulation must meet the regulation in many jurisdictions; thus, ingredients must be present on many lists. Even within a single jurisdiction, multiple lists may apply, such as the requirement for materials on both 40 CFR 180 subpart D and TSCA in the United States.

To remain within the regulatory parameters, formulators and customers often prefer to use the same inert ingredients in multiple formulations. Materials kept in stock by formulators and used routinely can be used predictably in formulation development and are preferable to manufacturing plants due to familiarity. However, the time-tested inert ingredients used by a formulation chemist are not always the best-suited products for the job, especially when newer, more advanced inert ingredients are available.

Consider the case of water-insoluble active ingredients that are used in Suspension Concentrate (SC) and SuspoEmulsion (SE) formulation types. In SC and SE, a critical inert function is the suspension of very small active ingredient particles in water. The system must be well-planned to prevent particles from agglomerating through the use of a dispersing agent. In SE formulations, this task is complicated by the need to emulsify droplets in water-immiscible liquid ingredients. Often, both SC and SE need a co-dispersant to support the performance of the main dispersant.
Historically, the most widely used dispersants possess significant aromatic character and function as either individual small molecules that coat particles or as more or less linear polymers that wrap around suspended materials. More recently, there has been a trend in dispersant technology toward comb polymers. These products consist of a polymeric “backbone” structure to which numerous “teeth” are appended at fairly regular intervals; molecular models of the backbones and teeth resemble combs. In suspensions, the backbone portions of the dispersant molecules interact with suspended particles, effectively coating each particle with a layer of dispersant. The teeth of the dispersant molecules project out into the liquid phase of the suspension. Comb polymers inhibit active ingredient particle agglomeration primarily by steric hindrance, in which dispersant teeth physically impede contact among the suspended particles. When the teeth of a comb polymer carry a charge, particle interaction can be further prevented by charge repulsion.

While mainstream comb polymers continue to afford acceptable, and even excellent, dispersion in some newly developed systems, novel chemistries are needed for problematic formulations. The increasing complexity of active ingredient combinations and a frequent applicator preference for liquid formulations call for next-generation dispersant chemistries.

One new dispersant, TERSPERSE® 2612 dispersing agent (As shown in figure 1), a product of Huntsman Performance Products, combines the advantages of aromatic dispersants and comb polymer dispersants into a comb polymer with aromatic groups on the backbone. The aromatic groups can interact more effectively than other comb polymer backbones with aromatic-containing active ingredients. Additionally, TERSPERSE® 2612 dispersing agent’s amine alkoxylates teeth are particularly effective in creating and maintaining spatial separation between suspended active ingredient particles in SC and SE.

Data from a broad range of active ingredient SC prove the superior stability of formulations containing TERSPERSE® 2612 dispersing agent. In the cases of difficult-to-formulate actives, such as metribuzin and imidacloprid, TERSPERSE® 2612 dispersing agent can significantly retard particle size growth during extended storage (As shown in figure 2). When used in conjunction with other dispersants, it sometimes enhances formulation stability over either dispersant alone. TERSPERSE® 2612 dispersing agent is an outstanding dispersant for SC formulations, and it is also highly effective in SE formulations. The addition of 1% or less TERSPERSE® 2612 dispersing agent to an SE can prevent the growth of suspended particles in the aqueous phase, and it does not interact negatively with emulsifiers used in such formulations.

As new, more-complex active ingredients are introduced into the agrochemicals market, and as the market demand for increasingly complicated combinations of actives continues, formulators will be unable to rely on older mainstay inert ingredients. For SC and SE formulations, TERSPERSE® 2612 dispersing agent, a new comb polymer with an aromatic backbone, is a problem-solver. In laboratory tests, it performs well; it is approved for food-crop use in the US, has demonstrated low environmental toxicity, and SCs made with it hold up in field trials, in comparison with other dispersant-containing products. Formulators now have a new tool in the limited inert toolbox for tackling difficult agrochemical formulations containing solid water-insoluble active ingredients; TERSPERSE® 2612 dispersing agent should be placed among other go-to dispersants on the formulator’s shelf.

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Figure 1. Structure of TERSPERSE® 2612 dispersing agent

Figure 2. Particle size data for a 3lb/gal metribuzin SC showing a significant reduction in particle growth after storage at 40°C.
Even though a report released in 2014, showed only 14% of registered products were biopesticides in China, it showed a huge market potential in the future.

In 2015, the Ministry of Agriculture of China published a national plan, where one of the key tasks was that National Plan of Sustainable Development of Agriculture (NPSDA) puts forward the volume of chemical fertilizers and pesticides used, which is to remain fixed in 2020. In 2017, the State Council released five new acts, perfecting the agricultural legislation at different levels, including registration management, production licenses, business licenses, test management for registration and labels management. These acts will change the market.

We also know about Regulation No. 1107 in the EU. The act releases a double legal effect with REACH. Unacceptable adjuvants are active substances, which have harmful effects on health and the environment. They shall not be accepted in the future. We believe the bio-based age is on the horizon.

We are strong on woody, especially with a focus on pine trees, eucalyptus and camphor trees. Our products are developed by the species. Terpinen-4-ol can be used for fumigation, 1,8-Cineole can be used as fungicides. The plant-based monomers usually effect an all-in-one function. In recent years, our export value of the crop protection market keeps growing and is set to exceed even the hygiene market.

Reviewing the issues discussed, we learn some facts from our customers: adjuvant application is a progressive process. It is an adaptable, compound treatment solution. Similar to the surfactants we export, we found the emulsion has excellent anti-evaporation and adhesion properties on aerial spraying. The adjuvants will increase the ROI for growers; hence, we are promoting them among our customers.
Global Adjuvants Company: Adjuvants for Use with Bio Control Products and Organic Production

By Gary Adkins
Product Manager at Global Adjuvants Company

The potential and continuing growth of the Bio Control (Bioinsecticides, Biofungicides, Bioherbicides, Bionematicides) market has been widely reported and is projected to reach US$6.60 billion by 2022, from $3.22 billion in 2017.

This increase is being driven by a combination of restrictions on traditional chemical controls, the increased adoption and understanding of Integrated Pest Management (IPM), resistance management and residue controls.

Organic Production is also a growth market. In 2016, there were 57.8 million hectares of organic agricultural land, and organic products with a total value of some $90 billion were sold globally, an increase of 15% compared with the previous year.

The higher price of organic inputs and the lower yields compared to chemically controlled crops, in many cases, result in a premium price being charged for organic produce. For organic products to become more widespread, this needs to be addressed. Bio Control has a synergistic and important fit with Organic Production. It offers the possibility to control diseases and increase saleable yield for organic growers in an environment of decreasing chemical control options and even fewer “traditional” products approved for organic systems.

Bio Control can work, as its increasing uptake shows, along with recent high-profile acquisitions of “biological” companies by multinationals. However, in many cases, Bio Control does not offer the same levels of disease control and/or ease of use of traditional chemical controls. Many Bio Controls are more complicated to use for the grower and must be applied more carefully and work effectively in a much narrower operational window than chemical controls. This creates opportunities for adjuvants.

For example, Entomopathogenic nematodes (EPNs) are generally applied to above-ground vegetation using conventional spray equipment, but EPNs will only survive for a few hours on exposed foliage because they desiccate quickly, and they are sensitive to UV rays. Therefore, an adjuvant that has humectant properties and some sticking properties would increase the survival of EPNs and, therefore, improve the control of the pests and the diseases they target.

Adjuvants offer an opportunity to improve efficacy and ease of use of Bio Control, but equally, Bio Control and Organic Production create their own challenges for adjuvants. "Bio Control" covers a wide range of different technologies—from plant oils and extracts, fungi, microbes to beneficial insects—so its stands to reason that there will not be one adjuvant product for all applications. The adjuvants will need to solve the application issue and, at the same time, be compatible, both in terms of tank mixing and not harming the Bio Control agent. Ideally, the adjuvant should also have regulatory approval for organic crops; otherwise, you are unable to use it in the key organic growing market. These requirements rule out many of the currently available adjuvants.

Global Adjuvants Company (GAC) is working on specific adjuvants for the Bio Control and organic markets. The first of these is Eco-Tac. Eco-Tac is an emulsifiable water formulation (EW) containing paraffin wax and comprises only components that are food safe. It is used as a sticker in combination with both conventional chemicals, and with Bio Control fungicides, miticides and insecticides in Integrated Pest Management (IPM). Crucially, it has full organic approval, with both Ecocert in Europe and NOP for North America. GAC is currently conducting extensive testing with various industry partners to ensure compatibility across a full range of Bio Control agents, including living EPNs and bacteria.

Eco-Tac contains paraffin wax that is similar to the composition of the leaf’s own waxy cuticle; this gives it perfect affinity with the leaf and no phytotoxicity. It does not damage the leaf cuticle, unlike paraffinic oils. It acts as a sticker with excellent persistence on the leaf; this keeps the active in contact with the target for longer, reduces off target application, improves rainfastness and limits evapotranspiration of the product off the leaf. Eco-Tac will also provide water conditioning benefits and anti-foam action, both of which are usually difficult to achieve when restricted to organic approved adjuvants.

Bio Control offers exciting possibilities for improving the efficiency of all crop production, especially Organic Production, but it will need specific adjuvant solutions to overcome efficacy and use issues. The adjuvants currently available will work in some cases, but much more work is needed to ensure compatibility. Just as a wide range of chemical adjuvants is now available for chemical controls, in the future, I believe we will see a new range of bio adjuvants.
Corbion: Going Green – Exploring the Potential of Biobased Solvents

The agrochemicals industry is facing an imminent challenge. With the population rising at a rapid rate, the demand for global food supplies, grains in particular, is greater than ever. Farmers are therefore facing mounting pressure to improve crop yield and quality, amidst an increasingly stringent regulatory environment. As pesticide formulators seek innovative solutions that deliver optimum efficacy, safety and legislative compliance, bio-based solvents are showing promise in a challenging market that is constantly evolving.

The changing landscape

The outlook for the agrochemicals market is positive; it is projected to reach US$70.57 billion by 2021, at a CAGR of 5.15% from 2016 to 2021. However, in addition to meeting the challenge of ensuring supply to the fast-expanding population, farmers must also navigate the lack of availability of arable land due to urbanization, as well as increased crop losses through pest attacks. As such, there is an ongoing need for agrochemical products that manage these challenges, while providing high-quality yields to meet the rising demand.

Despite ongoing market needs, growing concerns about the potentially negative effects of agrochemicals on the environment has led to more stringent regulations across the world. In fact, several recently published reports claim the widespread use of traditional synthetic pesticides, insecticides, fungicides and herbicides at industrial scales is not safe. With limits being placed on pesticide use, formulators are therefore seeking agrochemical formulations with reduced toxicological classifications.

Ongoing regulatory scrutiny

In recent decades, the number of new molecules brought to the market has decreased. This is partially due to increasingly stringent regulations, resulting in more time to bring new agrochemical active ingredients (AIs) to the market; it now takes 11 years, on average. With more and more governments around the world introducing new controls and legislations, the pressure on manufacturers to reformulate existing synthetic agrochemicals is not slowing down. The fact that the EU is likely to ban neonicotinoids – the world’s most widely used group of insecticides – gives an indication of the direction the market is taking. Meanwhile, the Chinese government is now demanding formulations that are safer, with minimal impact on the environment.

Safety is also high on the agenda for formulators, and remains a significant factor in developing new formulations. This is increasingly apparent in the EU, which continues to lead the way in setting regulatory standards – ahead of other countries around the world. For example, the introduction of the EU Directive 1107/2009 (effective from June 2011) and REACH means there is a greater requirement for innovative formulations that are compliant, while maintaining a critical competitive edge.
The current benchmark

Agrochemical formulations commonly comprise solvents derived from petrochemical sources. These include aliphatic paraffinic oils, aromatic solvents (hydrocarbons), alcohols and ketones. Examples include ethylbenzene, N-Methyl-2-pyrrolidone (NMP), cyclohexanone, and 1,2-Dichlorobenzene. Although effective, particularly in terms of solvency, the inclusion of these chemicals can have significant drawbacks. For example, some of them contribute to volatile organic compound (VOC) emissions, which can pose a threat to human health and harm the environment. Furthermore, some of them are also classified as hazardous air pollutant (HAP) substances (i.e. ethylbenzene). As such, they are considered toxic to users and farmers, as well as phytotoxic to crops in some cases. In addition, as these solvents are generally derived from an unsustainable source, their use is an additional cause of concern for the environment.

Bio-based solvents

Thanks to developments in recent years, green or bio-based solvents could offer significant value to crop protection formulations, as well as important improvements in operator safety. Although the definition varies across the industry, green or bio-based solvents generally refer to the fact that they are produced from renewable resources, are biodegradable, non-corrosive and non-toxic. It is a market that is experiencing exponential growth; the green and bio-based solvent segment is expected to rise to a value of $8.05 billion by 2023, further highlighting it as an area that offers huge promise for agrochemical manufacturers.  

Formulators are therefore looking for bio-based solvents that can perform at the same level, if not better than petrochemical alternatives, with comparable solvency properties and efficacy of AIs in formulation. It is also crucial that these benefits do not bring a significant cost impact, particularly given the rising costs of crop protection worldwide.

Lactate ester technology is a significant advancement in bio-based solvents that is gaining traction with formulators. In fact, it has been observed that lactate esters, which are derived from natural lactic acid via the processing of agricultural crops, can enhance herbicide efficacy, performing similarly to adjuvants. As such, lactate esters present a viable option for bridging the gap in the market, giving formulators the peace of mind to develop trusted formulations, that not only protect end users, but their businesses too.

Meeting the challenge

In addition to achieving optimum safety, manufacturers seek more diverse properties for their formulations. There is often a requirement to incorporate different formulations of fungicides, insecticides and herbicides into the same tank mix preparation, to save valuable time and costs when it comes to spraying the formulation onto the crops. The development of several AIs in the same formulation prevents physical-chemical incompatibilities, which can lead to reduced spray efficiency, as a result of clogging in the nozzles, for example. In the face of these increasingly complex formulations, complete solvency of AIs is becoming more important than ever.

An important consideration for formulators when choosing solvents includes solubility as a function of temperature. Lactate esters present little variation of solubility for tested pesticides. An additional consideration is the wettability (spreadability) on leaves once the formulation is sprayed. Again, lactate esters display excellent wettability characteristics across a wide range of water concentrations.

Innovative formulations

The current legislative climate, together with pressures from a rising population, are causing manufacturers to reconsider their agrochemical formulations. However, any alternatives to traditional solvents need to exhibit high performance, enhanced safety and strong sustainability credentials, highlighting an ongoing challenge. Bio-based solvents, such as Corbion’s PURASOLV® lactate esters, provide a practical alternative for formulators of agricultural insecticides, fungicides and herbicides. Using readily available ingredients, Corbion toolbox of bio-based solvents offers cost-effective, safe options, which exhibit good phyto-toxicological profiles and excellent solvency, so formulators can continue to innovate in a constantly evolving market, while also working towards ensuring a more sustainable future.

1. Crop Protection Chemicals Market by Type (Herbicides, Insecticides and Fungicides), Origin (Synthetic and Biopesticides), Crop Type (Cereals & Oilseeds, Fruits & Vegetables), Mode of Application, Form, and by Region – Global Forecasts to 2021.
AgraSyst: Dicamba Tolerant Crops – A Development Opportunity or A Debacle?

The 2017 growing season in the USA has demonstrated that the new dicamba tolerant crops have good tolerance (genetics) and dicamba is an excellent broadleaf weed herbicide. Wide acceptance of the technology indicates a sizeable need to control glyphosate resistant weeds. However, the new low volatility formulations combined with the anti-drift regulations included on the label have led to what many see as an environmental disaster. Regardless of who or what is to blame, the fact is approximately 3.6 million acres of soybeans were affected by dicamba “off-target” movement (Kevin Bradley University of Missouri).

The issue is that the agronomics systems required to apply dicamba over large acreages have not yet been developed. If this new technology is going to succeed, it will take localized development. Local agronomists and growers will have the task of taking the environmental data generated for the new dicamba formulations and integrating it for safe use in local agronomic systems.

The next step should be the realization that what we thought we knew about dicamba’s environmental profile is not only incomplete, but also inaccurate. New approaches to understanding drift, volatility on application, and volatilization events post application will have to be developed and then integrated into the local climate and agronomic systems.

This development will have to take place with a growing glyphosate resistant weed problem in the background. A recent survey by Straus Ag suggests that around 70-75% of corn, soybeans and cotton growers have glyphosate resistant weeds in their fields, up some 15% in one year. The resistance tends to be with broadleaf weeds, which are heavy seed producers, and are openly pollinated with a lot of genetic variability. This means that the need for better broadleaf weed control, including broadleaf herbicides, is going to increase.

Herbicide drift is reasonably well understood. Small droplets, less than 200 microns can evaporate quickly, and move away from the target on air currents. A five-micron droplet can move up to three miles. A 200-micron droplet can move some 30 feet and a 400-micron droplet moves some eight feet. A 1,200-micron drop does not move much. The new low volatile dicamba formulations such as XtendiMAX® and Engenia® with their label requirements put the spray droplets into the 1,200-micron size category. However, the droplet surface area to leaf surface area is so low that uptake and performance of most post applied herbicides is decreased. The optimum size spray droplet for these herbicides is 200 to 500 microns. Thus, many growers use higher rates of dicamba to ensure performance.

Another issue is that most of the drift reduction agents (DRA) approved on the new dicamba formulation labels are polymer type drift reduction agents. These DRAs are thickeners and can undergo polymer shear, breaking into smaller pieces when recycled through pumps that keep the spray mix agitated. Polymers work well when spraying on the first half of the tank, but pump shear will cause them to be non-functional as the last part of a spray mix is used. This may be a cause for unexpected increases in spray drift.

The likely culprit for the increase in dicamba...
off-target movement is volatility. Most research to date suggests that spray drift is more important than vapor drift; however, the 2017 experience strongly suggests that volatilization is extremely important.

There appears to be two types of volatility: one that occurs on the day of application and the other is a volatilization event triggered by environmental factors that occur sometime after the original application. Factors we know increase the risk of dicamba volatilization include higher use rates, higher temperatures, ammonium sulfate in the spray mixture, and lowering the pH of the spray mixture. Higher use rate will increase the amount of dicamba available to volatilize. Higher temperatures at application will also increase dicamba volatilization. Dicamba should most likely not be sprayed at temperatures above 75 degrees F. The addition of ammonium sulfate to the spray solution increases dicamba volatility. Lowering the pH of the spray solution will generally increase dicamba volatility. These generalizations are factors associated with its volatility on the day of application.

The low volatile formulations XtendiMAX®, Engenia®, FeXapan™, and Tavium™, plus volatility-reducing adjuvants such as Vapor Lock™ and Cado MAX™ have been shown to reduce dicamba volatilization. The original thought was that this was the critical time for dicamba volatility and these products worked well. However, the experience in 2017 indicates that the real misunderstood part of the off-target dicamba movement is that volatility events can occur for days after application. There is mounting evidence that volatilization events can occur up to four days, if not longer, after application.

There is little known about these types of volatilization events. Our ability to understand these volatilization events that occur later and the development of agronomic systems to mediate these events are the key to the long-term utilization of this technology.

The real unknown factor is the interaction between water, the micro-environment, and dicamba volatilization. Volatilization on the day of application is generally considered higher than post application volatilization events. Current data suggests that dicamba volatilizes off the leaf surface at a higher rate than the soil surface indicating that an organic (uncharged surface) with moisture increases volatility.

Rainfall after application has been shown to stop dicamba volatilization. It is likely that rain washes the dicamba off the vegetation and into the soil where dicamba becomes tied up. If this is true, it would follow that volatilization events that occur days after the application are driven from a water surface before dicamba penetrates the soil, and that moisture would either be on the leaf surface or the soil surface. Understanding the wet-drying events and the interaction with higher temperatures is likely to be the key to post application volatilization events.

Future development of this technology should be focused on post application volatilization events. Growers and agronomists should document conditions on application and follow field conditions for a week to 10 days after application. Use rate, air temperature, soil temperature, relative humidity, moisture on the crop, moisture on the soil surface, rainfall and an estimation of relative drying time should be recorded. This will build a database of agronomic conditions that can be correlated to the off-target movement of dicamba. Precision Ag should be a key tool in determining the environmental conditions that lead to dicamba volatility.

Researchers should be looking at surface volatilization and interactions with water. Does dicamba volatilize more from a dry surface or a wet surface? Are subsequent wetting events such as a heavy dew—not enough water to wash the dicamba into the soil but enough water to put dicamba into a water solution—important?

What are the factors that seem to diminish the low volatility technology of the new dicamba formulations over time? Can volatility reduction systems be built that reduce volatility with later volatilization events? Does the net movement of water into the soil reduce volatility? Does the net movement of sub-surface soil moisture to the soil surface increase dicamba volatility?

These are the questions that need to be answered if we are to develop agronomic systems and dicamba formulations that make dicamba a useful and safe tool for growers to use.
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AkzoNobel

AkzoNobel creates everyday essentials to make people’s lives more livable and inspiring. As a leading global paints and coatings company and a major producer of specialty chemicals, we supply essential ingredients, essential protection and essential color to industries and consumers worldwide. Backed by a pioneering heritage, our innovative products and sustainable technologies are designed to meet the growing demands of the growing world, while making life easier.

Within crop protection, we have a long track record of proven and successful solutions that are trusted by experienced formulators worldwide due to reliable performance and high quality. Our portfolio includes adjuvants, surfactants, polymers and solvents with well-known brands such as Morwet, Adsee and Agrilan. As a global leader in amine chemistry, with local presence, we can ensure support and delivery wherever you are. Every Day.

http://www.akzonobel.com/agrochemicals
agro@akzonobel.com

AgraSyst

AgraSyst is a specialty Agricultural Spray Adjuvant Company that uses science to design, and manufacturing high performance agricultural spray adjuvants.

AgraSyst designs, engineers and builds premium multifunctional spray adjuvants. Adjuvants that solve problems. Spray adjuvants are a key factor in improving herbicide performance. But not all Spray adjuvants are alike. AgraSyst’s adjuvants are engineered to maximize the performance of your herbicides and are designed to be simple and convenient thus saving you time and money.

http://www.agrasyst.com/
scott.parrish@agrasyst.com

AGPW Group

Four years ago AGPW Group began development of a new technology to manufacture, store, distribute and apply highly concentrated live microbial products for agriculture and T&O. This technology, which we call LiveGrow™ is designed to manufacture products based on live metabolically active microbes and maintain them live and active at high concentration throughout the entire process of manufacturing, storage, and application in order to insure that they are ready to start acting in plant/seed environment immediately after application. Our technology also allows us to use any free-living bacteria or fungi to make a product, significantly expanding the pool of potential organisms for novel and effective microbial products, including the highly sought after Gram-negative strains.

www.agpwgroup.com
info@agpwgroup.com

Advanced BioNutrition Corp

ABN specializes in providing unique and environmentally sustainable technology solutions across a variety of industries, including agriculture and human health. ABN’s superlative and experienced team of scientists and engineers have a proven track record of innovation in protecting, stabilizing and delivering bioactive ingredients in or through food, seed or industrial products. ABN’s proprietary encapsulation technologies offer superior performance with respect to stabilizing bioactive ingredients utilizing ingredients generally regarded as safe (GRAS) by regulatory agencies.

http://www.advancedbionutrition.com/apugh@advancedbionutrition.com

Adjuvants Unlimited

Being privately-owned allows for a focus on resource investment. We strive to make life easy for our customers by providing value through the art of formulation chemistry. We hold strong to our mission, which is based on the core values of integrity, sustained trust-based relationships, and work-life balance of our employees. We know the importance of lasting relationships in the agrochemical industry and will continue to value them.

http://www.adjuvantsunlimited.com/
sales@adjuvantsunlimited.com

Atlantic-Pacific Agricultural

AtlanticPacific Agricultural Company is a specialty chemical manufacturer that strives for “Simple Products, Smart Solutions” in our product applications, and results for growers. We provide a variety of innovative chemistry solutions for today’s expanding farming needs. Our products are engineered with cutting-edge technology that is unique and proven to generate superior performance. Farmers who use our products consistently experience increased profitability year after year. It’s the loyalty of our farmers and their reliance on getting the best results that has allowed Atlantic-Pacific Ag to thrive for more than 20 years.

http://atlantic-pacificag.com/
darrin.quern@atlantic-pacificag.com
Aquatrols

Aquatrols was founded in 1955, Aquatrols is headquartered in Paulsboro, New Jersey. For over fifty years, Aquatrols® has been the leading provider of surfactant and other technologies used to optimize soil-water-plant interactions. Aquatrols® offers turf management products that enhance the effectiveness of turf management programs by minimizing water and other resource use. University and independent researchers as well as growers worldwide have conducted research and demonstration with Aquatrols products. We currently have a significant presence in the American, Canadian, and International markets. Each division plays a unique but collaborative role in advancing our ultimate goal of sustainable water use and global resource conservation. We provide highly-effective solutions that address your unique challenges. Aquatrols® has built a global reputation for innovation, reliability and value.

http://www.aquatrols.com/ info@aquatrols.com

Adjuvants Plus Inc.

Adjuvants Plus Inc. was built on the premise that innovation with existing chemistry would open up new avenues in the crop protection industry by creating added value for growers. Product innovation can be measured in a number of ways, one of which is whether these inventions are patentable. As a result, Adjuvants Plus has built a very exciting, specialized product portfolio that has utility in North American and in global markets. Our technology provides growers with new tools to improve crop yields and increase returns in a sustainable manner.

http://www.adjuvantsplus.com/ info@adjuvantsplus.com

Borregaard LignoTech

Borregaard operates one of the world's most advanced and sustainable biorefineries. As a world leader for Lignosulfonates and modified Humic acids, we take great pride of offering the crop protection and the fertilizer industries environmentally friendly alternatives to petroleum and coal based chemicals.

Our wide range of dispersants like Borresperse, Ufoxane and Greensperse can greatly help to produce high quality dry and water-based formulations. We offer also natural performance-enhancing ingredients for Plant Nutrient and Fertilizer Formulators like our soil conditioners BorreGRO and our micronutrients Borrechel.

www.lignotechagro.com
• +47 69 11 80 00 for Europe/Midde-East/Africa
• + 1 715 359 65 44 for America
• +65 6778 0008 for Asia

Battelle

Battelle is the world’s largest nonprofit independent research and development organization. Battelle’s AgriBusiness provides comprehensive registration services for agrochemicals and biopesticides, from individual safety studies to turn-key projects and regulatory support. Battelle is distinguished through its technology offering including an independent service for the development of new formulations.

Battelle can help you accelerate your agricultural formulation development schedule, gain access to new markets and maintain your competitive edge. We provide an integrated approach to research, development and regulatory compliance to help you move to market quickly and reliably while controlling costs and risks. We offer customized research studies and full registration programs throughout Europe and NAFTA. Among the services and technologies available are:

Development Services
Develop and test new agrichemical products and complex co-formulation mixtures, or modernize your existing products by replacing potentially hazardous ingredients.
• Development services
• Feasibility studies
• Quality control
• Stability testing
• Batch preparation
• Factory process transfer

Formulation Technology
Update your product mix with cutting-edge formulation technologies for better performance and stability:
• Bioformulation of proteins, enzymes and bacteria
• Capsule suspensions
• Controlled-release systems
• Emulsions and microemulsions
• Seed dressing
• Ultra-fine sub-micron suspensions
• Water-dispersable granules
• Wettable powders

Biosorb Inc

Biosorb Inc. is a bio-based company founded in 1998, providing products for rainfastness and weatherability through patented Microsponge™ technology. One of the main problems in crop applications is the run-off or dilution of applied materials due to rainfall, irrigation or UV degradation. Traditionally, surfactants have been used to aid the spread of applications over leaf/foliage/ fruits surfaces; however, these surface-active agents have a tendency to facilitate the dissolution of chemicals in water and wash-off treatment areas. New
natural-based microsponge technology is replacing surfactants in chemical and biological applications due to absorption and adhesion properties, providing better contact time and more efficient delivery. Our products include: Biocar®, TopFilm™, TopFilm-F™, and HydraClear®. Our main focus is providing customers with bio-based adjuvants and inerts, which help lower the toxicity and chemical load on the environment. Private formulation development is also available. Our products can be used with biopesticides, as well as, with traditional chemical pesticides.

www.Biosorb-Inc.com
Biosorbinc@gmail.com

Clariant International Ltd

Clariant has long lasting experience in producing adjuvants and inerts for the crop protection industry. Our portfolio is one of the broadest in the market covering nonionic, anionic and cationic surfactants, blends, solvents as well as polymeric dispersing agents.

Clariant understands that the consistent quality of our products is a requirement for your formulation to be a success. Our deep understanding of chemistry enables us to provide formulation guidance, discuss adjuvant properties and regulatory issues involved in bringing your product to the market. Constant innovation is the key to future success. Our ability to transform market requirements into new products and services makes us a preferred partner in the crop protection industry. Our globally integrated production network ensures an optimized supply chain.

www.clariant.com/cropsolutions
john.aponte@clariant.com

Croda

With our industry-leading technologies and unique formulation expertise, Croda’s unmatched range of additives and adjuvants help agrochemical customers get the best performance out of their active ingredients, enabling farmers to get the best yields for their crops. Our adjuvants and formulation aids under the renowned brands, Atplus™ and Atlox™, are well known in the industry as high performance, reliable products. Our wide range of products cover many areas such as; drift reduction technology, uptake enhancement adjuvants, superior rheology modifiers, high electrolyte solutions and advanced dispersant technology. Our value adding technology helps our customers achieve more efficient, safer, high performing formulations that minimise impact on our environment.

www.crodacropcare.com
ron.kayea@croda.com

Chemorse

Founded on January 15, 1981, Chemorse Ltd. has since experienced successful growth levels that have allowed the company to position itself for the future in industries destined for change. This success has been achieved by providing our customers with prompt service of consistent quality products at a competitive price. Acting as a manufacturer/formulator of agricultural adjuvants and a distributor of industrial chemicals, our primary responsibility is to satisfy the "specialized needs" of these industries through innovation and integrity.

www.chemorse.com
info@chemorse.com

Corbion

Corbion is the global market leader in lactic acid, lactic acid derivatives, and a leading company in emulsifiers, functional enzyme blends, minerals, vitamins and algae ingredients.

We develop sustainable ingredient solutions to improve the quality of life for people today and for future generations. For over 100 years, we have been uncompromising in our commitment to safety, quality and performance. Drawing on our deep application and product knowledge, we work side-by-side with customers to make our cutting edge technologies work for them.

At Corbion, we live our brand promise "Keep creating", through our science, clear understanding of the markets we serve, and of course through our creative people.

Corbion’s strategy and every aspect of our operations are built around advancing sustainability and applying high ethical standards, whether this relates to the management of our global supply chain, responsible procurement of our raw materials, or the safety and wellbeing of our people.

http://www.corbion.com/
communications@corbion.com

Central America Toll Manufacture & Logistics (CTL)

Central America Toll Manufacture & Logistics (CTL), is a hub for manufacture AG products, focused in competitiveness & service. Covering Central America, Caribbean, Mexico & United States markets, manufacturing in a Foreign Trade Zone. CTL is a company dedicated mostly to manufacture under contract "CUSTOM MANUFACTURE" for crop protection products providing and efficient supply chain that integrates materials, productions and logistics, aiming to
continuously improve the level of competitiveness of our customers.

www.agroctl.com
gazzari@agroctl.com

D

Dow Crop Defense

Dow Crop Defense is a global solutions provider of inert and additive agrochemical ingredients for both adjuvants and pesticides with in-depth product performance expertise to meet specific needs of our customers by customized solutions and global supply capabilities.

Dow Crop Defense Solutions
• Focused on the agrochemical market: Preservation, Formulation, Ag Nutrition, Ag Intermediates
• Primary product focus – Surfactants, Amines, Solvents, Chelants
• Our newly introduced POWERBLOX™ Products serve as the building blocks for formulation success
• DOW: wide range of additional products for agricultural markets – Rheology Modifies, Preservatives, Polyurethanes

www.dowcropdefense.com
Lwu4@dow.com

Drexel Chemical Company

Drexel Chemical Company, founded in 1972, is a manufacturer and formulator of a broad line of agricultural chemicals. Drexel is successfully represented, and selling products, in over 80 countries. There is hardly a crop growing, anywhere in the world, that would not benefit from a Drexel product. Drexel has the potential to manufacture and distribute more than 500 different products under the Drexel triangle, resulting in one of the most comprehensive lines of agricultural chemicals available. Drexel has a full GLP lab, stringent Quality Control and full capability for proper product packaging, private labeling and shipping. Our product line contains many unique formulations, particularly with respect to our flowable materials. Growers know that they can depend on Drexel for consistent quality at an affordable price. As the best value in the market, Drexel delivers maximum yield at a minimal cost.

http://www.drexchem.com
lshockey@drexchem.com

DIACHEM S.p.A.

DIACHEM is a 100% Italian company with more than 50 years of experience in the market of products for agriculture. DIACHEM formulates agrochemicals, fertilizers and organic products in its plant, located in Caravaggio (BG - Italy), with the latest equipment, offering various types of formulation and packaging and valuable service in terms of promptness in solving problems and excellent adaptability to the needs of each. DIACHEM produces for its sister company DIAGRO, for its Italian brand CHIMIBERG and especially for many national and multinational companies in the industry.

DIACHEM formulates products belonging to different families: herbicides, fungicides, insecticides, fertilizers, biological products and biocide. Thanks to the flexibility and the dynamism typical of a medium well established enterprise, DIACHEM is able to formulate products in full service or in contract work, always ensuring full compliance with quality, safety of the formulations and deadline. DIACHEM is equipped with formulation lines for EC, EW, SC, SL liquid products and WP, DP, GR, SG, WG solid products, with also pilot lines for trial productions. DIACHEM offers a wide range of solutions for packaging: various materials and sizes, possibility of managing twinpack and flexible pack, bar code and data matrix traceability.

DIACHEM’s laboratory has the latest equipment to analyze and to verify the quality of the formulations: professionals with years of experience in products for agriculture provide qualified technical support, able to identify in steps the best practices and inspections to support production. The R&D activities of the Laboratory provides assistance to develop recipes and to optimize production process.

More than 50 years of experience make DIACHEM an industrial partner estimated by the leaders of the world market.

http://diachemagro.com
info@diachemagro.com

Evonik Nutrition & Care GmbH

Evonik is one of the world’s leading specialty chemicals companies. The central elements of our strategy for sustained value creation are profitable growth, efficiency and values. Around 80 percent of sales come from marketleading positions, which we are systematically expanding. We concentrate on highgrowth megatrends, especially health, nutrition, resource efficiency and globalization. In 2017 Evonik’s more than 36,000 employees generated sales of €14.4 billion and an operating result (adjusted EBITDA) of €2.36 billion. Around 81 percent of sales are generated outside Germany, providing convincing evidence that our business is global.

BREAK-THRU® - Surfactant technology from Evonik

We are committed to providing specialty additives to the agricultural industry used as spreaders, penetrants, antifoams, emulsifiers and dispersants in tank mix applications as well as in pesticide formulations. With an emphasis on innovative solutions, we offer agricultural chemicals based on both siloxane and organic surfactants under the BREAKTHRU® brand name.
Our formulation experts have merged their knowledge with that of our plant physiologists who link it to performance in the field. In this way, we offer a novel package of products and expertise.

www.evonik.com
break-thru@evonik.com

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Eastman Chemical Company

Eastman announced the completion of its acquisition of Taminco, a global specialty chemical company. Eastman and Taminco share several key fundamentals, such as complementary technologies, strong technology platforms, business capabilities, and a high performance culture. Eastman and Taminco also share a strong attribute in having leading positions in diverse, attractive end markets.

Eastman chemical intermediates are used in the synthesis of a variety of agrochemicals products including active ingredients such as insecticides, fertilizers, herbicides, formulation products and adjuvants.

www.eastman.com/agriculture
csweet@eastman.com

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Endura S.p.a.

We are an innovative, Italian-based company specialized in the business of active ingredients and synergists for household insecticide products and are the leading manufacturer world-wide of the well-known synergist, Piperonyl Butoxide (PBO).

The patented synthetic process for manufacturing PBO from catechol is one example of the results of Endura’s consistent investments in R&D and manufacturing. In this case, we were able to identify an environmentally-friendly alternative to the previous manufacturing process. Our constant search for innovation has led to numerous patents on “new” insecticides and “new” synergists, as well as on formulation and process technologies.

With more than 50 years’ experience in the field of active ingredients and synergists for household, professional, amateur, veterinary, pharmaceutical and vector control insecticides we can offer our customers a wide range of products and quick solutions to their sourcing requirements starting from the very first stages of R&D. A reliable supplier, the strength of our organization lies in our flexibility to offer tailor-made services to meet the specific needs of customers.

www.endura.it
info@endura.it

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Exosect Limited

Exosect is a lean formulations company. We exploit the characteristics of our unique, proprietary technology platforms and apply our extensive formulations know-how to enable the efficient, targeted delivery of biological and synthetic active ingredients.

Our technology platforms deliver a unique mix of commercial and environmental benefits and are underpinned by an extensive and robust patent portfolio.

We out-license access to our technology platforms, formulations know-how and intellectual property to industrial partners enabling them to grow their business and increase ROI.

Exosect’s Lean Formulation Technology® is based on the use of micro-powders to accurately target biological and synthetic active ingredients.

Using the micro-powder platforms, we accurately place active ingredients on targets, such as seeds, grains, pellets, insects, foliage and building structures.

Our technology and know-how enables us to help our partners with a range of formulation challenges such as reducing the concentration of synthetic active ingredients by 50%, increasing biological loading by 100% and improving the shelf life of biological material.

Our platforms have the potential to deliver in dry and wet format and to deliver multiple active ingredients in a single formulation.

www.exosect.com
info@exosect.com

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Foreverest Resource

Foreverest Resources Ltd. supplies pine-based chemicals since 1988. Our ranges focus on modified rosin resins, turpentine derivatives, polyterpene resins and flavor-fragrance raw materials. On the agricultural market, we supply the natural extracts adjuvants for fungicides, potentiators, pesticides. PINEYE Emulsion is our owned brand for this powerful application.

https://foreverest.cn/products
info@foreverest.cn

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GarrCo Products Inc.

GarrCo Products is an independent manufacturer and distributor of adjuvants and associated products that enhance pesticide performance and provides a wide range of services.

We’re committed to excellence in research and product efficacy. We focus on customer needs and market trends, which drives our research and product development efforts. This philosophy results in products that are superior, functional, and economical for the end user. Developing and marketing practical, value driven products that benefit the end-
user and not the marketers of adjuvants are a key, basic principle of GarrCo Products. This creates great value, and, easy to use premium performance products.

GarrCo can private label products, develop custom formulations and do research for many different applications.

www.garrco.com
mrfoam1@garrco.com

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GreenA BV

GreenA is the technology transfer company of the Institute of Physics at the University of Amsterdam. GreenA develops and markets the patented polymer adjuvant and co-formulant Squall to be used with water-based agrochemicals. Squall is typically mixed as a 0.5% solution in the tank mix of spraying installations. Rain fastness improves by 50% and giving a superior deposition of crop protection on the leaves. Adding Squall to in-tank mixtures reduces droplet drift to 5% of the total, compared to 20+% seen in standard mixtures of water and pesticides. Squall is widely used already in the Netherlands, Germany, Austria and starting 2018 in Switzerland.

www.squall.pro
p.buis@greena.nl

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GLOBAL ADJUVANTS COMPANY(GAC)

GAC was established in 2015 in UK to create a global brand in adjuvants by investing in data to secure registration positions whilst supporting sales with trials and marketing promotions. We aim to demystify the use of adjuvants for distributors and farmers, so they become a tool for environmental benefit and improved agronomy.

Historically adjuvants have been viewed with suspicion by many growers who viewed them as something used by distributors to increase profit margins, rather than a practical agronomy tool that can benefit the crop. Our mission is to show how the correct adjuvant, used in the correct conditions, can be a tool to improve the delivery of crop protection products, providing the farmer with higher efficacy, leading to better yields, and less waste of valuable pesticides. Increasingly adjuvants are also being used for their environmental benefits, such as reducing drift, reducing water use, reducing pesticide resistance, and reducing pesticide environmental effects such as soil leaching.

GAC is also at the forefront of developing new adjuvants suitable for us with biocontrol agents, and for use in IPM and organic (eco) farming. All of these can be said to have a “Positive Environmental Impact”.

http://www.global-adjuvants.com/
gary@global-adjuvants.com

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GAT Microencapsulation AG

GAT Microencapsulation AG is an agrochemical company specializing in the development, registration and manufacture of advanced plant protection products. These products are based on GAT’s proprietary formulation technologies.

GAT Formulation GmbH was founded in 1999 by a group of highly specialized scientists to provide R&D and analytical services to the industry.

2003 GAT Microencapsulation founded the plant site in Ebenfurth/Austria with state of the art GLP certified laboratories and manufacturing facilities. GAT Microencapsulation started industrial manufacturing of high quality agrochemical products and biocides.

GAT Microencapsulation has developed innovative and cost-effective technologies for the formulation of agrochemicals, most notably microencapsulation and oil dispersion. The company’s intellectual property in these technologies is based upon a complex combination of 95 international patents.

GAT Microencapsulation is currently engaged in the registration and marketing technologically advanced agrochemical products and biocidal products in the Europe, USA, South America, Asia and Africa.

GAT Microencapsulation is bringing to these markets proprietary products based on its own patented technologies. GAT Microencapsulation GmbH is a private company.

http://www.microencapsulation.at/
gat@microencapsulation.at

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Huntsman Performance Products

At Huntsman Agrochemicals, your success is our top priority. We use our expertise in regulatory compliance, state of the art science, manufacturing and global delivery systems to help you drive your business forward. Our portfolio of TERMIX® and TERWET® adjuvants have been proven to increase efficacy by increasing biological activity and / or broadening the spectrum of effectiveness. Adjuvants can increase pesticidal efficacy by influencing several key physiochemical characteristic. Adjuvants can be formulated as “built in” or marketed as stand alone “tank mix” adjuvants.

Huntsman’s adjuvant portfolio includes: Compatability Agents – TERMIX® 5270 & TERMIX® 6000
Drift Reduction Agents – TERMIX® 5920
Spread & Sticker Adjuvants – TERMIX® 5900 & TERMIX® 5910
Wetting Agents – TERWET® 245
Conditioning Agents – TERMIX® AIS-4000
COC Emulsifiers – TERMIX® 5800 & TERMIX® 5860

http://www.huntsman.com/corporate/a/
Home
athanasia_zavalas@huntsman.com
Hydroemission Corporation Pte Ltd

A Singapore headquartered materials science company, with operations in Johor, Malaysia is specialised in the development and manufacture of biodegradable, polymeric, controlled release delivery systems for a multitude of environmental applications such as vector control, agriculture, air purification, bioremediation, infrastructure protection, energy recovery and consumer goods.

Most treatment processes in environmental applications involve administering a high dose of actives at a given time, only to have to repeat that dose just days or weeks later. This is not economical and sometimes results in damaging side effects such as inconsistent treatment, environmental pollution, and resistance development in the targeted organisms.

In contrast, this controlled release delivery system offered is highly flexible. It can be designed to release actives with specified dosages, dosage intervals, treatment periods, and treatment depths (in water-based environments), in order to fulfill the unique requirements of each particular application. They are able to encapsulate practically any actives, ranging from powders, to gels and liquids, at room temperatures and pressures, while maintaining the integrity of the actives. They are also simple and easy to scale-up for mass production.

The technology enables improvement of existing products as well as the development of new products from traditional actives and formulations.

The company is interested to explore commercial partnerships with SMEs of any sizes or MNCs in the form of commercial agreements, manufacturing agreements, joint venture or technology licensing agreement.

https://www.hydroemission.com/
gc@hydroemission.com

Ingevity

Ingevity is a manufacturer of specialty chemicals and high-performance carbon materials and technologies that help customers solve complex problems. These products are used in a variety of demanding applications, including asphalt paving, oil exploration and production, agrochemicals, adhesives, lubricants, printing inks and automotive components that reduce gasoline vapor emissions. Specific to the agrochemical industry, Ingevity’s adjuvant portfolio is focused on enhancing the performance of pesticide formulations through tall oil emulsifiers, terpene stickers and lignosulfonates. These products are sold under the brand names of Altapine™, Altastick™ and Reax®. Headquartered in North Charleston, South Carolina, Ingevity operates from 25 locations around the world and employs approximately 1,500 people. Wherever you are formulating the world, Ingevity is there to supplement your adjuvants needs. The company is traded on the New York Stock Exchange (NYSE: NGVT).

www.Ingevity.com
chemicals@ingevity.com

iFormulate

iFormulate Ltd (www.iformulate.biz) was founded to provide customised R&D and innovation services to companies working in the field of Formulation Science and Technology. We offer consultancy, project management, idea generation and development, assistance with commercialisation, market and business development, training and events.

www.iformulate.biz
david@iformulate.biz

IMCD Group BV

IMCD is a global leader in the sales, marketing and distribution of speciality chemicals and food ingredients. The experience gathered over the last 20 years has allowed IMCD to acquire extensive knowledge on regulatory and technical requirements in the crop protection, adjuvants and nutrients markets.

IMCD focuses on partnering with prestigious suppliers that offer leading and innovative products into the agrochemical market. The vast portfolio of products available through IMCD’s distribution network provides the industry with a complete range of inerts to achieve optimised formulations such as developing more sustainable solvents; adjuvants to optimise the application target; co-formulants to reduce volatility and sensitivity of new active substances.

In addition, inerts for biotechnology allow IMCD to complete it’s product portfolio to overcome today’s environmental challenges. Through our human resources, supply chain expertise and the creation of open and lasting partnerships, IMCD provides optimum tailored solutions on formulation, production processes and application for multi-territory distribution management in EMEA, Asia-Pacific and Americas.

Headquartered in Rotterdam, The Netherlands, IMCD achieved a turnover of EUR 1,907 M in 2017 and employs over 2,200 professionals in more than 45 countries. IMCD offers its 37,000 customers a comprehensive and complimentary portfolio of 30,000 products together with expert technical advice and formulatory support.

www.imcdgroup.com
isabelle.jamet@imcd.fr
Interagro (UK) Ltd

Interagro was formed in 1994 and has since then been at the forefront of the development of surfactant chemistry as in-tank adjuvants. It continues to be the pioneering organisation it set out to be, developing and marketing a wide range of innovative products to optimise the performance of agricultural and horticultural inputs.

Today, Interagro boasts over 100 products in 30 international markets, making it one of the leading lights in the specialist spray adjuvant business throughout the EU, Eastern Europe and North Africa.

Interagro’s continued investment in R&D and technology partnerships has led to many significant milestones in product introduction and market development. With a rapidly expanding world population where cost-efficient food production on ever less available land has become top of the global agenda, its future remains bright.

Dedicated to improving overall spray performance and efficiency whilst maintaining a strong and positive environmental focus, Interagro products will remain at the forefront of new adjuvant technology.

One of Interagro’s great strengths is its understanding of customer and market needs and its strong relationships with third parties. It has a proven track record of obtaining products and developing them for specialist markets.

With alliances and partnerships stretching throughout the EU, Eastern Europe and North Africa, Interagro is recognised as providing technological solutions and management tools to meet the different challenges of growers in many different markets and climatic conditions.

Interagro work closely with a number of distributors to be able to offer farmers and growers even more cost-effective performance of crop protection products.

http://www.interagro.co.uk/
info@interagro.co.uk

Intracrop

Intracrop is a trading style of Brian Lewis Agriculture Ltd which as a company was started by Brian Lewis nearly 40 years ago. The company is privately owned and Brian Lewis still heads the company.

Intracrop’s principal business is the development, manufacture and marketing of adjuvants and specialist crop nutrients for the agricultural and amenity markets. The company is one of the largest UK adjuvant and crop nutrition companies and is a key supplier to some of the most important distributors within the UK and Europe. Intracrop also works closely with international primary pesticide manufacturers to develop adjuvant systems for use with their products. The company ethos is that of developing novel products that offer customers opportunities to improve the efficiency and cost effectiveness of their operations.

During its long involvement with agriculture Intracrop has developed an unparalleled understanding of the adjuvant and nutrition sectors. Our philosophy of being at the cutting edge of technology, providing market leading products and backing this up with superb customer service has been responsible for our continuing growth as a company.

Intracrop has a detailed understanding of the market, and in partnership with our customers has developed a range of cost effective and often unique solutions to meet market needs. All Intracrop products are only marketed after extensive research and development, and are supported by trials carried out throughout Europe conducted by independent GLP approved trials companies. Products are approved by the relevant regulatory authorities in each country where appropriate.

Our products are manufactured to the highest standards in modern factories within the UK where the highest standards of health and safety, quality assurance and environmental management are assured.

www.intracrop.co.uk
technical@intracrop.co.uk

Ionica

Over 15 years ionica has been the market leader in Canada & Latin America in the development of safer, cleaner formulations of crop protection, animal health and environmental husbandry products. Our technologies and those of our partners allow us to serve formulators & manufacturers with green adjuvants used in formulation plants to achieve safer, more effective crop protection, animal health and water, soil, seed treatment solutions.

We also have our own line of green “ready to use” on the field products (tank mix, soil protection, water retention, fertilizer & drift control adjuvants, improving the effect of crop, animal health & water treatment technologies sold through AgVetSolutie and EnviroSolutie.

Our aim is to provide technologies, technical support and advise for safer, cleaner, more effective solutions in rural areas.

http://myionica.com/indexE.html
columbus@columbus-grp.com

Jiangsu SINVOCHEM S&T Co., Ltd.

Jiangsu SINVOCHEM S&T Co., Ltd. is a chemical company dedicated to polymer surfactant development and its application in environmental-friendly pesticide formulations. Profound market insight, sustained product innovation and strong technical support are SINVO images on the market. Backed by a high efficient R&D team (30% of total staff), SINVO accumulates over 4000 recipes, which improve product quality or shorten time-to-market for more than 60% of Top 100 agro companies in China. Being a well-respected brand in China, SINVO also gains acceptance in overseas
markets by collaboration with MNCs and leading distributors. Up till now, we have sales in SEA, MENA, Oceania and Latin America. SİNOVO will continuously focus on polymer surfactants and expect to be your dependable supplier & valuable partner. SİNOVOCHEM gives you more than just a product!

- **Featured Products**
  - Polymeric Dispersant
  - Universal Emulsifier
  - Organosilicone Synergist
  - Tailored solutions

- **Strength**
  - Strong R&D backup
  - Adjuvants for SC, FS, SE, WG, WP,DF
  - Serves full range of your pesticide formulations
  - Sufficient experience in adjuvant innovation and recipe optimization

**www.sinvochem.com**

**export@sinvochem.com**

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**Lonza**

Lonza has a well-recognized presence in the world’s crop protection industry. A custom manufacturer of active ingredients and intermediates, for many years, the company has established strong relationships with leading plant protection manufacturers and innovators, as well as developing ready-to-use formulations such as the metaldehyde-based AXCELAR® slug pellet. As one of the world’s most trusted suppliers to the pharmaceutical, biotech and specialty ingredients markets. It harnesses science and technology to create products that support safer and healthier living and that enhance the overall quality of life. Its recent launch of VELCIS® provides a new range of formulation ingredients and development services, helping manufacturers to keep pace with new formulation trends, such as biostatements, added-value formulations of post-patent molecules, and regulatory-driven product reformulations.

**www.lonza.com**

**agroformulation@lonza.com**

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**Lamberti**

Lamberti SPA through the Business Unit Agrochemistry, develops and produces, within its technological platforms, molecules and solutions instrumental to generate value in the agricultural market, either as tank mix adjuvants or as additives, for new and better performing formulations of crop protection and nutrition products.

Thanks to continuous innovation and close collaboration with its partners, including consultancy for formulation development, the Company has earned the reputation of a solid technological partner. By combining environmental concern with sustainable development, Lamberti designs agrochemical delivery systems for the industry and the farmers aiming to improve efficacy and efficiency.

**www.lamberti.com**

**agrochemicals@lamberti.com**

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**LEVACO Chemicals GmbH**

LEVACO Chemicals GmbH has its headquarters and production site in the Chempark Leverkusen. Our product portfolio includes specialties such as dispersants, emulsifiers, wetting agents and anti-foaming agents. Our products are used in the segments of agricultural chemicals, fibre manufacture as well as paints and coatings. In addition, we also manufacture specialty chemicals for major chemical companies on a contractual basis. We are a member of the Diersch & Schröder Group based in Bremen.

**www.levaco.com**

**info@levaco.com**

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**Loveland Products, Inc.**

Loveland Products offers a complete line of high performance input products. Our portfolio of seed treatment, plant nutrition, fertilizer, adjuvant and crop protection products are second to none. We are constantly striving to bring new, unique chemistries to the marketplace to provide innovative solutions to problems across the agricultural and professional non-crop industries.

At Loveland Products, we only offer products that meet the highest quality standards. We are driven by the principal that our relationship with the customer does not end with the purchase of one of our products. With our Crop Production Services/Nutrien Ag Solutions team, we are there from the planning stage through the growing season to provide a high level of service and knowledge that farmers have trusted for decades. Loveland Products also provides the same performance, quality and value to the international community, providing sales support, technical training and quality products around the globe.

Our broad portfolio of high-performing crop inputs provides growers what they need for a successful season – and support from our Crop Production Services/Nutrien Ag Solutions team ensure we’re helping meet our customers’ goals.

**Loveland Products, Inc – Get Growing.**

**https://lovelandproducts.com/ joe.vaillancourt@cpsagu.com**

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**Momentive**

Since our introduction of the first silicone spray adjuvant on the market, our Silwet®, AgroSpréd® and SAG® specialty silicones have become among the best-known and most trusted tank mix adjuvants, in-
can adjuvants and foam control agents available. Used in over 70 countries around the globe, they consistently enhance spreading and coverage while helping reduce manufacturing and delivery costs.

*Our Silwet and AgroSpred adjuvants can provide exceptional spray coverage of crop and plant surfaces; excellent penetration for better agrochemical efficacy; and better adhesion and rainfastness to lower pesticide wash-off and waste.

*Our durable, stable SAG antifoams can produce rapid de-foaming and long-lasting resistance to re-foaming during pesticide manufacturing or tank mixing, while lowering use levels and improving performance.

With ever-growing demand for environmentally responsible agricultural productivity, Momentive will continue to work closely with our customers. Our reliable, sustainable solutions contribute vital assistance to the agriculture industry, today and into the future.

www.momentive.com
marcosaurelio.belle@momentive.com

OXITENO

Agriculture is a part of almost every aspect of our lives: eating, getting dressed, and transportation are all made possible by farming. The world’s population is increasing every day, while the amount of productive land is limited. Our proposition is to live in a world where everyone has access to food, clothing and energy.

Oxiteno believes that the FIELDS DRIVE THE WORLD. Using innovation and technology, we work to increase agricultural productivity, lessen the impact to the environment and protect all farmers’ health.

www.oxiteno.com
joaog.junior@oxiteno.com

P

Polaquimia

Polaquimia® offers a wide range of multifunctional chemical solutions with significant competitive advantages in industrial, energy, processes and in the manufacture of raw materials.

In agrochemicals, with own brands and third party manufacturing, we are committed to improve productivity in the field.

In general, products for this sector have an objective: to achieve stability of the different formulations and the easy application of the products. Our solutions are widely used with insecticides, herbicides and fungicides, that require among other characteristics, emulsifying, dispersing and wetting effects.

Our solutions for crop protection include a wide range of herbicides, insecticides, fungicides and adjuvants.

Polaquimia Agro solutions are always available in the precise formulation that our clients seek. We have what you are looking for!

• Emulsifiable Concentrates (EC)
• Emulsions in Water (EW)
• Concentrated Suspensions (SC)
• Wettable Powders (WP)
• Soluble Liquids (SL)

http://polaquimia.polakgrupo.com/
falbo@polakgrupo.com

S

Stepan Company

Stepan Company is a major manufacturer of specialty chemicals including surfactants, antimicrobials, fabric softening quaternaries, phthalic anhydride and polyurethane polyols, as well as specialty ingredients for the food and nutraceutical markets. Stepan was founded 85 years ago by Alfred C. Stepan Jr. Today, the company has 18 global manufacturing locations, more than 2,100 employees worldwide and over 1,800 product offerings.

Stepan Agricultural Solutions leverages the company’s core technologies of sulfonation, alkoxylation, amidation, oxidation, quaternization, and polymerization to deliver a complete line of products that meet our customers’ needs.

Stepan Company is committed to innovation and new product development in partnership with our customers. In listening closely to our customer’s needs, Stepan is focused on the continued development of environmentally sustainable solvents, improved adjuvant technologies, and our novel polymeric dispersant technology.

http://www.stepan.com/
techserv@stepan.com

Solvay

With an increasing demand and a limited potential of cultivated area the yield increase performance in plant protection and plant growth in a cost effective and safer way is crucial for tomorrow’s agricultural future developments.

All our solutions are expected to provide a wide range of benefits: protection of farmers and of the environment, and enhanced plant quality.

For crop-protection applications, Solvay is dedicated to optimize the use of pesticides while guaranteeing plant vitality and yield per hectare. Our solutions satisfy regulatory requirements and the challenges of sustainable development while simultaneously protecting human health, soil quality and crops.

For fertilizer protection, we provide innovative formulations based on urease and nitrification inhibitors.

www.solvay.com
benoit.abribat@solvay.com
Sasol

Sasol is an integrated chemicals and energy group based in South Africa with more than 30,000 employees in 33 countries worldwide.

Our Performance chemicals division is a leading global producer of linear alkyl benzene (LAB) fatty alcohols, isoparaffins, surfactants, waxes etc. We offer the formulator or manufacturer one of the most diversified global portfolios of C6+ alcohols, surfactants and specialty chemicals.

Sasol offers the agrochemical customer and manufacturer many choices from our diversified portfolio of products which can be used as components within a broad range of crop protection, fertilizer & dairy applications. Our portfolio of products can be tailored to the agrochemical application targeted. We can use our extensive alcohol portfolio and LAB production to manufacture a fully integrated surfactant portfolio from DDBSA to various anionic and nonionic surfactants.

The Sasol agriculture team leverages our manufacturing operations around the world to offer solutions to our customers. Since Sasol offers many of the same products in different regions of the world we can help our customers overcome many of the challenges of a global business.

http://www.sasol.com/
Paul.filler@us.sasol.com

Schneider Formulations Consulting

Schneider Formulations Consulting is an enterprise founded and owned by Dr. Rudolf Schneider and specialized in supporting agrochemical companies in development of crop protection formulations. We are based in Basel, Switzerland.

Profile:

Dr. Rudolf Schneider is a renowned expert in formulation of crop protection products. During his career with multi-national companies he has acquired extensive knowledge in formulating a wide range of active ingredients. He has developed a number of successful market products and has re-formulated many products to meet new regulatory requirements.

Fields of expertise:

Development of pesticide formulations:

In the lab of Schneider Formulations Consulting at Muttenz in Switzerland we develop liquid formulations such as EC, SC, SE, EW, ME, SL, OD, CS formulations and extruded WG formulations.

Consulting and support of crop protection companies in their development work and in production.

Training courses in formulation technology:

One-day training courses in development of EC, SC, OD, CS, EW, ME and WG formulations. These courses are suitable for chemists who are relatively new in formulation or for more experienced chemists who have not developed a specific formulation type yet. The courses may be combined with practical work in the lab.

www.rsformulations.com
rudolf.schneider@rsformulations.com

TENSI0FIX

Tensiofix is providing Surfactants (Surface Active Agents) solutions used as essential components for the formulation of agrochemical products, acting mainly for stability, dispersibility and biological efficacy.

The surfactant range consists of emulsifiers, wetting-dispersing agents and other additives.

This expertise enables to propose high-performance and cost-effective surfactants especially designed for agrochemical applications.

We also develop vegetable based biostimulants and bio-solutions for a greener agro world.

For more than 70 years, Tensiofix products have been used in agrochemical formulations all over the world we are committed to solving your formulation issues through a strong technical team with extensive expertise and innovation.

www.tensiofix.com
sales@tensiofix.com

Vive Crop Protection

Vive Crop Protection creates new ways to use trusted products using the targeted Allosperse™ delivery system, which improves the targeting and performance of pesticide active ingredients. This helps farmers do more with less, reducing the burden agricultural practices have on the environment, all while increasing crop quality and yields. Vive works with partners across the globe that share its vision of bringing effective crop protection products to growers everywhere.

Vive’s has two core product portfolios. AZteroid FC and Bifender FC are Vive’s fertilizer-compatible fungicide and insecticide for key field crops. Both products are designed to be mixed directly with liquid fertilizer and applied in-furrow to improve early season plant health and maximize yields. Vive also has a portfolio of products for use in turf and ornamentals - these products will be launched in late 2017.

www.vivecrop.com
products@vivecrop.com

www.agropages.com
2018 Formulation and Adjuvant Technology May 2018
Victorian Chemical Co. Pty. Ltd.

The Victorian Chemical Company (Vicchem) is a specialist manufacturer and global marketer of agricultural and industrial chemical products that is based in Melbourne, Australia.

We provide our customers with friendly, professional service and reliable, high performance products that have been manufactured according to an accredited quality management system ISO 9001. Vegetable oils are used widely in our manufacture, with the resulting products being typically non-hazardous to both end user and the environment.

Vicchem has a well-equipped laboratory that is used in formulation development and quality control testing.

Our agricultural products include spray adjuvants, wetting agents, surfactants, insecticides, growth regulators and bloat control products. Applications include broadacre cropping, horticulture, cotton and pastoral.

Vicchem has strong business relationships with all key Australian distributors of agricultural products and work with industry partners and customers in North and South America, Europe, Asia, The Middle East and Africa.

www.vicchem.com
products@vicchem.com

WuXi JingFung Technology Co., Ltd

WuXi JingFung Technology Co., Ltd is a professional manufacturer of surfactant & specialty chemicals. Our own manufacturing base is located in JiangSu WuXi. Our products include four categories: anion, nonionic, cation, amphion. The application covers coating, printing ink, textile printing and dyeing, leather, pesticide, metal processing, papermaking, adhesives, plastics and other industry fields.

Our agricultural chemicals include Calcium Dodecylbenzene sulphonate, Tri Styrenated Phenol Ethoxylates, Tallow Amine Ethoxylateds, Castor Oil Ethoxylates, Fatty Acid Alcohol Ethoxylates, EO/PO co-block polymer and other emulsifiers, phosphate, sulfate, polycarboxylate, and various of anion, cationic and amphoteric wetting agents, synergists, widely used in all kinds of agrochemical formulations. We aspire to become a professional, reliable and global supplier in surfactant and specialty chemicals industry! To provide global customers with a complete range, excellent quality, high performance products and services!

www.jingfung.com
andy.zhang@jingfung.com

Scan to visit the online company directory

New Media Platform for Global Agribusiness Industry
Crop Defense Solutions

Unlock the Power of Your Formulation

As you develop agrochemical formulation that address the challenges growers face to increase crop yields efficiently, economically and environmentally friendly, Dow is positioned to help you arrive at customized solution engineered to meet exacting specification with newly launched products:

- **DOWFAX™ D-865 Surfactant**, easy-handling with low pour point and fast dissolution in water, combination of wetting and emulsification performance.

- **POWERBLOX™ ADJ series**, rainfastness additives used in in-can and tank-mix to improve the efficacy delivery.

- **POWERBLOX™ SV series Solvent**, provide green alternative solutions with excellence dissolving ability

- **POWERBLOX™ D series Dispersant**, general-purpose type with good dispersion performance, high suspension rate and good wetting ability.

For more information about Dow Crop Defense solutions, please contact Dow Customer Information Group (CIG)

Toll Free:
400 880 0780 (China)
800 7776 7776 (except China)
Adsee ST4
Together we can cultivate a more sustainable future.

Caring about crops is your core business. Ours is innovative surface chemistry technologies. By focusing on your challenges, we can combine our unique technologies with your expertise to boost farmer’s productivity and yield.

Adsee™ ST4 is a unique starch-based polymer that represents a new way for formulatrs to create more natural and sustainable seed treatment products without sacrificing performance properties or cost targets.

This is an environmentally responsible solution that reduces dust-off from coated seeds, enhances flowability and maintains germination.

Our future depends on our ability to do more while using less. Together, we can make it happen.

Let’s talk.

www.akzonobel.com/agrochemicals
agro@akzonobel.com