

Agribusiness Magazine

2019 Formulation & Adjuvant Technology

Top Interview

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Nouryon: Formulation of Agrochemicals in High Electrolyte Systems



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The need to incorporate agricultural actives (ais) in high electrolyte systems such as fertilizers for in-furrow applications, or in tank mixes for spray applications, provides a significant challenge to the formulator. Many ais have poor water solubility and are often formulated in suspension concentrates (SCs). However, the addition of SCs to a starter fertilizer such as 10-34-0 will often result in a rapid flocculation of the system. This is clearly undesirable; farmers require a system that is sufficiently stable to allow them time to complete their application without the risk of blocked nozzles or uneven application.

SCs use a variety of surfactants and polymers to provide a stable concentrate that can be further diluted to the desired application concentration. However, many of the common surfactants used in SCs don't perform well in high electrolyte systems due to poor solubility or a loss of stabilization due to depressed electrostatic repulsion effects. Phosphate esters is a category of surfactant that shows good compatibility with electrolyte systems and also offers significant flexibility in design allowing their performance to be finetuned.

Phosphate esters are versatile anionic surfactants providing a range of performance characteristics. The variety of raw materials and methods of production provide ample scope for fine tuning of structure and performance. Phosphate esters are commonly prepared by reaction of an alcohol with either polyphosphoric acid or phosphorus pentoxide. This always results in a mixture of esters, however, depending on the method used you can get a product with a high level of monoester, or a product with a more even mixture of monoester and diester, Figure 1.



Figure 1. Structure of Monoester and Diester

Polyphosphoric acid yields a product with a high level of monoester which is more tolerant of electrolytes than a monoester/diester blend. As noted in Table 1, the ester distribution impacts the surfactant's performance, e.g. higher monoester leads to better hydrotroping and greater electrolyte tolerance, whereas increased diester aids in dispersion. Further tuning of the performance can be achieved by altering the carbon chain length of the hydrophobe or by using an ethoxylated alcohol. Ethoxylated phosphate esters have better electrolyte tolerance.

Property	Mono-ester	Di-ester
Hydrotropic	Excellent	Poor
Electrolyte tolerance	Excellent	Poor
Wetting	Good	Fair
Emulsification	Good	Good
Foaming	High	Lower
Dispersing	Poor	Excellent

Table 1. The ester distribution impacts the surfactant's performance

Our initial goal was to identify a surfactant that would provide a stable suspension concentrate that could be further diluted in a 10-34-0 starter fertilizer to afford a stable mixture. To achieve this a fine balance of surfactant properties was going to be required. While much of the effort was directed towards Bifenthrin and Imidacloprid as the ais other actives were also screened, as were other fertilizers.

A significant number of phosphate esters were tested before finding one that afforded a stable SC that diluted well in 10-34-0 fertilizer. Fine tuning of both the process and the structure resulted in Agrilan[®] 1028. Agrilan 1028 is a phosphate ester based on an alcohol ethoxylate. It has a high monoester content and is both TSCA and FIFRA listed; it also falls under the Reach polymer definition. In our evaluations we found that the degree of ethoxylation on the alcohol was critical and that a sharp fall-off in in-fertilizer performance was seen, particularly if the product was over ethoxylated by as little as one mole of ethylene oxide. A similar sensitivity was seen in the selection of the hydrophobe and alcohols with the same number of carbons exhibited differences in performance depending on their source. Thus, the source of alcohol and the degree of ethoxylation need to be well defined for optimum performance. For the SC formulations, we found that Agrilan 1028 works best in acid form and its good performance as a wetting agent can eliminate the need for a separate wetting agent.

A comparison of performance of Agrilan 1028 was made against commercial materials recommended for use in electrolyte systems. The comparative examples had the same number of carbons in the hydrophobe and similar levels of ethoxylation as Agrilan 1028. Despite the similarities, the SC made with the Agrilan showed no separation after 24 hours at room temperature whereas the comparative examples both showed clear separation. When these SCs were diluted in 10-34-0 fertilizer the comparative examples started to phase separate after a few hours while the Agrilan 1028 formulation remained stable for 24 hours, Figure 2. This result confirmed our original findings that the specific alcohol used, degree of ethoxylation, and method of manufacture are key to achieving stability in both the SC and the fertilizer dilution.



Figure 2. A comparison of performance of Agrilan 1028 was made against commercial materials recommended for use in electrolyte systems.

Conventional SC formulations using water as the carrier medium rely on dispersants and thickeners to provide a stable suspension. An alternative to this type of formulation, for infurrow applications, is to formulate the SC in the preferred starter fertilizer, which then avoids any incompatibility on dilution. We found that by using this approach with Agrilan 1028 we were able to produce a 33% Bifenthrin SC in 10-34-0 fertilizer which when diluted to 3% in the same fertilizers showed no separation after 5 hours of standing. This unconventional approach offers formulators a higher loading of ai than with standard SCs.

While 10-34-0 was our reference fertilizer we also looked at

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some other fertilizers. Figure 3 shows the results with different fertilizers and actives after 6 hours of standing. For this screening a very basic SC comprising 17.5% of the ai., 8% Agrilan 1028 and 0.3% defoamer was diluted at 2% in the fertilizer. The screening results indicate compatibility with both nitrogen and sulfur-based fertilizers.

Active Fertilizer	10-34-0	NH3- Thiosulphate 12-0-0	K-Thiosulfate 0-0-25	28% AMS
Bifenthrin				
Trifloxystrobin				
Atrazin				

Homogenous dispersion after 6 hours Phase separation within 6 hours



Bifenthrin dispersions after 6h Figure 3. The results with different fertilizers and actives after 6 hours of standing

Our initial focus was on in-furrow applications, but we also were interested in tank mix formulations. To evaluate the potential of Agrilan 1028 as a tank mix compatibility agent we looked at a 3-component mixture. For this evaluation, 4 commercial 540K Glyphosate formulations were used alongside 4 formulations utilizing our own adjuvants. Added to these solutions were an Atrazine WDG and a Trifluralin EC. All these 3-way component mixtures flocculated upon mixing. However, this could be avoided by adding Agrilan 1028 – the addition of 0.5% Agrilan 1028 gave full compatibility with no phase separation or flocculation in all 8 cases.

Conclusion

Formulation in high electrolyte systems severely limits the tools available to the chemist. Due to the complexity of many agrochemical formulations the ability to fine tune surfactant properties to meet the formulation challenge is highly desirable. We have seen that some systems can be sensitive to relatively small differences in surfactant structure. Phosphate esters have been shown to be a useful surfactant class for this application due to the variety of structural options they provide and their tunable surfactant properties. Phosphate esters, in particular Agrilan 1028, have proven to be a versatile addition to our toolbox when working with high electrolyte systems.

Future Requirements, Challenges and Core Competences in Formulation Innovation and Development



Dr. Roy C. Chen Agrochemical/Biopesticides Formulation Consultant

"Regarding the formulation technology innovation, an agchem company core competence should have the following strategies and objectives: 1) developing new pesticide molecules, 2) discovering new biopesticides, 3) design formulations of either single or combo AIs (both new and generic) with the aid of effective, safe co-formulants, and 4) manufacturing the resultant formulation products in a safe and cost-effective manner, which should be deliverable and efficacious for the farmers," said Roy C. Chen, PhD, former ADAMA US Formulation Team Leader, in a recent interview with AgroPages. He also shared his views on the future development trends of novel formulation and app lication technologies, regulatory and R&D challenges that affect formulation innovation and development, as well as core competence to drive formulation technology innovation.

What novel formulation and application technologies are needed to meet the needs for growers over the next 5-10 years in different global regions?

In the next 5 to 10 years, the worldwide population will demand more secure and reliable food crop production, in terms of quantity and quality, while adjusting to climate change and reduced arable land. The future of novel formulation technological development for agrochemical companies will center around developing not only new AI molecules by R/D companies, but also combo Als, or so-called hybrid mixture formulations by most generic companies. The latter direction is due to the need to differentiate oneself in local and global market places. Furthermore, there is also a desire to be environmental-friendly, while keeping safe and efficient applications, and breaking weed resistance, such as those of glyphosate and triazines, among others. Formulation technology could be part of an integrated approach involving a weeder machine, and crop rotations in conjunction with novel agri-formulations. How about using chemical/biological combo formulations to fight against resistance? For example, one could use certain fungal spores in the formulation. The major formulation challenges lie in dealing with formulation mixtures which are becoming more complex, so do the coformulants needed to make that happen. Usually, these include new functional coformulants, green solvents, biostimulants and other related adjuvants.

Q2

What are the regulatory challenges to affect future formulations? Could you share some specific cases of how an agchem company develops agrochemical formulations suited to different global regions?

As national authorities manage formulation registrations individually, through various local laws and policies, agrochemical producers may face challenges in cases of the same coformulants which may not be globally accepted. Therefore, separate versions of the same product formulations may be necessary, so do the corresponding tox data requirement. As a result, more resources are needed for registering the same product. By the same token, managing the downstream supply chain issues would be just as challenging and costly. Furthermore, due to different pesticide regulations among countries, there could be issues

involving pesticides in international trade. A recent example concerns glyphosate re-registration in the EU. Because glyphosate formulations, particularly those coupled with polyethoxylated tallowamine emulsifiers (POEA), have been shown to cause elevated cytotoxic or endocrine disrupting effects, compared to the active ingredient glyphosate. However, this is not an open and shut case for some. Opinions among scientific communities, health officials and environmental authorities/organizations are divided. Essentially, the case touches upon fundamental aspects of risk assessment and product regulation. A very recent news item is that a French court has issued a ban on glyphosate sales in France. Several other countries outside the EU, including Argentina, Australia, Bermuda, Brazil and Canada, are banning or restricting glyphosate use, while the US has not. Because of the glyphosate issues, the fate of POEA Tallowamine coformulant has also been affected. In response, Bayer/Monsanto, the glyphosate formulation manufacturer, is now removing the Tallowamine emulsifier away from all glyphosate formulations. There is also movement in the EU to use alternative weeding methods, in addition to IPM techniques, plus using other safe organic herbicides, such as essential oils, acetic and citric acids, as well as fatty acids, as in soap formulations which may be necessary to help manage post-glyphosate market needs.

Q3

What are the challenges in R&D for new formulations and possible solutions?

In the broad background of satisfying the overall agricultural production needs in food, fiber and fuel crop productions, farmers usually rely heavily on agrochemicals in modern farming to enhance crop yield, increase plant growth, neutralize the soil, and protect against pests, including weeds, insects, and fungi. The issues are how to increase and optimize the agricultural output in each region through smart utilization of agrochemicals. The corresponding formulation R/D challenges resides in developing new combo formulations, which are becoming more complex to formulate. Take a close look at potential formulation components that a formulator must face; including the chemical active ingredients, wetting agents, emulsifiers, surfactants, dispersants, polymers, solvents, oils, adjuvants, suspension aids, powders, buffers, rheology modifiers, water, adjuvants and more. Their physical and colloidal interactions with one another must be appreciated and acted upon accordingly. Obviously, the goal is to have an end formulation product which must be physically and chemically stable in storage, and easily applicable for tank mixing, while delivering the pesticidal efficacies. More challenging are those combos of agrochemicals and biopesticides. For example, there are biopesticides consisting of bacterial or fungal spores for seed treatments, combined with the chemical insecticide on crop seeds, such as corn, soybean, and cotton. The seed

treatment combo formulations may be one of the reasons why the biopesticides market is growing. Prominent examples are BASF's Poncho Votivo and PV 2.0 (nematicide) and Syngenta's Clariva Complete (Soybean Cyst Nematicide).

Q4

Could you share some cases of digitalization technologies that enhance efficacy for formulation development / application/ delivery?

As we are living in a digitized world, it is only natural that digital technology can be utilized or considered in agrochemical formulation development, such as data collection and organization for formulation definition and registration purposes. Databases of co-formulants, including their chemical and physical properties, can be searched for data mining. For now, there is still no computer modeling or simulation of agrochemical formulations. Actual formulations still need to be put together physically, according to compositions on the bench for realistic testing and monitoring. This is an area yet to be explored.

A very useful statistical methodology applied to formulation development is the "Design of Experiment" (DOE). It is a wellestablished systematic approach to create good formulations. There are commercial computer software packages marketed to perform formulation DOE. This statistical method is a powerful tool for formulation optimization, particularly when multiple ingredients are involved to achieve the final performing formulations. Generally, DOE technique is highly recommended, as most formulators have been trained or are used for employing traditional techniques of changing onevariable at a time (OFAT), versus something like factorial designed experiments through DOE techniques.

Other areas of agrochemical digitization start from digitizing lab formulation test equipment, which can be computer controlled and monitored, and examples include lab viscometer and incubators for freeze-thaw tests. Regarding the downstream agrochemical pilot plant operation and the further down-stream production, the associated digitization is expected to follow those of a digitized chemical plant, both in unit operation and unit process. From plant control panel to process unit feedback, modern digital technology can be a great tool, in terms of safety and good quality control. One critically new area for all agrochemical companies to consider is the formulation production simulation for formulation plants. Not only can a normal formulation operation be simulated, but also an inconceivable formulation mishap. A simulation software module can be a cost-effective training tool for pilot scale up and production crews. The final area to consider is formulation plant automation. This can be an effective way to increase productivity, minimize costs and make your facility

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operate more ergonomically. Plant automation should be well suited to a stepwise type of processing for a production facility which manufactures agrochemical formulations.

In the near future, delivering formulations to the field will be done by robots in modern farms, usually by Agbots plus flying drones. Accordingly, agrichemical formulations can

have higher concentrations, while formulation types and design also can be more versatile, without human safety concerns. For the same reason, formulation sprays can be more flexible, as well.

Furthermore, formulation application can be performed in a high precision manner and be far less polluting to the environment.

Q5

What's the core competence to drive formulation technology innovation in an agchem company? What innovation formulation technologies have been launched in the agchem industry?

As far as a modern agrochemical company is concerned, regarding the formulation technology innovation, the company core competence should have the following strategies and objectives: 1) developing new pesticide molecules, 2) discovering new biopesticides, 3) design formulations of either single or combo Als (both new and generic) with the aid of effective, safe co-formulants, and 4) manufacturing the resultant formulation products in a safe and cost-effective manner which should be deliverable and efficacious for the farmers.

Furthermore, regarding the formulation technology innovations necessary to follow up the above strategies, the agrochemical company needs to excel in the traditional formulation technologies such as the emulsifiable concentrate (EC), soluble concentrate (SL), suspension concentrate (SC), water dispersible granule (WG), and wettable powder (WP) by Improving and optimizing the compositions. Have a pipeline of formulation products each year for the market. Beyond the traditional formulations, other specific formulation types may be considered, such as suspo-emulsion (SE), oil dispersion (OD), and capsule suspension (CS) formulations utilized to deal with the specific cases including physical or chemical incompatibility, bioefficacy improvement, reduced environmental toxicity, etc. Typically, these formulation types require longer time to screen and test. Lastly in the case of microbial spore biopesticides, the up-stream fermentation excipients usually are mingled with the spores in the very formulation mixture, that can be a challenge to the formulators!

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Bayer, Corteva Agriscience and ADAMA: Insight Into the Innovation and Development of Formulation and Application Technology



By Grace Yuan Editor of AgroPages grace@agropages.com WeChat: nanagrace2014

The agrochemical formulation development is facing significant challenges not only from a technical perspective, but also regulatory and market demands. These challenges facilitate the iterative upgrading of formulation and application technologies. It is worth mentioning that the digitalization technologies are enhancing both formulation development and the application of delivery of products. AgroPages recently invited three key players Bayer, Corteva Agriscience and ADAMA in this field to share their views on future development trends of novel formulation and application technologies, challenges that affect formulation innovation and development, strategies of formulation development, digitalization technologies to enhance efficacy for formulation development/application/delivery, as well as innovation formulation and application technologies launched by them.



What novel formulation and application technologies are needed to meet the needs of growers over the next 5 to 10 years in different regions of the world?

Bayer: New advancements in application technologies, such as drones, direct-injection systems and autonomous field robots, change the way our crop protection products are applied. Improvements in sensor-technology and image recognition, combined with ultra-fast computing power, are allowing high-resolution weed detection and increasingly precise disease and pest prediction, which form the basis of new service offerings for our customers.

The fundamental formulation solutions and approaches will not change. Nevertheless, I believe that the overall relevance of formulation technologies will increase in the future, specifically as the rate of introduction of new active ingredients has declined in recent years. Formulation technologies have to meet increasing regulatory requirements for reducing the environmental impact, such as the reduction of off-target losses, biodegradability and also technical challenges resulting from new active principles such as biocontrol solutions, peptides, and RNA-based or antibodybased solutions. However, this will also help to generate IP and introducing new competitive solutions.

Further advancements in formulation science are key to improve bio-delivery, reduce environmental impact, ease handling and increase stability, particularly in low-volume applications by drones, boom-sprayers and robot applications. These features are quickly becoming key selling points for our customers, and increase the perceived value for important Bayer product brands. Another example of the relevance of formulation technologies are innovative solutions allowing a slow/controlled release of active ingredients, thereby improving crop safety and duration of control in soil or paddy fields. Encapsulation technologies can also reduce the volatility of active ingredients, chemical compatibility and the shelf-life of biological crop protection products. Other formulation technologies aim at reducing off-target losses, such as dust from seeds, drift, wash-off or improving rain-fastness.

Finally, despite their relatively low market share today, biologicals (or biopesticides) will offer clear growth opportunities for our industry in the future. Due to the active nature of biological crop protection products, formulation technology will help to address challenges around shelf-life, formulation stability and the efficacy of these solutions.

Corteva Agriscience: It is an exciting time for agriculture with new advances in active ingredients, biotechnology, application technology and data science all impacting new product development. Despite rapid change in many areas, the macrolevel trends continue to be consistent. Growers require convenient products and solutions that maximize yield potential in a cost-effective manner, while enabling them to be good stewards of the land, environment, and human health. Growers will continue to need easyto-use solutions to address resistance challenges through multiple modes of action. I expect there to be significant growth in naturally-derived and biological control products coming to the market to meet the increasing public and regulatory pull for these types of products, especially in some highly developed regions. Additionally, product sustainability in terms of low use rates, as well as use of low environmental-impact and inherently safe coformulants, will be prevalent. Application technologies that enable crop protection products to be applied only where needed will also be required to continue to improve the profitability and environmental footprint of agriculture.

ADAMA: Growers today are facing multiple challenges that are driving two primary industry needs.

The first challenge is presented by the growing resistance to the different crop protection products that are being applied around the world. This phenomenon is quite similar to what we've seen in the pharma industry - where different bacteria are becoming immune to the antibiotics that have protected the world's population against illness for decades - although possibly escalating at an even faster rate.

In the AgChem industry, such resistance is posing great challenges to growers. Namely, as pests become more resistant, more products need to be applied at a higher frequency. Clearly, this bears great financial and ecological consequences.

In some cases even increasing application rates and frequency does not effectively control the disease. As a result, output decreases, crops are lost, and prices increase. In fact, there is no part of the supply and value chain that is not impacted.

One example of resistance comes from black grass, a weed that is particularly prevalent in Europe, but also beyond. Black grass grows next to cereal crops, such as wheat and barley, adversely impacting yields. Despite the variety of herbicides applied to combat it, black grass has developed resistance to most products and requires increased application rates of others.

Another example comes from a fungal infection called Asian Soybean Rust, common in Brazil and surrounding countries, including Bolivia and Paraguay. Over the last number of years, this fungal disease has developed significant resistance to existing fungicides and has caused profound economic losses to both farmers and the food chain.

For effective resistance management, plant protection products based on several chemical classes and different modes of action need to be available to farmers. The development of new formulation and application technologies needs to evolve accordingly. We need to be innovative and user-focused in our approach, while balancing the various and competing factors we need to take into consideration, including environmental, regulatory and financial aspects.

While players in the industry are working hard to bring new innovative active ingredients (Als) to market, the rate of innovation appears to be slower than the rate of the evolution of resistances. As soon as a new product is launched, work on the next one needs to start, if not before.

The second challenge that farmers face is the often adverse public perception of the environmental and health impact of plant protection. As ADAMA we understand that societal

Interview



Dr. Bernhard Grimmig Head of Formulation Technology, Crop Science Division of Bayer



Melissa Merlau Johnson, PhD Formulation Science & Technology Leader, Corteva Agriscience



Yoav Avidor Head of Formulation and Delivery Technologies at ADAMA

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concerns need to be addressed and we also need to be clear that all our products have undergone a rigorous and robust regulatory assessment before being allowed on the market. If applied correctly, plant protection products are an important and safe tool for farmers to help safeguard yields and increase the quality of their produce.

I believe that there has to be a wider discussion on the issues of food and feed production, which should include farmers, scientists, manufacturers, regulators and NGOs. There should be an informed and fact based debate on how to sustainably secure food supply and food safety for a growing population.

So yes, our formulation research and development should address a complex environment, balancing technological, biological and regulatory challenges. This is what makes our job so interesting and rewarding.

2 Could you share some specific cases of how your company develops agrochemical formulations suited to different global regions?

Bayer: One example is in Europe, as well as the cereal market where EC Fungicide formulations with good leaf activity and penetration of cereal fungicides are needed. In North America, we typically develop liquid formulations, such as SL-type herbicides or non-adjuvanted SC-type formulations, in light of the established strong tank-mix adjuvant market. In the Asia-Pacific region, and especially in Japan, we focus on specialty solutions for rice growers. For example, we develop shaker bottle solutions, granules and jumbo granules, and there is a growing market for drone applications with a need for ultra-low water volumes. In Latin America, where the market is dominated by large farm operations, there is a particular need for the easy handling of products and preparation of spray solutions.

Corteva Agriscience: The development of any new agricultural product at Corteva Agriscience starts with the customer in mind and a clear understanding of local application practices in the targeted markets and regions. Corteva Agriscience has a global R&D presence for both formulation and application technology – in North America, Latin America, Asia-Pacific, and Europe – to ensure that we can easily collect first-hand knowledge of local application practices and test our products under relevant conditions, often in partnership with growers and applicators.

For example, a product that will be applied by backpack sprayer needs to have excellent "bloom" upon addition to water because mixing in the application is uncertain. Products designed for the northern United States and Canada need to disperse quickly in cold water, and products designed for drone application in Asia should have exceptional compatibility at high concentration to maximize payload. Our scientists take these and many other region-specific considerations, such as typical equipment, water quality, application rates, and storage conditions into account when developing design and testing protocols for both the lab and field to ensure a positive applicator and grower experience.

ADAMA: Our product development process starts with ideation. That is, first we investigate and identify the needs of growers in different regions of the world. We translate these needs into product concepts, and then make decisions about which products we want to develop and prioritize.

A variety of functions are involved in this decision-making process, including local as well as global assets. This ensures that we stay close to the local needs, even as we build on our wider global resources.

Indeed, our product concepts come from the field – literally. It's not just about headquarters bringing in the ideas and making decisions. The countries themselves are deeply involved.

As a company, we are locally driven and globally backed. We have a presence in 50 countries, endowing us with great access to nurturing mutually-beneficial relationships with farmers. And the result is a product development process that is tailored to meet the specific needs of farmers in every region and key market.

At ADAMA, we invest in both internal and external capabilities. We are expanding our internal resources, and recently opened two new state-of-the-art R&D centers, in Nanjing, China, Hyderabad, India and the recently launched R&D center in Beer-Sheva, Israel.

In addition, we've also established more third-party partnerships, in order to accelerate our access to innovative technologies and methodologies.

I would highlight our network of agronomists located in dozens of countries, a number of local formulation labs, including in Israel, India, Brazil, China, and the US.

Beyond resources, I believe that our culture and mindset enables us to react rapidly to change, to be agile, and to innovate in the way we connect the needs of the market to our expertise and ability to deliver on them.

I am proud of how we mold local with global, and apply agility and an innovative spirit to many things we do daily at ADAMA. Q3

What are the challenges in R&D for new formulations and possible solutions? What technologies has your company adopted to speed up formulation technology innovations?

Bayer: Our R&D efforts are focused on a variety of key areas. For example, we devote a lot of time on environmental and human safety aspects of our formulations, such as reducing the off-target movement of products or further minimizing risk to operators. We work a lot on areas around mixing, including developing premixes with multiple active ingredients to ensure chemical compatibility, or compatibility with tank mix partners, such as fertilizers. And product quality measures are critical: stability of products, efficacy and shelf-life, and robustness of the formulations.

To continually improve our ability to bring new innovations to the market, we rely on our extensive background in formulation design with the latest data science tools. Over the past decades, we have gathered a wealth of formulation recipe data and related analytical data (chemical and physical stability data), as well as data from bioavailability and efficacy testing of various formulation concepts. Making best use of these data sources remains a key challenge, but also offers a great opportunity for us. It is important for us to continue establishing data platforms for data capture in the formulation space and also improve our data analysis capability by combining formulation data with analytical and biological data, in order to make better predictions for the design of formulations.

At the heart of all of this advancement is our people. We have formulation expertise built on diverse and complementing expertise: colloid scientists, chemists, physicists, biologists, biotechnologists, people with engineering backgrounds, and more. We built an internal formulation community across the various Bayer divisions for know-how sharing, and we collaborate and exchange with universities to foster fundamental science in the formulation area, and to have access to talents.

Corteva Agriscience: Corteva Agriscience is working to develop new products that address the opportunities and unprecedented challenges of the rapidly-changing agricultural marketplace. For example, we are developing multi-active ingredient products with multiple modes of action to help farmers manage weed, insect, and disease resistance. Stabilizing multiple active ingredients in a formulation can be a challenge, but predictive models and data science are becoming valuable tools to help screen initial formulation parameters and focus research quickly on leading prototypes. New predictive test methods and technologies enable formulation scientists to effectively evaluate physical stability

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of formulations, like crystallization or phase separation potential, before these effects can be observed by the human eye. We also use predictive methods to proactively understand the human and environmental safety of our products during development, so we can ensure the safest and most sustainable products make it to market.

New analytical tools allow scientists to measure and visualize with more definition whether the active ingredient is reaching its target site and subsequently modify formulation and application parameters to maximize efficacy without relying solely on biological response data. These tools are particularly useful as active ingredients become more complex and efficiency is critical to ensure cost-effective solutions for the grower.

ADAMA: As pest resistance increases quickly, one of the challenges to R&D is undoubtedly shortening the development process for new formulations.

Every market player wants to be the first to market. But with resistance playing a major role in our industry, there is a greater sense of urgency than ever to accelerate the process of getting a product from the research stage to the end user. Resistance cycles are getting shorter and shorter, and we simply can't afford not to keep up.

Moreover, with the increasing demands of our regulatory environment, accelerating development cycles has become an even more complicated endeavor. There is a lot of uncertainty, where you can be working on a product for perhaps three years. On starting the registration process, you might discover that regulation has been passed during the development period. At that point, the formulation and application rates of the product might have to change, and you find yourself back to square one.

Q4

Could you share some cases in the digitalization technologies that enhance efficacy for formulation development/ application/delivery?

Bayer: Digital tools are enhancing both formulation development and the application of delivery of products. In Development, we use modeling and prediction tools to speed up screening or to simulate operating environments. We are also able to use robot technologies in formulation screening to improve accurate handling and dosing of a large range of active ingredients and formulation inerts.

Digital tools are rapidly changing how our products are used. For example, digital weed control is being used on railways. With partners, we have developed a train equipped with camera systems to detect weeds, which opens spray

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nozzles only in the presence of weeds, reducing the need for herbicides to keep tracks clean and safe. Similar technologies are being deployed for farmers to use in their fields.

Corteva Agriscience: The digitization of agriculture offers a powerful new opportunity to enhance the efficacy and sustainability of crop care. The ability to monitor crop health with directed scouting tools, like those offered through Granular Insights, allow applicators to refine when and where they apply crop protection or nutrient products, optimizing for yield while minimizing product usage. We also continue to transition away from whole-field applications and move towards managing by sub-field zone, and in some cases even to each individual plant, thanks to the precision ag technology available from Granular Agronomy.

Meanwhile, advances in sensors, imaging and data science help to more quickly identify problems in the field, and advances in equipment and robotics are making the tools available to apply products in a targeted manner. One example is our use of satellite imagery to identify areas of invasive brush species and improve treatment timing. Another example is testing and optimization of Unmanned Aerial Vehicles (UAV) application for weed and disease treatment in rice.

What is the core competence that drives formulation technology innovation in your company? What innovation formulation technologies have been launched by your company? What are the agricultural concerns solved by them?

Bayer: Our core competence is combining the vast knowledge and experience we have across Bayer in a wide range of disciplines, such as chemistry, biology, field development, application technology, and more. To do this, we have an in-house innovation platform in the formulation area, which allows exploration of blue-sky ideas and new formulation concepts, and ensures cross-site know-how exchanges between different formulation teams.

And while we have an excellent understanding of product performance attributes, such as efficacy, application behavior and shelf life stability, we continually look outwards to improve. For example, we partner with our commercial teams to ensure sound understanding of market needs and involvement in the design of new commercial product concepts to best meet our customers' needs. And we actively collaborate with universities and other outside experts to expand knowledge and perspective.

Recent launches demonstrating how formulation

technology enables new product concepts:

• Bayer, inventor of Oil Dispersion technology for a range of highly potent herbicides, e.g. Laudis™OD, and newer introductions, such as MaisTer™ Power / Monsoon™ active OD, oil required for chemical stability of SU herbicides and boosting biological efficacy.

• XtendiMax[™] Herbicide with Vapor Grip Technology to minimize off-target losses and vapor drift of dicamba

• Fox[™] Xpro Fungicide in Brazil, our new benchmark fungicide for outstanding soybean rust control combining 3 different modes of action with SDHI chemistry (Bixafen), azole (Prothioconazole) and strobilurin fungicide (Trifloxystrobin) providing superior performance through innovative formulation technology, such as adjuvants for improved wetting and rainfastness.

• K-Othrine[™] Polyzone, an example of a new innovative formulation which added new features to an existing pyrethroid insecticide via a polymer-enhanced suspension concentrate, which provides excellent long-lasting control (used for in-door control, e.g. mosquito).

• Specticle[™] Herbicide for pre-emergence weed control in turf. The challenge was to avoid movement of herbicides into the turf root zone, which has been achieved through the addition of suitable polymers / carriers.

Upcoming new launches include:

Vayego[™] Insecticide based upon novel diamide chemistry for lepidopteran control, where the technical quality (i.e. crystal modification of the active ingredient) posed significant challenges during formulation development.

New developments based on RNAi:

BioDirect, RNAi for varroa control - We recently submitted a new Varroa Control Product to the U.S. EPA for registration, based upon double-stranded RNA, which is the first U.S. EPA submission for an exogenously applied, dsRNA biopesticidal active ingredient in the industry. Contributions from formulation technology were key in developing this new technology, ensuring sufficient stability and uptake of this new active ingredient principle.

Corteva Agriscience: Developing formulation and application technologies that are efficacious, sustainable and easy-to-use requires collaboration among our highly skilled and diverse chemists, engineers, analysts, and field scientists. However, at Corteva Agriscience, the most important element is a deep understanding of what growers and consumers need and value -- at a local level -- that can be translated into exciting new products. Examples of our award-winning formulation and application technologies are below:

Enlist Duo[®] and Enlist One[®] herbicides provide superior

control of resistant and hard-to-control broadleaf weeds in Enlist E3 soy, Enlist corn and Enlist cotton fields – including Palmer amaranth, waterhemp and giant ragweed. Both products use new 2,4-D choline and Colex-D[®] technology to help address challenges beyond controlling tough weeds, including minimizing potential for physical drift and delivering near-zero volatility to ensure that the product lands and stays on-target. Colex-D technology also provides applicators the benefit of better handling.

As farmers continue to fight herbicide-resistant weeds, Resicore[®] corn herbicide brings together three modes of action and a wide rate range to fit a variety of agronomic programs, including pre-emergence and post-emergence. Resicore[®] corn herbicide gives farmers power over weeds deep into the growing season. With strong residual control and versatile application timing, Resicore controls more than 75 high-anxiety broadleaf weeds and grasses, including waterhemp, marestail and Palmer amaranth. Resicore[®] was awarded the Agrow Award for Best Formulation Innovation 2016.

Loyant[™] herbicide, with Rinskor[™] active, provides excellent control of ALS-resistant grasses and sedges in rice with an alternative mode of action. The product received a U.S. EPA Reduced Risk designation for its favorable environmental profile and was recognized by the US Green Chemistry Challenge Award. Also, Rinskor[™] has been recognized by R&D 100 and by Agrow as the Best New Crop Protection Product. Loyant[™] herbicide utilizes novel NeoEC formulation technology, to deliver a similar sustainability profile to water-based formulations, while also achieving many of the benefits traditionally associated with solvent-based formulations, including high efficiency, good stability and excellent handling properties

Pexalon[™] insecticide, powered by Pyraxalt[™] active is a crucial insect management tool specifically for rice farmers in Asia. Pexalon[™] can control damaging plant and leaf-hoppers with one application, followed by a different mode of action chemistry, reducing the number of spray applications compared with traditional treatments due to the long-lasting nature of control and excellent rain-fastness.

ADAMA: ADAMA strives to create simplicity in agriculturewith one of the most comprehensive and diversified portfolios of differentiated, high-quality products, we provide farmers around the world with crop protection solutions that help to produce safe and nutritious food for a rapidly growing population.

Soybean rust is a highly impactful disease which causes significant damage. It is particularly destructive since it can develop very quickly, be carried by wind over large distances, and cause rapid, irreparable loss of leaves, with the possibility of causing crop losses of up to 80%. In 2018, ADAMA launched a unique three-way mixture fungicide to combat soybean rust, CRONNOS[®] (picoxystrobin + Tebuconazole + mancozeb). Its

Interview

liquid formulation, CRONNOS TOV[®] provides effective protection for soybean diseases, saves time for growers by strongly adhering to the plants' leaves and preventing spray nozzles from clogging. Its flexibility provides farmers with further benefit by being able to apply the fungicide at any time during the plant's development.

BREVIS[®] (metamitron) was developed with the aim to replicate the known effects of shade thinning on apple and pear trees and is the most effective Carbaryl substitute among all other thinning candidates. It combines a photosynthesis inhibitor and a commonly used fertilizer (Calcium formate). For the last 6 years ADAMA has been testing and improving the formulation of BREVIS[®] in a wide range of varieties, growing conditions and geographical zones (Europe, Americas, Asia, Africa, and Australasia). BREVIS[®] is now registered in 23 countries worldwide, with other key apple and pear markets to follow in the coming years. BREVIS[®] is an innovative product now patented in Europe and other countries globally.





BIS Research: UAV Delivery Systems and UAV Application of Formulation & Adjuvant Technologies

Rakhi Tanwar Principal Analyst at BIS Research

Crop protection chemical products play a pivotal role in controlling the pests and diseases that infect and damage overall farm produce, and can further reduce the quantity and quality of food production. Excessive and unsuitable applications of crop protection chemicals, such as pesticides, herbicides, insecticides, and fungicides, among others, through traditional manual spraying, has resulted in an intensification of hazardous elements in the environment. Moreover, these crop protection chemicals demand high prices, leading to an increase in operational costs. Thus, incorporation of precision technologies for spraying of these chemicals has emerged as an ideal alternative to address the limitations faced by farmers. and to ensure ecological sustainability. This article covers the following points in detail about:

• Major applications, use cases, and downsides of UAV/drones in the agriculture industry

• Stakeholder Analysis: Effect of UAV Based Delivery System on the Adjuvant's Supply Chain



Market Consolidation

Companies are expected to merge, acquire, or partner to offer consolidated drone business solutions i.e., end-to end solutions including hardware, software & services



Drone-as-a-Service

Aiming for affordable drone solutions, an increase in number of service providers for drones is expected thus lowering the entry costs associated with the drone technology



Artificial Intelligence Rise in AI driven drone solutions, especially for data analysis, aerial mapping & imaging

for data analysis, aerial mapping & imaging is expected to drive the drone industry for autonomous solutions

Figure 1. Mega Trends to Impact the Drone Industry in 2019 Source: BIS Research Analysis Companies Producing Adjuvants Compatible with UAV
Applications

UAV- The Future of Pesticide Spraying

Agricultural UAV Market by Applications

The advancement of Unmanned Aerial Vehicles/ Unmanned Aerial Systems (UAV/UAS) technology in a variety of industries, such as aerospace and defense, healthcare, retail, and others, is resulting in the proliferation of a number of uses across the globe, including the growing usage of UAVs/UAS in agriculture. These UAVs, in conjunction with image data analytics, are being widely used in the agriculture industry.

The agriculture industry has become a favourite among interested businesses and consumers of drones, and is expected to witness a sharp uptake of drones in the next 5-10 years. There are various ways in which UAVs are effectively reshaping



Counter Drone Solutions

Rising need to protect critical infrastructure and ordinary people from malicious drones is expected to fuel advancements in antidrone technology and increased awareness about drone threats

Regulations As the drone industry matures, formidable



advancements in strengthening the regulations across the globe is expected. Major developments from FAA in the U.S. and EASA in Europe is being speculated

Business Expansions



Companies are expected to expand their business solutions across end-user industries. Internal teams shall also expand to manage large data & workflows and assisting the overall crop life cycle, based on their imaging, real-time data gathering, processing, and analytical capabilities, including:

• Providing precise 3D maps for early soil analysis, useful in planning seeds and nutrient status to further reduce the overall cost of plantation and other expenses

• Adjusting the altitude, scanning farms, spraying appropriate amounts of liquid (fertilizers, adjuvants), and ensuring uniform coverage of the affected area

• Precisely tracking and assessing the growth of crops and providing data about inefficiencies and deficiencies, as well as bacterial or fungal infections, and ensuring better crop management

• Identifying areas of the farm which are dry, less irrigated, and need improvement, with the help of sensors, combined with UAVs

Use Cases of UAV Delivery System and Application in the U.S., India, and Africa

The U.S. is currently at the forefront of the global agricultural adjuvants market, with the Federal Aviation Administration (FAA) dictating the use of UAVs for farming operations in the country. The Yamaha RMAX, an unmanned helicopter developed by the Yamaha Motor Company, is being used in the USA. It consists of a two-bladed rotor and is remote-controlled by a line-of-sight user. Initially used only in Japan for agricultural spray applications, the UAV is now approved for operations in Japan, Korea, Thailand, Australia, New Zealand, and the U.S. Another renowned Chinese drone manufacturer, DJI, has introduced the Agras MG-1, designed for precision variable rate application of pesticides. The company is now working on automating these UAVs to apply chemicals to broadacre crops.

Likewise, in India, a farmer from the state of Haryana deployed customized drones that can aerially spray pesticides on crops. These drones (still unnamed) are of two versions - manually operated and automatically operated, and can carry a 35 kg load.



Figure 2. Stakeholder Analysis Source: BIS Research Analysis

Insight

Even in Africa, some 26% of the countries have stringent regulations governing the use of UAVs. Countries such as South Africa, Mauritius, Rwanda, Morocco, and Tanzania, among others, have successfully deployed UAVs for inspecting crops. In Morocco, UAS is used primarily for efficient application of crop protection chemicals. Les Domaines Agricoles, the largest Moroccan agribusiness, is one such company, which is utilizing UAV technology and image data analytics to ensure effective fertilization.

Stakeholder Analysis- Effect of UAV Based Delivery System on the Adjuvant's Supply Chain

UAV/Drone providers effectively contribute a large value to the entire crop supply chain. Spraying of crop protection chemicals for disease, weed, and pest control is currently one of the emerging applications of drones in the agriculture sector. Drone manufacturers are expanding their market capabilities in this industry by partnering with various farm cooperatives and agriculture consultants.

Farmers use real-time information extracted with the usage of UAVs to plan their cropping cycle, and also for better decision making. Though the initial cost of implementation is high when compared to the benefits/returns received from this technology, UAVs as a viable technology is a justified investment.

Adjuvant manufacturers and companies providing crop protection chemical products can reduce wastage of their stocks and pre-plan accordingly through this data-driven approach.

Credit and insurance companies play an important role in the crop cycle, considering that majority of farmers' livelihoods are largely dependent upon farm produce. Crop insurance protects farmers against any form of loss caused by crop failure, while credit institutions provide much-needed credit to them, to purchase technologically advanced products and utilize their efficient inputs. By analyzing the real-time information generated by UAVs from the field, these companies can judge the credit worthiness of farmers and pay out monetary compensation with a better degree of reliability.

Agronomists and distributors operating in the market can also use extracted crop indicators and harvesting schedules to plan their distribution schedules and prevent losses.

Companies Producing Adjuvants Compatible with UAV Applications

Adjuvants are primarily used in the agricultural industry to improve the performance of insecticides, pesticides and herbicides, which further improve the effectiveness of the crop protection chemical and help in providing better distribution and drift reduction. As per a report by BIS Research, the global agricultural adjuvants market is expected to grow from \$2.8 billion in the year 2016 to \$3.6 billion by 2021 at a CAGR of 5.5% from 2016 to 2021. Companies such as Adjuvant Plus Inc., ORO AGRI, Helena Chemical Company, Wilbur Ellis Company LLC, Solvay AG, Nufarm Ltd., Momentive LLC, Akzo Nobel Inc., BASF SE, Evonik Industries, and Elkem Silicones, are the key players operating in the agricultural adjuvants market.



Figure 3. Global Agricultural Adjuvants Market and Key Driving Factors Source: BIS Research Analysis

Spray drift is presently considered to be the most challenging problem faced by applicators and pesticide manufacturers. It can damage plants, animals, and the environment, and can even affect human health. Companies have come up with adjuvants and formulations compatible with UAV applications. These formulations (with their wetting, spreading, sticking, reducing evaporating, and also spray drifting properties) have the ability to minimize or even eliminate spray application problems by controlling physical and chemical properties.

Adjuvant Name	Manufacturing Company
Silwet Low Drift Adjuvants	Momentive Performance Materials Inc.
AgRHO Aero-mate 320	Solvay S.A.
Maifei	Beijing Grand AgroChem Co., Ltd.
TIS 331	Jiangxi Tiansheng New Materials Co., Ltd
Pineye Emulsion	Foreverest Resources Ltd.

Table 1. Adjuvants Compatible with UAV Application Source: Secondary Sources and BIS Research Analysis

The potential of adjuvants and formulations to reduce spray drift can be judged by measuring spray droplet sizes at different concentrations. Thus, ensuring the selection of the correct adjuvant for spraying though UAVs is one of the main practices adopted to reduce the negative effects of spray drift.

Downsides of UAV Delivery System for Spraying Purposes

One major downside of deploying UAVs on farms for spraying or other purposes is the exceptional high cost of fully equipped UAVs, including sensors, radars, and related hardware and software. The high prices further increase when combined with the cost of acquiring technical skills and knowledge of piloting UAVs. Though cheaper UAV options are also available, these are primarily ill-equipped and inadequate for farming operations. In the majority of cases related to UAV equipment, increases in the performance directly proportional to the rise in prices.

Another key concern for users about UAVs is privacy. A UAV can gather data without being detected, leading to the risk of breach of privacy. There also exists certain safety concerns while dealing with UAVs, hence, these should be equipped with sensors-andavoid systems to prevent potential collisions.

Rules and regulations for the use of UAV/ UAS for agricultural purposes vary across countries. For instance, the use of UAVs for farming purposes is considered a commercial activity by the Federal Government of the U.S. Farmers need to undergo operator training from the FAA and receive a certification in order to qualify for a remote pilot license. It is mandatory for remote pilots to adhere to a specified altitude for

UAVs flights, failure to which can lead to heavy fines and penalties.

According to Pest Management Regulatory Agency (PMRA) by Health Canada, spraying a pesticide with the help of a drone/UAV in Canada is still not allowed under the Pest Control Products Act. One needs to apply to PMRA with data stating the added hazards and risks, in order to receive approval.

UAV- The Future of Pesticide Spraying

With the help of current advancements in drone technology, spraying is the one application of UAV technology that is currently witnessing unprecedented growth in the agriculture industry. Deployment of drones in the agriculture sector is gaining at a high rate of acceptance by farmers across the globe. Drones have enabled farmers to gather invaluable data to further augment profits and



Figure 4. Agricultural UAV Market by Applications Source: BIS Research Analysis



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productivity, along with alleviating environmental hazards. As per a report by BIS Research, the global agriculture drone/UAV market generated over \$950 million revenue in 2018, out of which the spraying application of UAVs held approximately 9% of the market value.

The use of drones for various pesticide spraying applications leads to an efficient input of resources by farmers and allows for timely protection of crops from pests. The end users are rapidly identifying the benefits of the efficiency and affordability that drones provide to secure high yields and guality crops. The demand for drones for pesticide spraying is expected to further rise in the upcoming years. However, privacy and safety are still a cause of major concern for farmers. Addressing issues related to privacy, safety, and security can assist in the successful implementation of this technology.

UAV technology has effectively bestowed upon users innumerable benefits, which makes it worth taking a risk. Farmers would be able to save time, energy, and money in crop production, along with drone technology effectively working in tandem with environmental protection and efficient degrees of productivity.





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TERI-Deakin Nanobiotechnology Centre: Nanotechnology-based Agrochemicals as"Nanonutrifights" and Its Application Practices



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Problems with existing technologies and corresponding solutions

Agrochemicals are the chemical products composed of active ingredients that are used in agriculture as fertilizers and pesticides, to enhance the productivity of plants and management of plant diseases, respectively.

The disproportionate use of agrochemicals in high concentrations has led to the contamination of soil and groundwater by entering in the food chains, causing hazards to humans and animals. In addition, the runoff (or leaching from the soil) of agrochemicals into water resources can cause an adverse impact on the life-cycle of fish and other aquatic animals.

There is a large list of hurdles associated with conventional pesticides, such as non-biodegradability, resulting in long time persistency of pesticides in the field, frequently drift away (due to wind or air convection arrays) from the targeted field, high doses required because more than 30% of effective doses leach out from the soil, off target applications that contaminate much wildlife. Furthermore, conventional agrochemicals might not be helpful under these circumstances, as these have become expensive due to high energy requirements and being environmentally unsafe (Figure 1).



Figure 1. Schematic representation of use of nanotechnology innovations helps in the delivery of agrochemicals in plant systems and soil

Introduction

Nanotechnology has the potential to deliver novel products to improve the performance of vistas, especially in the agriculture and allied sectors. According to TERI's press release entitled, "Are Natural Alternatives to Pesticides and Fertilisers by Nanotechnology Safe? (2018), various industries, from biotechnology, agrochemicals, pharmaceuticals, and health, as well as the food sectors, seem to be on firmer footing to use the cutting edge technology using nanoscience. Considering its wide range of uses, the global nanotechnology market is likely to develop at a CAGR of around 17% during the forecasted period of 2019-2024. This will provide a great opportunity for research institutes to develop and collaborate with industry and stakeholders to seek inroads in the fast growing market, which would garner enormous revenues on the back of commercialization of the technology. However, nanotechnology is a multidisplinary branch of science and needs groups of experts from several disciplines to deliver complete solutions to varied problems to allow it's safe, efficient and cost-effective commercialization

In terms of agriculture, nanotechnology represents a new frontier by offering potential applications in the field of nanofertilizers and nanopesticides, jointly referred to as "Nanonutrifights". This desegregation approach of agrinanotechnology has not only revolutionized agriculture with innovative nutrients, in the form of nanofertilizers (NFs), but also protects plants from phytopathogens. According to leading R & D analyses, research in agricultural nanotechnology applications has been on-going for much of a decade, searching for solutions to several agricultural and environmental challenges, such as sustainability, improved varieties and increased productivity. Several institutes have shown the growing trend of both scientific publications and patents in agricultural nanotechnology, especially for disease management and crop protection. The nano based delivery system for delivery of "Nanonutrifights" will offer a very cost effective approach, with the enhanced efficacy of active principles. Nano based system in agriculture attempt to reduce the dose of active ingredients, minimise nutrient losses and increase yields through optimised water and nutrient management.

Insight

To address these limitations, the exploitation of the nanobased delivery system could be a promising alternative for sustained release of agrochemicals, to maintain the desirable activity and alleviate the potentially damaging impacts on the environment.

Recent translational innovations in the field of nanotechnology have transformed the world with distinctive nanomaterials, such as "Nanonutrifights", and increased growth and productivity of crops. These forefront applications require the appropriate chemical functionalization of nanoparticles with organic molecules, or their absorption in an appropriate polymer matrix for sustained release. The polymer based nanocomposites material is a ground-breaking product, offering nanofillers dispersed in the matrix of polymers, and has received much attention recently. We have developed biodegradable and biocompatible chitosan-metal nanocomposites with prolonged antimicrobial activities of metals (copper, silver and zinc oxide nanoparticles) and lower toxicity toward mammalian cells. Various attempts have been made to improve the antimicrobial activity of active ingredients, such as structural modification, adjustment of molecular factors, and forming complexes and their sustained release using nano based delivery systems. In practice, agrochemicals have been modified with the help of nanotechnology as "Nanonutrifights", which are considered alternative routes to conventional fertilizers and pesticides.

The National Centre of Excellence in Nanotechnology for Agriculture and Environment and National Facility for Toxicology, Life Cycle and Regulations at -TERI-Deakin Nanobiotechnology Research Centre (TDNBC), supported and funded by the Department of Biotechnology, India, is committed to sustainable activities and practices to reduce environmental hazards of agrochemicals, which is one of the globally defined challenges, and engaged in various research activities, such as synthesis of nanopesticides and nanofertilizers, and their encapsulation using eco-friendly nanomaterial with prolonged activities, providing benefits to the plants beyond basic nutrition. In addition, TDNBC has been developing smart delivery systems loaded with nanoforms of iron and zinc, primarily focusing to reduce the loss of active ingredients in conventional delivery systems due to volatilization or chemical reactions, microbial degradation, etc. Developing such nano-carriers can contribute to minimizing these losses. Furthermore, we have developed plant nutrients from industrial waste and will be the initiator to offer such an innovative approach towards providing sustainable solutions in agriculture around the globe. Also, we are participating in advanced research by developing more stable "nano emulsions" of pesticides having increased efficacy with lower application rates and controlled release.

Future development prospects

In order to improve the prevalent properties of agrochemicals, interactions between agrochemicals and plants can provide vital clues for the development of the translational technology, which can further generate significant benefits to farmers by improving field performance and reducing input expenses, not only in terms of cost, but also by reducing application losses. In the agrochemical sector, there are two main key players, industries and research institutes. Research institutes have robust capabilities to develop "nano-actives" or "nano-formulations" and industries typically deliver the product from research laboratories to the market. Moreover, both players can progress effectively and find better solutions for sustainable agriculture with nanotechnology.

We have also been developing next generation agronanoproducts, such as nano fertilizers, nano-pesticides and nanocarriers, with their complete life cycles, toxicity and regulatory assessments for agricultural use and increasing our research and market capabilities for ongoing growth in the agricultural field. There are various methods and technologies that have been developed by TDNBC for increased production, market access, and promoting sustainable farming practices. TDNBC is looking forward to creating collaborative research platforms which will be ready to translate its knowledge base at the grass root level, together in a coordinated fashion. The collaboration between TDNBC, TERI, New Delhi and industrial partners will create solutions in sustainable agriculture throughout world using nanotechnology.

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The TERI-Deakin Nanobiotechnology Research Centre (TDNBC) offers to join in and support the government's vision to promote and assist further in implementing innovation and translational research", said Alok Adholeya, senior director (sustainable agriculture) at TERI, New Delhi, India.

Vision

Research in frontier areas of precision and smart agriculture, through innovative disruptive nanotechnology, might be the most promising step which may replace hurdles of existing agrochemicals. Understanding the development of these technologies and their applications, as well as public acceptance and societal impact in the coming era, will be crucial in bringing nanotechnology to the market to provide better and more sustainable solutions.

About TERI- Deakin Nanobiotechnology Centre (TDNBC)

The TERI-Deakin Nanobiotechnology Centre (TDNBC) was established in 2011 by The Energy and Resources Institute (TERI), one of country's leading think-tanks, in collaboration with Deakin University, Australia, with the directive of developing groundbreaking nanobiotechnology centred solutions to address current challenges in the field of agriculture and environment. Conjointly supported by both organizations, the Centre aims to take global platforms through nanobiotechnology interventions in agriculture, environment, and energy, by developing multidisciplinary methodologies, tools and technologies.

Considering the importance of translational research in agriculture and environment, the Centre is uniquely poised to develop disruptive technologies using biocompatible nanomaterials. Such events are being brought together through strategic alliances with Deakin University and partners worldwide.



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iFormulate : The Challenges of **Biopesticide Formulation**

Dr Jim Bullock Director and Co Founder at iFormulate

Aided by a favourable regulatory climate, as well as by concerns about conventional pesticides, the biopesticide market continues to grow. The global market is projected to grow from USD 3.0 billion in 2018 to USD 6.4 billion by 2023¹. Alongside the increased use of biopesticides (and other bio-actives used for agriculture, such as plant growth regulators and biostimulants) have come developments of more effective Integrated Pest Management application methods which take into account the health of the wider ecosystem and of the possible environmental impact of using control methods. However, with a total pesticide market (i.e. including conventional chemical pesticides) of around USD 56 billion, there remains considerable potential for further biopesticide growth.

The definition of biopesticides is not standardised but they are usually defined guite broadly and include the following general categories:

· Macroorganisms (e.g. insects, nematodes and other organisms that predate on pest species)

· Microorganisms (e.g. bacteria, fungi and viruses that kill or inhibit pesticides via a number of mechanisms)

· Naturally derived biochemicals (such as peptides or enzymes) or other biological extracts (such as natural oils).

As with conventional pesticides, biopesticides must be formulated to provide a usable product that performs according to customer needs. The main functions of formulation are:

· To provide a finished product which is stable during manufacture, storage and use;

• To provide a product which is convenient to handle and to use in the application;

• To ensure that the full potential efficacy of the active ingredient is realised and that its delivery for maximum effectiveness is ensured;

• To ensure that the product can be used in a way that is safe for the user and the environment, and that it complies with regulatory requirements;

· To provide a robust process by which the finished product

can be manufactured and packed with a low level of manufacturing defects.

So where do the challenges of biopesticides lie, and do these challenges present any barriers to their further growth? Taking the category of naturally derived biochemicals and biological extracts first, these can essentially be formulated in a similar way to conventional synthetic chemical actives. The main additional challenge is that these compounds tend to be less chemically and physically stable than synthetic compounds. Peptides and enzymes, for instance, are prone to denaturing when exposed to heat and may readily degrade in acidic conditions. Therefore, for instance, it may be necessary to use formulation technologies, such as microencapsulation, to protect and deliver the active ingredient effectively or to include a UV-stabiliser to protect the active ingredient against photo-degradation.

In all cases, one very critical task is to ensure that any coformulants used (e.g. surfactants, oils, solvents, carriers, binders, fillers, humectants, preservatives, etc) are chemically compatible with the active ingredient. Stability apart, however, actives in this category of biopesticides can be formulated similarly to synthetic pesticides. The formulator then needs, first, to consider the key physical properties of the active ingredient when selecting the formulation type, e.g.:

 Water-soluble actives may be formulated as soluble liquid concentrates (SL) or soluble granules (SG);

· If a liquid product is desired, water-insoluble actives may be formulated (with an oil if necessary) as emulsifiable concentrates (EC), oil-in-water emulsions (EW) or microemulsions (ME);

· Active ingredients which are solid at room temperature can be formulated as water-based suspension concentrates (SC) or may be combined with co-formulants to produce water dispersible granules (WG) or wettable powders (WP) which will disperse readily in a spray tank. If a fine particle size is required, usually only those actives which are heat-resistant and relatively highmelting can be milled before formulation;

· Actives which are solid but are water-sensitive can be formulated as oil dispersion (OD) formulations which then require further emulsifiers in order to disperse the oil phase in the water of the sprav tank:

• As mentioned earlier, actives which need to be protected in some way or where the release needs to be controlled can be formulated as microcapsule suspension (SC) formulations.

However, the formulator has to consider the categories of biopesticides based on living organisms very differently from the naturally derived bio-chemicals described above. In the case of microorganisms such as bacteria, the objective is usually to ensure that the active organism is kept alive but in a dormant state during manufacture and storage, but on application it must be viable to then reproduce and become effective when applied to crops.

If the organism is not dormant in the formulation, then there is a danger that the culture will rapidly reproduce and consume any nutrients present and die out while still in storage. In addition, a living and growing culture can produce undesirable by-products, gas and odour during storage. For this reason, the simplest approach is often to reduce the water activity of the formulation to a low level, so that the organism will not reproduce on storage. Prior to formulation, the starting point is normally a water-based suspension of microorganisms. This suspension can be dried by methods, such as spray drying and freeze drying, in a way that does not cause heat damage. Then, solid final formulations with a low moisture content, such as granules (WG, GR) and powders (WP, DP), are often preferred. Additionally, to ensure initial microbial growth on application, nutrients such as carbohydrates may be added to the formulation.

On top of these considerations, the compatibility and stability of microbial actives need to be considered in the same way as for biochemical and synthetic chemical pesticides. So, the coformulants used need to be assessed, with aggressive solvents and extremes of pH being things to be avoided.

Protection of microorganisms during formulation and afterwards can be enabled by the use of encapsulation technologies. There is a huge variety of possible methods to do this, here are just two interesting examples:

 The popular microbial biopesticide Bacillus thuringiensis (Bt) can be encapsulated, using a technique called Pickering emulsions, whereby emulsions are stabilised by solid particles².

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The resulting formulations were shown to perform better than conventional Bt formulations. The co-formulants used for the encapsulation were relatively innocuous, from a safety and environmental point of view (acrylic particles, sunflower oil, iron oxide nanoparticles, ethanol);

. The UV resistance of the fungal bio-insecticide Beauveria bassiana has been improved by the use of feruloylated soy glycerides (FSG), which were subsequently encapsulated in starch³. Additionally, soluble lignin was used as a spray tank adjuvant to protect against UV. Again, the use of environmentally benign co-formulants is favourable for the safety profile of biopesticides.

Increasingly, bio-derived active ingredients are being formulated, together with conventional synthetic pesticides. One example of this is REGEV[™] from STK. The two actives are a biofungicide based on a plant extract (Tree Oil or TTO), as well as difenoconazole, a conventional synthetic fungicide. The relevant patent⁴ claims that the TTO is delivered in the form of an oil-inwater emulsion. The patent also claims the use of TTO with a large number of fungicides – so perhaps further new mixtures are to be expected.

Biopesticides and conventional pesticides are also being formulated together in seed treatments. Poncho®/VOTiVO® (now being marketed and sold by BASF) combines the systemic insecticide clothianidin with Bacillus firmus I-1582 in a seed treatment. The clothianidin is immediately absorbed by the roots and the Bacillus firmus I-1582 forms a barrier around the seed. It is claimed that this protects against up to two generations of nematodes⁵

In conclusion, the potential incompatibilities between conventional synthetic active ingredients and microorganisms, as well as other bio-actives, can clearly present challenges to the formulator - who may also have to deal with issues, such as UV-stability and the delivery of microorganisms. In addition to dealing with the usual challenges of efficacy and stability that the formulator has to handle for all kinds of crop protection products, it is clear that formulation will have a very significant role to play if the market for effective bio-control products is to continue to grow at a rapid rate.

2. "Controlled-release of Bacillus thuringiensis formulations encapsulated in light-resistant colloidosomal microcapsules for the 3. "Improving Formulations for Biopesticides: Enhanced UV Protection for Beneficial Microbes", Behle et al, in ASTM STP1527 "Pesticide

^{1.} Markets and Markets "Biopesticides Market" 2019 via www.marketsandmarkets.com

management of lepidopteran pests of Brassica crops", Bashir et al, PeerJ. 2016 Oct 11;4:e2524. eCollection 2016. Formulations and Delivery Systems, 30th Volume: Regulations and Innovation" 2011. 4. World Patent Application WO2013068961

^{5.} BASF: https://agriculture.basf.com/us/en/Crop-Protection/Poncho-VOTiVO-2-0.html

Stepan: Next Generation Compatibility Agent for Today's Complex Tank Mix Systems



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Over the past couple of decades, it has become increasingly common, if not necessary, to combine multiple crop protection products into one spray application. Beyond the obvious advantages of time savings and reduced application costs, this strategy combats the ever-present challenge of pest and pathogen resistance by employing multiple modes of action (MOA).¹ Leading crop protection companies implement MOA by combining several active ingredients into one formulation. In cases of single-active ingredient formulations, growers will tank mix multiple crop protection products to achieve the same desired MOA effect.

Regardless of approach, today, spray tanks increasingly contain more active ingredients than in years past, leading to a delicate system between tank partners. Further complicating matters, growers will often use liquid fertilizer as a carrier in place of water to gain even more efficiency. Given the complexity of modern crop protection strategies, it's not surprising to see a rise in compatibility issues surrounding tank mixtures.

These incompatibilities can occur between active ingredients, but more commonly arise when formulations are diluted into liquid fertilizer, where hydrophobic organic molecules and water-soluble salts are at odds with each other. These incompatibilities can present in many forms, including the formation of particles or gels that rapidly settle out of suspension, separation of the mixture into layers, or excessive foaming. As one might imagine, spraying an incompatible mixture can result in a loss of efficacy due to uneven distribution, poor performance, or crop injury.^{2, 3} In severe cases, these issues can clog sprayers that lead to equipment shutdown and cleanout.

In the crop protection industry, compatibility agents are used to combat stability issues before and/or after they arise. Our research has determined that more than 75% of commercial compatibility agents use phosphate esters, a majority of which are based on nonylphenol ethoxylates (NPEs).⁴ NPEs have been the backbone of compatibility agents for decades and remain dominant in the market due to availability and low cost. However, while NPE-based compatibility agents are effective in simple tank mixtures, they have marginal performance in complex systems. As incompatible



Figure 1. Reaction schemes of phosphate esters.

systems have become more challenging, innovation has stalled in the development of new compatibility agents that can meet the demands of tank mix systems today. Furthermore, NPEs have well-known environmental and health concerns, resulting in their use being slowly phased out across the agrochemical industry.

Considering today's complex nature of tank mixtures and regulatory concerns surrounding NPEs, Stepan saw a need to develop a next generation phosphate ester compatibility agent. We believe the market has yet to take full advantage of the immense potential phosphate esters offer, given the ability to tune monoester/diester ratios, select from a wide range of hydrophobes, and vary the degrees of ethoxylation (Fig. 1). Thus we launched an initiative to study these parameters in detail to find the optimal phosphate ester, then leveraged our experience in formulation development to further enhance performance with additional additives to produce a top market compatibility agent.

With access to a wide array of hydrophobes, we synthesized and screened more than 70 unique molecules, identifying trends for each parameter. Each iteration was evaluated in nine incompatible systems containing a formulated pesticide and fertilizer. Our screen included a variety of formulation types, including emulsifiable concentrates, suspension concentrates, and soluble liquids. Performance was assessed based on the number of incompatible systems a phosphate ester was able to improve.

The first parameter that we studied in detail was the phosphate ester's monoester/diester ratio. Phosphate esters with either high monoester or high diester content were evaluated across multiple carbon chain lengths and moles of ethylene oxide. The results demonstrated that high monoester containing phosphate esters were equivalent or better than their high diester counterparts across all systems, regardless of hydrophobe or moles of ethylene oxide (Fig. 2). This suggests that the more hydrophilic nature of monoesters enhances solubility in high electrolyte environments. For the rest of the study, we chose to work with only high monoester phosphate esters.

Next, we studied the effect of ethoxylation across various carbon chain lengths. Performance was found to improve when a lower degree of ethoxylation was employed and was not dependent on carbon chain length (Fig.3). As moles of ethylene oxide were increased, the effect on compatibility became more variable based on a specific incompatible system and phosphate ester molecule. There appears to be a minimum degree of ethoxylation required for water solubility and broad-spectrum performance, beyond which performance begins to deteriorate as ethoxylation levels become too high.



Figure 2. Comparison of monoester and diester counterparts at CN.



Figure 3. Effect of moles of ethoxylation across four carbon chain lengths (CM, CN, CO, and CP).



Carbon Chain Length

Figure 4. Effect of carbon chain length across three levels of ethoxylation (EOX, EOY, and EOZ)

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Last, we evaluated a range of carbon chain lengths at multiple degrees of ethoxylation. An optimal carbon chain length was identified that displayed peak performance for all ethoxylation levels (Fig. 4). Combined, these trends led to a final phosphate ester with high monoester content, a low degree of ethoxylation, and an optimized carbon chain length.

With our top performing phosphate ester defined, we leveraged our formulation expertise and extensive portfolio of inerts to further enhance the compatibility performance. The phosphate ester was paired with an array of secondary components, including

emulsifiers, wetting agents, and other compatibility aids. Light scattering measurements were implemented to track instability over time and identify the most stable formulation candidate (Fig. 5). Ultimately, optimized secondary components were identified and found to significantly increase the performance of the phosphate ester, leading to our new tank mix compatibility blend, TOXIMUL[®] CT.

TOXIMUL CT was tested against commercially available compatibility products (Fig. 6a). The commercial products all contained phosphate esters as their primary component, many of



Figure 5. Light scattering results for the top performing phosphate ester vs. formulated blends for two incompatible systems. A rise in light scattering over time indicates instability in the form of separation, precipitation, or gelling.



Figure 6. Light scattering results for compatibility products for two incompatible systems (A). Atrazine/paraguat tank mix with TOXIMUL CT and commercially available products (B).

which were NPE based. The results demonstrate that TOXIMUL CT provided superior compatibility performance over current commercial solutions in high electrolyte systems. For situations where incompatibilities between active ingredients were observed, we also saw an improvement using TOXIMUL CT. For example, compatibility is significantly improved in an atrazine/paraguat system with TOXIMUL CT over competitive products (Fig. 6b).

In conclusion, TOXIMUL CT is an excellent option for solving difficult compatibility issues over a wide variety of tank mix systems. In the design of this new blend, we evaluated more than 70 unique phosphate esters and screened more than 2,000 incompatible systems to find the best product. TOXIMUL CT is an innovative solution that can help meet the demands of today's increasingly complex spray tank mixtures.

2019 AGCHEM FORMULATION & APPLICATION TECHNOLOGY CONGRESS

Organizer: Nagropages

Facilitating the innovation of agrochemical formulation and application technology and building a business docking platform for agchem companies.

Key themes

Market and Regulation Formulation Custom

Formulation and Application Technology Digitalization Technologies



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Dow: High Performance Oil Dispersion Adjuvant Development



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Oil dispersion (OD) formulation is an emerging formulation in Ag industry, which is claimed as environmental friendly, better pesticide efficacy than water-based formulation. Because the continuous phase is oil, like methyl oleate, methyl soyate, it shows high affinity with plant leaves, thus providing better spreading, wetting and penetration performance. However, the existing OD products have common issues of inadequate long-term storage stability, phase separation and caking in the bottom after several months storage. This hinders the booming development of OD formulation. Therefore, it is of high importance to explore high performance adjuvants of emulsifier, dispersant and thickener, exclusively used in OD formulation, promoting the industry technology progress.

Dow possesses rich product portfolios in emulsifiers and dispersants. How to develop the high performance products to address industrial challenges is our high priority these years. In this paper, high performance OD adjuvant development process had been described, followed by formulation preparation and performance evaluation. Currently, POWERBLOX™ OD products is ready to deliver to the market for formulation trial and performance validation.

Lego Unit Approach

It is well known that the OD formulation is a complex system, even for adjuvants, including wetting agents, emulsifiers, dispersants and thickeners. If all of the factors are considered together in the design of experiments, it will generate a huge amount of experiments and heavy workload. In order to accelerate product development progress, Lego unit approach was utilized to reduce design parameter as shown in Figure 1. At the initial stage, we investigated the performance between thickener and oil and the performance between emulsifier and oil, to select proper thickener and emulsifier. And then, the thickener and emulsifier in oil were fixed as the base system to evaluate the compatibility and stability of screened dispersants. Finally, the active was incorporated into above system to prepare OD full formulations and evaluate their storage



Figure 1. Lego unit approach for OD formulation development

stability. The technical hypothesis for this approach is:

- Thickener plays a dominant role in oil phase thickening. The better thickening effect, the higher viscosity of oil phase, little related to active and other additives.

- Emulsifier is decisive to emulsion quality and stability when OD formulation is diluted into water.

Thickener Performance Evaluation

Methyl oleate is the largely used oil phase in OD formulation. In the following experiments, the methyl oleate was used as received from Wilmar. Various kinds of thickeners from different producers, more than 30, were collected to evaluate their thickening performance to methyl oleate, including organic, inorganic and organicinorganic combination type. The comprehensive performance was tested, in term of oil compatibility, thickening effect, dispersing effect and cost effectiveness. It revealed that organobentonite was still the best choice in the market. The recommended dosage was 2.0-4.0 wt%.

Emulsifier Performance Evaluation

In the application, OD formulation needs to be diluted into water firstly, prior to spraying. Therefore, emulsifiers play a critical role to get the high quality emulsion, thus affecting drug efficacy. Emulsifiers with various HLB values were selected to evaluate their effect on initial emulsification performance and emulsion stability over time. The emulsifier dosage was fixed at 10wt% in methyl oleate and the dilution was 200 times in water. When oil phase was added into water phase, turned the mixture upside down for 20 times for further emulsion stability observation over time. As shown in Figure 3, the performance of one series of emulsifiers with HLB value from 8.5-13.6 demonstrated that the higher the HLB value, the better the initial emulsification performance and the emulsion stability. However, high HLB value generally means high polarity, it may have compatibility issue with oil phase, which is of relatively low polarity.

Span and Tween were taken as starting emulsifiers to mix in different ratios to get various HLB value emulsifier mixtures, which were used to study the compatibility with methyl oleate. As shown in Figure 4a, with the increase of HLB value, the compatibility between emulsifier mixture and oil phase became worse and worse, from transparency and homogeneous to turbid. In Figure 4b, the performance of the screened Dow' products with even the HLB value at 12.0-13.0 showed excellent compatibility with oil phase with transparency and homogeneous appearance, which resulted from the specially designed structure. Besides the good compatibility, excellent emulsification performance is the final target. It was shown in Figure 4 c1, the mixture of oil and emulsifier with mediocre emulsification ability was added into water; as a result, the oil droplets couldn't be emulsified spontaneously, but fell to the bottom still as oil droplets. When the mixture of Dow's emulsifier and oil phase was dropped into water phase,





11.0

11.7

12.3

12.9

13.6

0 min

10:0	9:1	8:2	7:3	6:4	Γ
Ş	Ģ	Ģ			6
23322		-			Γ
a					

HLB value from low to high Figure 4. Compatibility of emulsifier with various HLB value with oil: a) Span and Tween emulsifiers with different ratio, b) Dow emulsifiers with high HLB value, c) emulsification effect comparison

the oil could be emulsified quickly with fine emulsion and excellent stability.

Dispersant Screening and OD formulation Development

Dispersant is used to disperse and stabilize pesticide particles, providing OD formulation long-term storage stability and ensuring sufficient shelf life. After thickener and emulsifiers were confirmed, dispersant was screened firstly by verifying its compatibility with oil and then by formulation development and optimization via altering the ratio of each components. As mentioned

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above, the components were complex in OD formulation with wide changing range, it was of high workload and time consuming. Dow high throughput platform could prepare a large amount of formulations in short time, facilitating to performance comparison and formulation optimization. Through scientific experiments design to get a lot of formula, the high throughput process was utilized to prepare target formulations as seen in Figure 5, more than 200 formulation within 1 week. Followed by, the excellent formulation could be screened out, on the basis of performance evaluation.

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Taking 2.5wt% penoxsulam OD formulation development as example, 12 formulation had been selected out of all of the designed experiments, due to superior thermal storage stability to benchmark (seen in Figure 6). After 2 weeks thermal storage, benchmark product (commercially available product and used as received, non fresh sample) had around 8% phase separation. For our developed samples, there was no phase separation by naked eyes, keeping homogeneous system.

In order to differentiate the formulation perforamance difference caused by dipersant, accelerated stability testing method combining centrifugation and transmitted light scanning was used for performance evaluation to the formulations with good thermal storage stability. As seen in Figure 7 of each graph, the X axis stands for sample bottle height, the left is bottleneck and the right is bottom of bottle. And the Y axis indicates the tranparency of the sample in the bottle. The lower the transparency, the better the sample stability. Moreover, the more the high transparency, the better the sample stability. The results demonstrated that the number 12 sample showed best stability, thus providing an optimization adjuvant package to target formulation.

At the same time, to know more clearly

the detail difference among each formulation, instability index was introduced to quantitatively measure formulation stability. Instability index is a specific value combining with Stokes' Law and Lambert-Beer' Law, demonstrating the relative value of the sum of transparency change to the maximum clarification during centrifugation, with the value range of 0-1^[1, 2]. For the same active particles (same density) in close viscosity, the lower instability index, the better formulation stability. It was seen in Figure 8, the instability index of all of evaluated formulations were not so high, and the value of number 12 was the lowest, indicating the best stability.

In a word, the thorough process had been built-up on adjuvant development, formulation preparation and performance evaluation. The explored high performance POWERBLOX™ OD adjuvant is ready to go to the market for customer trial, addressing the incumbent issues effectively.

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Figure 5. High throughput platform for OD formulation development process







Figure 7. Accelerated stability testing



Figure 8. Quantitative index for stability



Evonik: Sustainable Surfactants for Crop Protection Solutions



Dr. Daniela Kruse Marketing Manager EMEA Surface Technologies at Evonik Nutrition & Care GmbH

The agricultural market is under increasing pressure as consumers ask for food containing lower, or no amounts of residual chemicals, but at the same time growers need to prevent the development of pathogens and pests resistant to active ingredients. Regulators demand less agrochemical input and some chemical pesticides have already been phased-out.

Well-known in the agrochemical market, Surfactants are used in formulations and as tank mix adjuvants. The benefits of adjuvants are important in plant protection products from pesticide formulation to storage, tank-mix dilution, spraying, targeting and finally acting on the pest. In water-based formulations, their main task is to decrease surface tension resulting in better wetting of the dispersed particle in water and more stable formulations. In oil-based formulations, emulsification properties support the quality of the emulsion ensuring higher stability and lower droplet size. In tank mix dilutions for all kinds of formulations, surfactants prolong physical stability as they reduce the surface tension of water. Targeted delivery is the main purpose of surfactants during spraying, which enhances efficacy and decreases the active amount needed. Targeted delivery is achieved by: 1) reducing driftable particles 2) enhancing adhesion and retention of spray droplets on the plant. 3) Improving uptake and penetration of active ingredients, and 4) increasing rain fastness.

However, regulatory pressure is rising with additives like NPE based solutions phasedout globally. With the agrochemical market demanding innovative, more sustainable additives, Evonik has developed benign surfactants which enable a more environmentally friendly plant protection.

New adjuvants that comply with eco-toxicological, safety and sustainability criteria provide solutions to support the plant protection industry. Evonik is introducing sustainable and biodegradable adjuvants in the following four classes: Wetting agents and multifunctional additives based on biodegradable trisiloxanes, polyglycerolester and sophorolipids.

Due to their chemistry, the way these novel surfactants work is different. Roughly speaking, the lower the surface tension of spray droplets the better adhesion and retention on the leaf. Water with 72 mN/m gives a strong bounce off of spray droplets. Trisiloxanes help to reach the lowest surface tensions and Evonik has developed readily biodegradable[method OECD 301 F, OECD 301 A] trisiloxanes based on a unique patented technology. The reduction of water surface tension down to 21 mN/m facilitates the best adhesion and retention of droplets on very difficult to wet surfaces. Due to their special phase behavior in water, they provide superspreading of water, solutions and dispersions to ensure the best coverage of contact actives on surfaces thanks to the contact angle of 0°. This also enables the highest biological efficacy. In contrast to other superspreading trisiloxanes, these biodegradable trisiloxanes have no ecotoxolocial classification and are not dangerous goods for transportation.

BREAK-THRU® S 301 is soluble in water and many oils, so it can be used in all kinds of liquid formulations and as a tank mix adjuvant to give excellent adhesion and retention of spray droplets. Commercially available products with living microbial actives rarely contain surface-active molecules, and alongside the low wetting and low dispersing properties of solid

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formulations in water, can often provide low and inconsistent field performance. BREAK-THRU® S 301 can be used as a carrier liquid in dispersion concentrates for increased shelf life of living microbial products. As a tank mix additive, BREAK-THRU[®] S 301 leads to a better dispersion of microbial actives in the spray solution, and to excellent wetting in the application, helping increase the efficacy of microbial-based pesticides.

BREAK-THRU[®] SD 260 is developed specifically for use in WP - formulations for chemical pesticides or for biopesticides. The product is the first water soluble, solid trisiloxane to provide humectant properties, and to offer excellent wetting properties as it includes BREAK-TRHU[®] S 301. The addition of 1 - 5% w/w BREAK-THRU[®] SD 260 to the powder or granules of biopesticides significantly increases the surfactant properties of the final tank-mix dilution. At a concentration of 0.1 w/w-% it reduces the surface tension of water to 22 mN/m and the humectant property supports the field efficacy of the microbes.

Unique readily biodegradable adjuvants based on polyglycerol esters and sophorolipids fulfill modern requirements for all types of plant protection products and consist of a natural carbon source. They reduce the surface tension of water down to 30-35 mN/m. Incoming droplets solutions with such surface tensions normally show a strong and fast receding effect from the contact line, often leading to bounce off and loss of spray droplets. The new action is based on the interaction of the hydrophobic emulsified droplets with the cuticle leading to a so called 'pinning effect' preventing the droplet receding from the contact line of the water droplets. These droplets also stick to the surface so retention is excellent. It's well-known that polyglycerol esters and sophorolipids lead to a swelling of the cuticle wax which improves the penetration through the cuticle. This facilitates the uptake of lipophilic and hydrophilic active ingredients through the cuticle and epidermal cells (see Figure 1 and Figure 2). This physico chemical interaction of the biobased molecules with the cuticle wax can be shown nicely with confocal laser scanning microscopy as reported previously [Haensel, et. al. (2015) Polyglycerolester as Sticker Penetrant Adjuvant]. For systemics and contact active ingredients these products are well suited, and due to their hydrolytic stability these surfactants can be used for water-based and oil-based formulations.

BREAK-THRU[®] SP 133 has a natural carbon content of 93%, is readily biodegradable and comes without a hazardous label. Its raw materials glycerol and fatty acids are derived from different vegetable oils. This polyglycerol ester-based product also provides excellent adhesion and retention of difficult to wet target species. Wind tunnel trials at the University of Nebraska have shown that BREAK-THRU[®] SP 133 reduces the amount of driftable particles due to an increase of the spray droplet size: the expanding water film is broken up directly after the nozzle,

Figure 1. CLSM study of BREAK-THRU[®] SP 133 penetration of the pseudo-lipohilic pesticide mimic (RHODAMINE [®] B) into bean leaves [2 HAT 63 x mag.]. Near-surface horizontal and vertical cross-sections

a) pure RHODAMINE [®] B Dye

+ 0.1% BREAK-THRU[®] SP 133





Figure 2. CLSM study of BREAK-THRU[®] SP 133 penetration of the hydrophilic pesticide mimic (Oregon [®] Green) into bean leaves [2 HAT 63 x mag.] Near-surface horizontal and vertical cross-sections a) pure Oregon [®] Green + 0.1% BREAK-THRU ® SP 133



which induces bigger droplets that are less prone to drift. Less driftable droplets means not only a higher field efficacy, but also less harm to the environment.

BREAK-THRU® SF 420 is a sophorolipid-based surfactant manufactured by the fermentation of rapeseed oil and sugar. This vegetable, not genetically modified feedstock is sourced in Europe. The yeast strain used is also a natural microorganism: Starmerella bombicola. It is a readily biodegradable biosurfactant with dispersing und wetting properties. Due to the special geometrical structure, BREAK-THRU[®] SF 420 is an excellent dispersant for metal hydroxides like Cu(OH)₂ in water which makes it an excellent option for SL and nutrient SC formulations. Due to the more even distribution of, for example, copper spray solution on the foliage, it improves the control by fungicides. However, it was proven to also improve insecticide performance and enhance the activity, the speed of action and the duration of herbicides.

At the same time this multifunctional biosurfactant performs very well as a water soluble, low foaming tank mix surfactant by reducing the surface tension of water down to < 35 mN/m. However, due to the novel mode of action BREAK-THRU[®] SF 420 provides excellent adhesion and significantly higher retention on very difficult to wet species. After drying the remaining film generates with rainwater a gel layer by a hydration effect of the polymeric sophorolipid. This results in excellent rainfastness (see Table 1 and Figure 3).

Taken together, all the features of our sustainable multifunctional surfactants help increase the biological efficacy of agrochemicals and biosolutions. This has already been proven in many field trials around the globe. BREAK-THRU[®] additives



Figure 3. Effect on mean copper deposits ($\mu g/cm^2$) retained on wheat, cabbage and bean foliage - Post Rain Analysis

g/L	Ingredient
383.0	Copper hydroxide
75.0	BREAK-THRU [®] SF 420
3.0	BREAK-THRU [®] AF 9903
3.3	NaOH (20% solution)
2.5	Xanthan gum
50	Propylene glycol
q.s.	Water

Table 1. Evonik Cu-formulation: Copper hydroxide 383 SC

enable microbials as active ingredients to have the lowest environmental impact, leading to a higher acceptance of these solutions by farmers and addresses the need of consumers for food with lower chemical residuals.

Approvals for organic farming become more important, even for conventional farming, as it demonstrates the superior sustainability of the products. Therefore, the possibility of getting these approvals is a key criteria for Evonik in the development of new additive products. BREAK-THRU® S 301 and BREAK-THRU[®] SP 133 are already approved for OMRI, and BREAK-THRU[®] SP 133 is additionally FIbI registered and thereby the first surfactant for the German speaking organic agricultural market.

Function
Active ingredient
Dispersing and wetting agent
Antifoam
Neutralization
Thickener
Antifreeze
Solvent

Huntsman: Solvents as Solutions for Formulations



Todd O'Connell Senior Technology Manager of the Surface Sciences group at Huntsman Performance Products

When a formulator begins a project on a new active ingredient, the appropriate solvent is one of the early considerations. Since many pesticide actives have aromatic characteristics, back in the 1960s, the formulator might use any number of aromatic hydrocarbons or halogenated solvents. As we began to understand the potential environmental and health impacts of various compounds, the field of choices naturally began to narrow. During the 1980s, N-methylpyrrolidone (NMP) became the choice for otherwise difficult formulations. Upon further study, however, it became clear that NMP was not the savior everyone had thought it would be.

The movement in the 1990s and 2000s to more environmentally responsible and, lately, to more sustainable ingredients, has changed the available choices. Paraffins are currently preferred if a hydrocarbon is needed, but they need help solubilizing aromatic actives. Aromatic hydrocarbons are still available, but with stricter regulations may not be a sustainable ingredient for the future, which leads them to be rarely, if ever, considered in a modern formulation. The future alternatives may very well be weaker solvents for the actives or not sustainable long-term.

The modern developer of a formulation to be used locally, regionally, or globally must consider an array of regulations that sometimes severely limit choices. The available choices are usually limited to a menu provided by regulatory authorities from which formulator must choose those solvents that may be compatible with the active. In addition, the other ingredients, such as wetting agents, compatibility agents and other ingredients, generally further narrows the available choices. Also, the company may have a particular solvent of choice for a particular class of ingredients

The job of the solvent is to carry the active in liquid form in the container to primarily provide a stable environment for the rest of the ingredients. Solvents provide flowability and ease-ofdelivery, two characteristics that make liquid formulations highly desirable.

The challenge is to choose the right solvent from the available menu. Modern solvents can include ingredients derived from both petroleum and biological sources. Biological sourcing is important for many companies, due to their environmentally responsible and sustainable credentials. Farmers, formulators and applicators around the world have understood, and integrated the need for environmental responsibility for many, many years, and so have naturally dialed into their thought and decision processes.

Since environmental factors are built into the choices by companies and governments, the primary key to making the right choice of solvent is driven by the core purpose of the solvent. The choice must be made from the available menu based on how well the solvent provides a stable liquid environment for the active and the other ingredients.

While solvents like paraffins and methylated vegetable oils (MSOs) are available, they tend not to solubilize the most difficult actives very well. In addition, MSOs can have temperature and other stability challenges. Other, more exotic choices may be available, but tend to be expensive.

"Simple" tends to be best. "Simple" small molecules tend to have very low freezing points. Small esters with small side chains or groups tend to dissolve many ingredients well. Aromatic solvents tend to dissolve aromatic actives.

JEFFSOL[®] AG 1700 solvent and JEFFSOL[®] AG 1705 solvent are two effective "simple" choices. Their aromatic character makes them compatible with various active ingredients. The simplicity of the molecules gives them a low freezing point with JEFFSOL® AG 1705 being able to remain liquid by itself down to -50 C.

When aromatics are not the answer, but rather a more polar solvent is needed to bring in polar molecules, the formulators are recommended to look at carbonates as an alternative. They are available in a variety of forms, such as JEFFSOL® AG 1555 solvent. JEFFSOL[®] AG 1555 solvent is both polar and has a high degree of biodegradability. Used in non-aqueous systems, JEFFSOL[®] AG 1555 solvent has been useful in a variety of formulations where NMP and other polar solvents may no longer be used.

Now as ever, the choice of solvent is critical. However, with the environmental and toxicological limitations driven by today's regulations, those choices are more and more limited. Choices of solvents may vary in the market, but "simple" solvents with low melting points can help with a diversity of performance needs, such as cold tolerance, viscosity and stability. Overcoming challenges such as these by using modern solvents, such as those mentioned above, will help bring success to your formulations



To you, together 筑建关爱

Aiming at perfect solutions to green agriculture and serving global agrochemical market, SINOAGRO is specialized in researching and processing eco-friendly types of end-use preparations and various combinations. With strict quality control and strong technical supports, we are dedicated to offering our customers both excellent products and efficient services. To you, Together, SINOAGRO can always be your reliable partner.

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Clothianidin	Cyproconazole	Clodinafop-propargyl	Matrine
Dinotefuran	Difenoconazole	Clomazone	Ningnanmycin
Emamectin Benzoate	Dimethomorph	Cyhalofop-butyl	Oligosaccharins
Fipronil	Famoxadone	Dicamba	Paecilomyces li
Imidacloprid	Fluazinam	Ethoxysulfuron	Rotenone
Indoxacarb	Fludioxonil	Glufosinate-ammonium	
Lufenuron	Propiconazole	Glyphosate	PGR:
Methoxyfenozide	Prothioconazole	Imazethapyr	Brassinolide
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Pymetrozine	Tebuconazole	Penoxsulam	Ethephon
Thiamethoxam	Trifloxystrobin	Pyribenzoxim	Gibberellic Acid
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34 2019 Formulation & Adjuvant Technology



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We know what you need

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Agrovista Steps Up Marketing of **Spray Application Aids Into Europe**



Peter McDonald Head of Commercial Strategy & Discovery Europe at Agrovista E-mail: peter.mcdonald@agrovista.co.uk

After two highly successful decades building a multi-million pound market around its range of Discovery spray application aids in the UK, agronomy company Agrovista is using its sector-leading expertise to accelerate its marketing drive into continental Europe.

Target regions include Central Europe, Russia, Ukraine and Turkey, which have the potential to greatly increase company revenues, says Peter McDonald, Agrovista's Head of Commercial Strategy & Discovery Europe.

"Discovery products are an increasingly important part of Agrovista's business, and the brand has the potential to become very significant.

"These application aids improve the performance of plant protection products. Pesticide efficacy is reduced by water guality, 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."

Many leading UK growers now use Discovery products to maximize the potential of their agrochemical applications. McDonald believes farmers in the target regions will soon be following suit.

"We have had a presence for some 10 years in north-west Europe, and two to five years in the target countries. European revenues have the capacity to be five times that of the UK, perhaps more in the longer term.

"Regardless of where they farm, growers are facing tight profit margins. They need to make use of every tool in the box to help them achieve maximum yields and returns."



Figure 1. Agrovista's Discovery products are trialled extensively across Europe

Comprehensive trials across continental Europe have demonstrated the value of Discovery products in improving the efficacy of plant protection products(Figure 1), underpinning findings from up to two decades of research work and commercial use in the UK and, more recently, northwest Europe.

"By enhancing the effects of agrochemical products, our Discovery range can deliver significant increases in yield for a relatively modest outlay," noted McDonald.

"We believe they offer significant benefits at any time, and particularly when returns are being squeezed. Growers don't have to take our word for it – they can see the impressive results the Discovery range has achieved in trials. These products are proven across a range of crops and climates."

As legislation tightens and pest, weed and disease resistance increases, some active ingredients will disappear, while others will be subjected to tighter dose restrictions. "This strengthens the case for using Discovery products - growers need to extract maximum performance from remaining chemistry," said McDonald.

Three products are spearheading the European campaign. Companion Gold, the most popular spray application aid 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).

"Each Discovery product has completed a multiyear pan-European R&D screen to ensure efficacy," said McDonald. "This comprises laboratory studies and high quality replicated field trials across a wide range of geographical locations, soil types, climatic conditions and crops. Physical chemical, environmental and regulatory studies are completed to ensure consistent product performance.

"We also put great emphasis on conducting quality trials with our distribution partners and respected research organizations in each country we market. And our ground-breaking spray application trials explore the relationship between plant protection product, application technique and tank mix additive, giving a unique insight into performance on farms."

Discovery products are manufactured by Agrovista UK, which can trace its roots back 60 years. 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 added. "Most people will not 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."

Tests include laboratory studies and high-quality trials conducted at sites throughout Europe that encompass a wide range of soil types and climates, as well as key crops for different areas, such as cereals, maize, oilseeds, pulses, sugar beet and potatoes.

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

Discovery range

- · Supported by pan-European R&D program

Key Discovery products



Discovery R&D

Each Discovery product is put through a multi-year pan-European R&D screen to ensure they perform to the optimum in all market locations.

To ensure maximum performance, Agrovista has designed and developed its own self-propelled sprayers, 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.

- Spray application aids
- Tank-mixed spray additives and adjuvants
- · Designed to enhance efficacy of plant protection products
- Targeted formulations, focused by pesticide requirements
- Improved spray application
- · Comprehensive efficacy data to support use

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

Technology and Product

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. 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.

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 also reduces spray drift, ensuring accurate spray deposition over the target surface.



the key early flowering spray timing.

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

* For further details on Agrovista's Discovery range, please go to www.discovery-eu.com



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

 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

Spray application aids

Adjuvants & spray additives

Improve the performance of your plant protection products





www.discovery-eu.com

Tradecorp's ADJUSTAR Adjuvants Range to **Revolutionize the Adjuvant Market**

Javier Bernabéu, Marketing Director at Tradecorp - International Division

What is an adjuvant? How do they work? · Adjuvant is a product that optimizes the efficacy of another, mainly; herbicides, insecticides and fungicides, and ultimately reduces limiting factors during spraying of Crop Protection (CP) products.

· Limiting factors for a successful application of CP products:

- Climate/weather
- Water quality
- Specific CP management
- Droplets
- Sprayers
- Etc.

Adjuvants offer solutions for farmers in three beneficial areas:

1. Technical benefits:

a. Limiting factors for successful treatment

b. Modern spraying:

- i. Increasing application speed
- ii. Reducing water volume (Figure 1)

2. Economic benefits:

a. Better CP treatment balance cost/ha vs effectiveness

b. Better CP application management

c. Sufficient product effectiveness >> a.i (active ingredient) full protection = 100% biotic action

3. Environmental benefits:

a. Better applications focused on pest/ diseases targets

> b. Less CP product waste: i. Reduced drifting



Benefits derived from using adjuvant products are applicable in the treatment tank, during spraying, as well as directly on weeds, pests or target diseases.

In the treatment tank, these substances mainly act on two factors. These directly influence protection of the active ingredient (a.i) from chemical, fungicide, insecticide or herbicide products, such as the pH control of the treatment broth and water hardness

The pH is intimately linked to the preservation and the phytosanitary degree of effectiveness dealing with the phytosanitary product's active ingredients. This decreases drastically if we move away from the optimum range (5.5 - 6.5 pH). In this way, the adjuvants produce an acidifying effect, which ensures an optimum pH, guaranteeing maximum phytosanitary expression of the products.

On the other hand, they act and modify the complexation process, which immediately shows cations in hard waters (Ca ++, Mg ++, Fe +++, Si ++++, etc.), produced by hard waters, blocking anions (more of phytosanitary products have negative charge) that interfere in the dissolution of chemical assets during treatment broths. Ultimately, allowing to free assets in order for it to carry out its action on the target pest and, or, disease.



Figure 1. Foliar spraying coverage comparing different volumes of water vs water + adjuvant

During the spraying process, they give the treatment broth physicochemical characteristics. This calls for a more precise and controlled spraying. The main features are described below:

- Spreading, reduces the surface tension of droplets (Figure 2)

- Penetrating, facilitates passage of active ingredient from phytosanitary product into plant tissue

- Retaining, prevents runoff and losses of a.i into the soil

- Sticking, sticks contact products to the leaves

- Moistening, captures humidity from the air and extends droplet lifespan

- Diffusing, facilitates plant translocation

- Drift control, improves the performance and precision of spray applications

- Anti-leaching, protects from rainfall



Figure 2. Differences between a drop water and a drop water (left) + adjuvant (right)

Finally, the adjuvants bear their effect directly on the targeted weed, pest or disease, enhancing phytosanitary action Next, we highlight the effects which are the most important features:

 Offers retention in irregular / non uniform plant shape

· Improves spreading on foliar surface · Adds penetration properties on foliar

cuticle/thickness Works to facilitate spreading,

wettability and retention on hydrophobic leaves/plants (Figure 3)

· Persistence which improves efficacy along with its target coverage over a long period of time. This limits the adverse factors (long flight distances, humidity, cuticle waxes, etc.).

· Reduces the risk of off-target drift



Figure 3. Drop effects on a hydrophobic leaf surface; Right leaves show only water. left leaves have adjuvants

radecorp International is developing a wide range of agricultural adjuvants, with the objective of creating a relationship with the farmer while providing effective solutions that help improve product competitiveness. This is all within an agricultural market that is increasingly demanding. This range will be on the market under the name ADJUSTAR. Strengthening and simultaneously completing Tradecorp International's agricultural solutions portfolio. Showcasing a clear commitment to continue being the benchmark of the fertilizer market and that of biostimulant specialties.

Customized solutions for your needs today

Innovating for the challenges of tomorrow

Did you know ...?

Adjustar is Tradecorp's new range of adjuvants, specially designed to help farmers optimize management of plant protection products.

ADJUSTAR RANGE, will revolutionize the adjuvant market. Some features include:

- Super spreading and leader adjuvant on market for preemergence herbicides

high capacity of soil penetration

· ensures horizontal and vertical herbicide distribution on the ground, improving coverage with less water volume

- Triple use adjuvant, combining:

- spreading
- retaining
- penetrating

High performance on hydrophobic leaves and safer for crops than classic oils

- The first multifunctional organically-sourced vegetable product

· Made from sunflower (oil properties) and sugar beet (adjuvant properties)

- The dual-action adjuvant, water corrector + adjuvant

- · Helps to solubilize pesticides in mix tank
- · Safeguards compatibility and stability
- Increase half-life by lowering pH

- Stick adjuvant containing pine terpene

· Ultra-concentrated stick adjuvant

. Low dose rate of 0.05% (2.8-4 times lower dose/ha compared to competitors)



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The Application and Development of Pesticide Precision in Japan



Shoichi Yuki, Ph.D Head of Planning Development Sector at Yamabiko Corporation

The agricultural working population has been decreasing in Japan. On the other hand, the average age of farmers has been increasing. These factors have caused farmland to be consolidated, though agricultural management hierarchy is becoming polarized. To solve these problem, a national project in the agricultural machinery field, entitled "Smart Agriculture", has been started. The purpose of "Smart Agriculture" is to increase working efficiency and reduce labor costs by using robotic techniques, as well as information and communication technology.

Yamabiko Corporation is one of the leading companies manufacturing crop protection equipment in Japan. Yamabiko Corporation has been encouraged to create smart agriculture by producing crop protection equipment, such as spraying equipment for UAVs and self-propelled boom sprayers for paddy rice.

The main crop in Japan is paddy rice, occupying 38% of the cultivated areas. It's very important for the Japanese agricultural machinery manufacturer to take care of paddy rice cultivation. Many types of machines are used in rice fields. In small fields, farmers use knapsack type sprayers and power sprayers. In this case, farmers need to spray by hand. Farmers who have big fields, for example, the size of some 5 ha, want to use high performance machines, such as self-propelled boom sprayers and industrial multi-rotors. Helicopter applications offer the most efficiency for spraying applications. Recently, farmers were willing to use multi-rotors for spraying applications, since multi-rotors are cheaper than helicopters and easier to use.

Japanese agricultural began using UAV's in 1990. Yamaha motor began to sell the single rotor helicopter R50 in the Japanese market. Some 30 years ago Yamaha motor modified aircraft introduced the latest technology. The latest generation YF390 and FAZER are driven by 4-stroke gasoline engines, and implement the turn assisted system and auto-cruise control system. Before using UAVs, manned aircraft were used for agri-chemical spraying in Japan. And then, aerial machines switched to unmanned helicopters for spraying applications for paddy rice fields. In 2018 May, the number of certified helicopters in the country is 2,788. The number of licensed operators is about 10 thousand. Regarding the share of helicopters in Japan.

Regarding industrial multi-rotors, there are a variety of multirotors produced by the Japanese and Chinese manufacturers. The multi-rotors is a new technology for spraying applications, and the practical use in the agricultural field is just starting. Japanese farmer are very interesting for using this unique aircraft in their field. The number of the certified multi-rotor in 2018 May is 889, and the number of operators who have license is over 3,600.

In the management schemes for UAV's agricultural applications, UAV manufacturers are needed to take certification tests conducted by the Japanese agricultural ministry. If they pass the test, manufacturers can release the machines for use in Japanese markets. For operators, including farmers and teachers in the training school, they need licenses to operate UAVs in paddy fields. For practical use, there are some rules for spraying applications. Farmers need to have the notification of spraying plans for the year, which include information, such as when to spray, where to spray, who is spraying, and so on. When finishing the spraying season, every UAV, including spraying equipment, needs to be taken for inspection and maintenance. When any accidents unfortunately happen, farmers need to submit accident report to UAV manufacturers and the government. Japan has a variety of types of high performance self-propelled boom sprayers. Farmers can control all the boom movements, such as tilt up/down, lift up/down and flapping out/in. Japanese boom sprayers have unique structures in their "telescopic boom". Farmer can adjust the working width according to field shape by using switch lever operations from 9.3m to 15.9m. Basically, sprayers have boom control systems to maintain the boom horizontally. Self-propelled boom sprayers can turn at a minimum rotation cycle of 2.5m at the end of field.

Self-propelled boom sprayer has kind of flow rate control system. This can realize to keep the flow rate per area constant. Thanks to these high quality functions, sprayer can realize very high working efficiency. If farmer use knapsack type sprayer in the field with 30 area, it takes 60 minutes to work. Regarding selfpropelled sprayer, it takes only 8 minutes.

In the current solution for self-propelled boom sprayers in paddy fields, Yamabiko self-propelled boom sprayers use GPS assisted guidance systems and automatic steering systems for the vehicle. In the paddy field, it is difficult for farmers to drive the vehicle to avoid driving on rice rows. Auto steering systems



Technology and Product

handle steering automatically by using GPS signals. This high performance system will contribute to optimize spray operations and saving labor by farmers. To use very high accuracy GPS signal by RTK system, tracking accuracy will be 2 - 3cm during spray operations. Self-propelled boom sprayers can drive and trace pre-programmed tracks automatically, which greatly improve spraying efficiency and productivity. Farmer can also use LCD touch panel monitors. The area sprayed is displayed on the monitor and is effective in preventing duplication or skipping. Turning points are shown on the monitor and helps to achieve smallest turns.

The benefit of the auto steering system for self-propelled boom sprayers is that the sprayer can drive automatically from point A to point B, which are set in advance, without steering. Sprayers can drive according to rice rows, thus avoid damage to rice. At the end of field, farmers steer the handle wheel, sprayers can drive to the next truck by watching the sprayed area on spray monitors. Auto steering systems for self-propelled boom sprayers can realize easy operation of vehicles during spaying operations with high efficiency, high accuracy and high performance.



Growth opportunities using Vive Crop Protection's Allosperse technology

Jordan Dinglasan

VP Product Development at Vive Crop Protection

Vive Crop Protection makes proven products cutting edge using the Allosperse[®] Delivery System. Allosperse is a nanotechnology "shuttle" that enables active ingredients to mix better – with liquid fertilizer, other chemicals, micronutrients and hard water. This allows farmers to use these products in new ways to increase efficiency, crop quality and yield.

AgroPages has recently had a dialogue with Jordan Dinglasan, VP Product Development at Vive Crop Protection,who shared his viewpoints about Allosperse[®] delivery system and its application situation, as well as their future plan etc.

What do you see for the future of applying nanotechnology-based agrochemicals?

This is an interesting question because there's some misinformation out there about what nanotechnology can do. Nanotechnology doesn't change what a chemical does – it just changes how it behaves in its environment. Nanotechnology brings incremental – not revolutionary - changes to ag chem.

For example, Vive developed AZteroid FC 3.3 fungicide that contains azoxystrobin. Our use of nanotechnology doesn't change the azoxystrobin properties – it still controls diseases and increases plant health like any other azoxystrobin would. In this case, nanotechnology allows azoxystrobin to mix with other things in the spray tank or irrigation pivot, which wasn't possible before. Any performance benefits come from azoxystrobin – our technology just allows the product to be applied in different ways and at more beneficial times in a crop's life.

Tell me more about Allosperse - what is it?

The Allosperse Delivery System is a nanoscale, polymerbased delivery system with extremely high 'tunability.' We can produce many different types of polymer encapsulation particles with different internal and external chemical properties. The inside can be tuned for optimal association with an active ingredient, while the outside can be tuned for whatever behavior is desired mixability, targeted mobility, stability, etc.

So is Allosperse technology the future?

We view Allosperse as a critical component to innovation in agriculture. Industry consolidation and increased regulatory barriers mean that fewer new active ingredients are being developed each year. We, as an industry, need to find new techniques to improve existing active ingredients, to help them be used in new ways. Delivery systems that help improve how active ingredients behave can provide new life to older chemistry, as well as improving environmental impact. Allosperse technology can be readily applied across multiple crops and/or active ingredients.

Is Vive doing this alone or in partnership with other companies?

We work with many other agrochemical companies to improve their proven products or new active ingredients using the Allosperse Delivery System. We view ourselves as being the "Intel Inside" in these unique products as they hit the market.

Are any products using Allosperse technology commercially available?

Vive was the first to bring nanotechnology to US crop protection and has two commercially-available products and three more awaiting US EPA approval.

Vive's AZteroid FC 3.3 fungicide (azoxystrobin) and Bifender FC (bifenthrin) insecticide are worry-free, convenient and easyto-use products that mix uniformly with liquid fertilizers. They maximize yield and profitability in a broad range of crops including corn, soybean, alfalfa, sugarbeets and potatoes. In fact, AZteroid FC 3.3 has been proven to increase sugarbeet yield by an average of 3.1 T/ac and sugar content by up to .6%.

Arysta Lifescience utilizes Allosperse technology in two commercially available products. Arysta and Vive received the Agrow Award for Best Industry Collaboration in 2017.

So what's next?

Vive has a deep pipeline of branded products under development and the ag chem industry is very interested in Allosperse and what it can do - now and in the future. Our next generation of nanotech polymers will improve various active ingredients by improving their ability to reach targets below the soil surface by targeted soil mobility.

The third generation of Allosperse technologies will optimize the adhesion and uptake into foliage to improve retention and residual control of foliar applied products, improve viability of formulated biologicals or improve stability of formulations for moderately soluble active ingredients.

All of these are designed to help growers do more with less and create new ways growers can use and benefit from existing active ingredients.

COMPANY DIRECTORY

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Nouryon

Nouryon

We are a global specialty chemicals leader. Markets worldwide rely on our essential chemistry in the manufacture of everyday products such as crop protection formulations, pharmaceuticals, personal care items, paper, plastics and building materials items. Building on our nearly 400-year history, the dedication of our 10,000 employees, and our shared commitment to business growth, strong financial performance, safety, sustainability, and innovation, we have established a world-class business and built strong partnerships with our customers. We operate in over 80 countries around the world and is a leading supplier of specialty surfactants, polymers and solvents.

Our agrochemical portfolio of industry-leading brands includes Morwets® (wetting agents and dispersants), Adsee™ adjuvants, Agrila n[®] dispersants, Armid[®] solvents, Ethyla n[®] and Ethomeen[®] (alcohol and amine alkoxylates). As a global company, with local presence and a robust supply chain, we can ensure support and delivery wherever you are. Every Day.

www.nouryon.com/agriculture agro@nouryon.com

Innospec Active Chemicals



Innospec Agrochemicals offers a diverse range of surfactants, emulsifiers, rheology modifiers, chelating agents and specialty solvents for the agricultural market. We supply formulation additives for crop protection, home & garden, animal health. fertilizers. micronutrients.

and tank mix adjuvants.

Established Innospec brand names such as NANSA[®], EMPICOL[®] and EMPILAN[®] are well known in the industry as time tested and high quality products. Combined with the newly established ENVIOMET[®] brand, the full product line offers effective components and coformulants for optimizing formulations and enhancing active ingredient performance and delivery.

Innospec believes in close customer collaboration, commitment to continual innovation and product development contributing to a sutainable environment without compromising on performance.

www.innospecinc.com agrochemicals@innospecinc.com



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



Working in partnership with leading universities, research institutes and independent scientists, IntraCrop develops and distributes speciality

crop inputs throughout Europe. With significant financial backing, we focus on producing adjuvants, biostimulants and seed treatments that help agronomists and farmers improve productivity and reduce the unit cost of crop production

www.intracrop.co.uk admin@intracrop.co.uk

Battelle UK Ltd.

Battelle UK

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 cuttingedge formulation technologies for better performance and stability:

and bacteria

- Capsule suspensions
- Controlled-release systems
- Seed dressing
- Water-dispersible granules
- Wettable powders

www.battelle.org j.groome@battelleuk.com

Victorian Chemical Co. Ptv. 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.

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

Company Directory

Bioformulation of proteins, enzymes

· Emulsions and microemulsions

• Ultra-fine sub-micron suspensions

Vegetable oils are used widely in our

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 pastural.

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

www.vicchem.com products@vicchem.com





Α

Agrovista is a leading supplier of agronomy advice, seed, crop protection products and precision farming services. With the most comprehensive integrated arable trials programme in the UK, we can ensure that the evidence-based advice we provide you is unrivalled in our marketplace.

With depots and regional agronomy centres throughout the UK, we are your local crop care experts, committed to helping you farm more effectively and more profitably.

Agrovista Discovery spray application aids improve the performance of plant protection products. Pesticide efficacy is reduced by water quality, poor application and inadequate coverage, retention and uptake on the target surface. Discovery products overcome these challenges

- improving the level of control and increasing your yields. To ensure consistent performance, each product is tested under a rigorous R&D screening programme.

Discovery range of spray application aids:

· Tank mix spray additives and adjuvants

· Designed to enhance plant protection product efficacy

· Targeted formulations focused by pesticide requirement

 Improved spray application · Supported by a pan-European R&D

programme · Comprehensive efficacy data to support use

· Made in Britain

www.agrovista.co.uk peter.mcdonald@agrovista.co.uk

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

Aquatrols

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

Adjuvants Unlimited



Adjuvants Unlimited, LLC, develops formulation solutions for the adjuvant market. We also bring new and unique adjuvant chemistries to market to complement existing technologies. We offer state-of-the-art production of adjuvants offered in bulk and packaged goods, as well as surfactant blends and pesticide additives.

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

B

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 performanceenhancing 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

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

С

Clariant International Ltd.

CLARIANT

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

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

Company Directory

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

Central America Toll-Manufacture & Logistics (CTL)



Central America Toll Manufacture & Logistics (CTL), is a hub for manufacture AG products, focused in competitivity & 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 competiveness of our customers.

www.agroctl.com gazzari@agroctl.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



Dow Crop Defense



Dow 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.

· Focused on the Agrochemical market: Preservation, In-can Formulants, Tank-mix Adjuvants, Fertilizer Additives Nutrition, Agro 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 and Silicone.

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



Evonik Nutrition & Care GmbH

EVONIK

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

Eastman Chemical Company

ΕΛSTΜΛΝ

Eastman is a global specialty materials company that produces a broad range of products found in items people use every day. With the purpose of enhancing the quality of life in a material way, Eastman works with customers to deliver innovative products and solutions while maintaining a commitment to safety and sustainability.

Eastman's diverse AgChem Intermediates portfolio includes neutralizing agents, intermediates as raw materials, insecticides, fertilizers, herbicides, adjuvants, and a variety of solvents and catalysts. With a rich history of providing targeted, innovative, and sustainable solutions, Eastman remains the cream of the crop.

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

Protection products using granulation technologies. Specialising in the following:

Formulation of Herbicides & Plant Growth Regulators: · Low Pressure Extrusion of Water Dispersible Granules (WDGs) & Soluble

Granules (SGs)

Pan Granulation

 Roll Compaction Impregnation and Coating of

Granules

Formulation of Highly Active (SU) Herbicides in a dedicated facility using extrusion.

Formulation of Insecticides & Fungicides :

· Extrusion of WDGs/ SGs · Impregnation and Coating of Granules

Support Facilities We have ISO 9001, ISO 14001 & most recently ISO 45001 certificates. We also have Top-tier COMAH authorisation at the Brenda Road site where we handle & store incoming raw materials. In addition, we have a fully equipped laboratory and pilot plant to assist with

product scale-up. **Our expert Technical Management** team have an innovative approach to finding solutions, which allows us to

support new product introduction & add value to your products, making Exwold a strategic partner for our clients.

www.exwold.com enquiries@exwold.com

Exwold Technology



Exwold have 5 manufacturing sites based in the UK and specialise in contract formulation & processing of Crop

Foreverest Resources Ltd. supplies pine-based chemicals since 1988. Our

· IPPC authorisation for formulation of Herbicide acids into metal salts in-situ

F

Foreverest Resource



Company Directory

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



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

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

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 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.

can benefit the crop. Our mission is to

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

Η

Huntsman Performance Products



Enriching lives through innovation

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 improve 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

Spreader / 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 kent shu@huntsman.com



ingevity

Ingevity provides specialty chemicals, high-performance carbon materials and engineered polymers that purify, protect and enhance the world around us. As the world's largest producer of Kraft lignosulfonates, Ingevity is committed to quality, consistency and control in the manufacturing of dispersants and surfactant systems. We offer a range of bio-based specialty inerts for plant health and crop protection, and find customers' solutions by combining quality products and unsurpassed technical expertise. Ingevity's adjuvant products are sold under the brand names Altapyne[®] and Altastick[™]. Headquartered in North Charleston, South Carolina, Ingevity operates from 25 locations around the world and employs approximately 1,750 people. Learn more at www.ingevity.com.

www.Ingevity.com chemicals@ingevity.com

iFormulate

iFormulate

iFormulate Ltd provides customised R&D and innovation services to companies working in Formulation Science and Technology. We offer consultancy, problem solving, R&D support, idea generation and development, assistance with commercialisation, and training. Our clients come from the agrochemical and biopesticides industries as well as all other formulating industries (e.g. pharma, biocides, coatings, inks, food, cosmetics, household, specialty chemicals).

www.iformulate.biz info@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.

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 2,379 M in 2018 and employs over 2,800 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

Ionica



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





- Over 15 years ionica has been the



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

Lonza



Lonza has a well-recognised 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 metaldehydebased AXCELA[®] 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 biopesticides, added-value formulations of post-patent molecules, and regulatory-driven product reformulations.

www.lonza.com agroformulation@lonza.com

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

LEVACO Chemicals GmbH



LEVACO Chemicals GmbH has its headquarters and production site in the Chempark Leverkusen. Our product portfolio includes specialities 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 speciality 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



Momentive

MOMENTIVE

Since our introduction of the first silicone spray adjuvant on the market, our Silwet*, AgroSpred* 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 longlasting 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



Polaguimia



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 commited 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 in 1932 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 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.

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 speciality chemicals.

Sasol offers the agrochemical customer and manufacturer many choices

Company Directory

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 makes 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 multinational 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

SINVOCHEM



SINVOCHEM is a chemical company specializing in polymer surfactant and adjuvants for agrochemicals. With sustainable innovation and timely technical support strategy, SINVOCHEM has gained good reputation as main supplier for formulators in China. Backed by a high-efficient R&D team and wellconstructed lab platform, SINVOCHEM succeeds in setting customized services as priority. Now SINVOCHEM maintain a

good relationship with top 70% domestic formulators and main agro institutes. In recent years, SINVOCHEM also successfully promoted overseas market by collaboration with MNCs and leading distributors. SINVOCHEM offers an allin solution over pesticide formulating, contributing to dose reduction and

- Polymeric Dispersant and wetting

- Support to full range of formulations

- Customized services including lab establishment \equipment selection \

production line design\ personnel training\

- Tank-mix adjuvants and built-in

efficacy improvement.

pilot process assist...

www.sinvochem.com

TENSIOFIX

efficacy.

and other additives.

TENSIOFIX

A division of Ajinomoto OmniChem

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

The surfactant range consists of

This expertise enables to propose

We also develop vegetable based

biostimulants and bio-solutions for a

highperformance and cost-effective

surfactants especially designed for

agrochemical applications.

emulsifiers, wetting-dispersing agents

export@sinvochem.com

agent

solutions

Service & Strength:

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 makes proven products cutting edge using the Allosperse[®] Delivery System. Allosperse is a nanotechnology "shuttle" that enables active ingredients to mix better - with liquid fertilizer, other chemicals, micronutrients and hard water. This allows farmers to use these products in new ways to increase efficiency, crop quality and yield.

Allosperse is used in a number of fertilizer-compatible insecticides and fungicides on the market, including partner brands. Vive works with various companies to improve formulations to improve shelf life, mixability and longevity (in the case of biologicals). Vive's lead products are AZteroid FC 3.3 fungicide and Bifender FC insecticide.

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HUNTSMAN

Enriching lives through innovation



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Jingkun Chemistry Company A subsidiary of China National Petroleum Corporation Expert of Guar Derivatives since 1989

Guar Derivatives Unlock the Power of Your Formulation

Function:

- Increase droplet size (drift reduction) and improve deposition rate(improved efficacy) in aerial application
 - Enhance water and nutrient uptake in seed caring & fertilization



Origin: Based on green chemistries

- Guar gum bio-polymer
 - A cold-water-soluble polysaccharide derivative

