The effective delivery of active ingredients is increasingly reliant on the incorporation of adjuvants into the formulation. The choice of adjuvant is determined by the end use requirements. Optimum performance can often be achieved by using a balance of adjuvants to achieve the desired effects.

Croda presents a wide range of multifunctional adjuvants in this guide and explores how these products can solve problems in each stage of the adjuvancy process.

**Spray Formation**

Adjuvants can help reduce the amount of driftable fine droplets generated after spraying, which in turn reduces the problems associated with spray drift.

- Driftable fine droplets (<105 µm) can be a problem
- Preventing contamination of waterways and neighbouring crops is important
- Spray nozzle choice also reduces drift but combining it with surfactants has an even bigger effect
- Croda supply products that can be built-in or tank-mixed
- Spray drift can be measured using wind tunnel technology

**Spray Retention**

The addition of adjuvants enhances the ability of the spray droplet to remain on the surface of the leaf making the active ingredient more available to the crop.

- They dissipate kinetic energy of the droplet during impact
- They rapidly reduce surface tension

**Recommended Use Rates**

Adjuvant use rates can vary considerably depending on the mode of application (tank mix vs built-in), head space available in the formulation, the rate of dilution for formulations in the tank or the desired adjuvancy effect being targeted.

Typical inclusion levels would be:
- Tank mix: 0.1 – 0.5%  Built-In: 50 – 200g/L

**Surfactants Help?**

- They dissipate kinetic energy of the droplet during impact
- They rapidly reduce surface tension

**What type of surfactants are required?**

- Small, dynamic surfactants that move rapidly to the interface
- Low molecular weight, branched, end capped, nonionic

**Figure 1:** Pesticide being applied to crops through spraying

**Figure 2:** Droplets adhere to or bounce (run off) from the leaf surface

**Figure 3:** Effect of ethylene oxide (EO) chain length on surface tension at critical micelle concentration (CMC) for linear and branched alkyl C12 EO surfactants

**Figure 3 shows that surfactants with lower amounts of EO are better for spray retention as they lower the surface tension. Branch chains are also better than the equivalent linear chain. For example if you look at the eight moles of EO on the graph, the branched version has a much lower surface tension than the linear chain.**

A lower surface tension can be favourable for spray retention as the droplet has a better ability to dissipate kinetic energy, reducing bounce off.

**Recommended Use Rates**

<table>
<thead>
<tr>
<th>Adjuvant</th>
<th>Formulation</th>
<th>Use Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atplus DRT-EPS</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Atplus DRT-100</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Atplus DRT-245</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Atlox AL-2575 LF</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Atlox MBA 11/8</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Tween 22</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Tween 23</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
<tr>
<td>Tween 24</td>
<td>Tank mix</td>
<td>0.1 – 0.5%</td>
</tr>
<tr>
<td></td>
<td>Built-In</td>
<td>50 – 200g/L</td>
</tr>
</tbody>
</table>
Adjuvants can help pesticide spray droplets to wet waxy surfaces or soil substrates, which ensure the active ingredient is distributed evenly across the leaf or within the soil.  
- Effective leaf wetting  
- Increased foliar coverage  
- Improved soil wetting

What role do surfactants play?  
- They reduce surface tension and contact angle  
- They provide efficient packing at the interface

**Wetting**

**Humectancy**

![Graph showing water content over time](image)

The results from the soil moisture retention test demonstrate that **Hydravance 200** has the ability to reduce the evaporation rate of water over that of water alone and Hydravance 100. As a result more moisture is retained in the soil plug profile.

**Deposit Formation**

Active ingredient deposit structures can be directly linked to the incorporation of adjuvants which influence evaporation of droplet water and prevent precipitation of the active ingredient.  

Which properties of surfactants are important?  
- Humectancy (measured by Dynamic Vapour Sorption)  
- Film forming

**Hydravance 200** – Proprietary blend  
**Atlox** AL-2575 LF – C8-C10 alkylpolysaccharide  
**Tween** 22 – Polyoxyethylene (8) sorbitan monolaurate

**Atlox** AL-2575 LF – C8-C10 alkylpolysaccharide  
**Atplus** UEP-100 – Alkoxylated polyol ester

Micro deposit structure of an active ingredient on a cuticle surface is studied by Scanning Electron Microscopy (SEM).

**Increased humectancy** is linked to keeping the active ingredient in a more bioavailable state which results in increased delivery and/or delivery over a longer period of time. The evaporation rate is significantly lower (probability value of significance <0.05) with **Atplus UEP-100** when compared with glycerine and polysorbate 20.
Wetting
Deposit Formation Uptake

Adjuvants can influence penetration of systemic pesticides through the leaf cuticle resulting in increased bioavailability of the active ingredient.
- Effective systemic foliar uptake is achieved
- Adjuvant choice can be active dependent (hydrophilic / lipophilic)
- Surfactants enhance diffusion through the cuticle
- Large molecules of high molecular weight are favoured over small molecules which can cause necrosis of the leaf (phytotoxic effects)
- Uptake is studied by Franz Cells and active ingredient detection using high performance liquid chromatography (HPLC)

Adjuvancy Characterisation Techniques and Capabilities

It is important to determine which adjuvant is best suited to your active ingredients, therefore predicting the behaviour of your product before investing in expensive performance field trials and product registrations is crucial. In Croda’s five dedicated Crop Protection R&D centres located globally, we have a range of characterisation techniques and methods that can assess the performance of your products. These capabilities will enable you to have a more complete understanding of the adjuvancy effect Croda’s product has on your active ingredients to get a successful final formulation.

Uptake

Adjuvancy Characterisation Techniques and Capabilities

Spray Quality & Retention
- Spray Formation
- Spray Retention
- Low Speed Wind Tunnel (LSWT)
- Dynamic Surface Tension (DST)
- Single Droplet Generator
- Rainfastness

Droplet Characterisation
- Wet Droplet Analysis and Drying Droplet Analysis
- Contact angle
- Equilibrium Surface Tension (CST)
- Dynamic Vapour Sorption (DVS)

Uptake & Penetration
- Deposit Formation
- Uptake
- Franz Cells
- Laser Ablation Electrospray Ionisation Mass Spectrometry Imaging (LAESI-MSI)

Interested to know more about these techniques? Download our Beyond Chemicals brochure today to find out more!

Figure 7: Test done at 25 °C, 40-45% relative humidity, duration 72h. Imidacloprid was applied at 0.5 g/L containing 0.25% w/v adjuvant. All other active ingredients were applied as a 1:200 dilution in water from concentrates (Azoxystrobin 250 g/L SC, Tebuconazole 430 g/L SC and Chlorpyrifos 430 g/L EW) with a final adjuvant rate of 0.05% w/v.

Aptus™ UEP-100 combined with a selection of active ingredients, improved penetration over no adjuvant (1.8 to 4.1 times higher than control) and the typical adjuvant, polysorbate 20 (typical adjuvant 1.5 to 2.8 times over the control)
<table>
<thead>
<tr>
<th>Product</th>
<th>Chemical Name</th>
<th>Physical Form</th>
<th>HLB Value</th>
<th>Surfactant Type</th>
<th>Cloud Point</th>
<th>Spray Retention</th>
<th>Deposit Wetting</th>
<th>Formation Penetration</th>
<th>Drift Reduction</th>
<th>EPA Features and Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlox 390</td>
<td>Polyoxyethylene alkyl ether phosphate</td>
<td>Liquid</td>
<td>1-1.5</td>
<td>Anionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
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<tr>
<td>Atlox 395</td>
<td>Polyoxyethylene alkyl ether phosphate</td>
<td>Liquid</td>
<td>1.5-2.5</td>
<td>Anionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
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<tr>
<td>Atlox 396</td>
<td>Polyoxyethylene alkyl ether phosphate</td>
<td>Liquid</td>
<td>2.5-3.5</td>
<td>Anionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
</tr>
<tr>
<td>Atplus DRT-100</td>
<td>Alkoxylated Alcohol Liquid</td>
<td>Liquid</td>
<td>0-0.5</td>
<td>Non-ionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
</tr>
<tr>
<td>Multitrope 1214</td>
<td>Sorbitan monolaurate polyoxypropylene (10)</td>
<td>Liquid</td>
<td>11-12</td>
<td>Non-ionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
</tr>
<tr>
<td>Hydravance 200</td>
<td>Polyoxyethylene alkyl ether phosphate</td>
<td>Liquid</td>
<td>1.5-2.5</td>
<td>Anionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
</tr>
<tr>
<td>180</td>
<td>Atplus DRT-EPS</td>
<td>Liquid</td>
<td>0-0.5</td>
<td>Non-ionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
</tr>
<tr>
<td>910, 930</td>
<td>General purpose adjuvant built on Tween 20 technology, offering enhanced surface activity to provide better wetting, depositing and spreading properties</td>
<td>Liquid</td>
<td>5.3-8.8</td>
<td>Non-ionic</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Not determined</td>
<td>Sanitation, 12 - Responsible Consumption &amp; Production and 15 - Life on Land.</td>
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</table>

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**Reaches:**
For further information please contact your sales representative.

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For further information please contact your sales representative.

**Contact Information:**
- **North America:**
  - Marketing-usa@croda.com
  - 910-930 General purpose adjuvant built on Tween 20 technology, offering enhanced surface activity to provide better wetting, depositing and spreading properties.

- **Europe, Middle East & Africa:**
  - Europe@croda.com
  - 920 Multitrope 1214 is a phosphate based anionic surfactant and leaf penetration aid adjuvant.

- **Asia Pacific:**
  - Asia Pacific cropcare@croda.com
  - 910, 930 General purpose adjuvant built on Tween 20 technology, offering enhanced surface activity to provide better wetting, depositing and spreading properties.

- **Latin America:**
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  - 960 Lowest polarity modified Tween 20 technology with improved dynamic properties and reduced foam while retaining surfactant safety advantages.

- **North America:**
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  - 960 Intermediate polarity modified Tween 20 technology with improved dynamic properties and reduced foam while retaining surfactant safety advantages.

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