ALTAHANCE™ MULTIFUNCTIONAL ADJUVANTS WITH TUNABLE RAINFASTNESS

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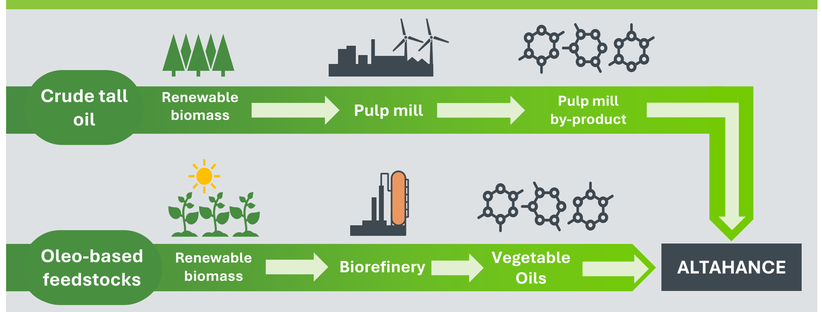
ABSTRACT

Rainfastness is a key property of sticker adjuvants characterizing their ability to withstand rainfall and is defined as the time needed between an application and a rain event for a pesticide formulation product to maintain its effectiveness when compared to the same product applied in the absence of rain. Rain immediately following application of a pesticide formulation presents a common challenge in agrochemical crop protection applications and leads to diminished pesticide efficacy, pollution of soil, ground and surface water streams, and reduced crop yields. Therefore, new, innovative, and sustainable solutions extending the time an agrochemical active ingredient is retained on the leaf or improving leaf penetration while addressing the adverse effects are highly desired. Here, we present a new technology of **ALTAHANCE** sticker adjuvants based on sustainable and bio-derived materials offering minimal to no toxicity to biological active ingredients with tunable performance even at a very low use level. We showed that AltaHance sticker adjuvants enhance the effectiveness of agrochemical agents by improving the active ingredient's rainfastness and leaf penetration even under challenging conditions, such as those presented by cold temperatures and hard water applications. Moreover, we showed the ALTAHANCE products provide increased wetting, and compatibility with solvents and surfactants commonly used in active ingredient formulations while offering an extremely low VOC profile. We demonstrated the new ALTAHANCE adjuvants (REACh compliant) contain more than 99% of bio-based content and can provide rainfastness performance comparable with or exceeding the existing market benchmarks and may be considered as suitable candidates for biological pesticide formulations.

MARKET DRIVERS AND OPPORTUNITIES



ALTAHANCE bio-based sticker adjuvants are sourced from crude tall oil isolated from the loblolly pine (*Pinus taeda*), native to the Southeastern United States, and derivatized vegetable seed oils sourced through biorefinery processing. ALTAHANCE are microplastics free and biodegradable sticker adjuvants featuring tunable rainfastness performance that allow for reduced dosage and increased efficacy of pesticides leading to higher crop yields through enhanced leaf penetration even under cold temperature and hard water application conditions. Altahance adjuvants help farmers meet our world's challenges including growing demand for higher crop yields and increasing need for higher pesticide efficacy.

ALTAHANCE STICKER ADJUVANTS

ALTAHANCE sticker adjuvants are easy-to-handle liquids biocompatible with a wide range of commonly used microorganisms used in biological pesticide formulations.

ALTAHANCE: KEY PRODUCT FEATURES

- Increasing rainfastness: **ALTAHANCE S (lowest) < ALTAHANCE 2S < ALTAHANCE 3S (highest)**
- Easy-to-handle: Low viscosity and low pour point *vs.* polyterpenes
- Safe-to-use: Non-flammable due to high flash and boiling points with zero VOC emissions
- Easily adhere when applied to the leaf surface (low surface tension)
- Stomatal penetration enhancement leading to increased pesticide uptake
- Increase of stability of emulsifiable concentrate (EC), and oil dispersion (OD) in cold and hard water conditions
- Regulatory: REACh compliant, TSCA active

Bio-compatibility with Biological Active Ingredients (typical use rates)*
Beauveria bassiana
Bacillus subtilis
Burkholderia cepacian
Rhizobium leguminosarum
Bradyrhizobium japonicum
Bacillus megaterium
Trichoderma reesei
Other *bacillus* type organisms

**) Based on the Kirby-Bauer diffusion disc assay.*

	Density (g/cm³)	Pour point (°C)	Flash point (°C)[1]	Acid number (mg KOH/g)	Viscosity @ 25 °C (cP)[2]	pH[3]
ALTAHANCE S	0.91	-4	>149	166	56	3.5
ALTAHANCE 2S	0.93	-6	>149	171	88	3.8
ALTAHANCE 3S	0.97	-6	>149	153	440	4.1

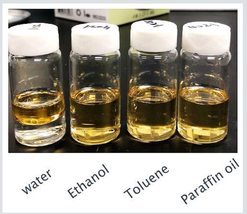
Notes: [1] Flash point: Closed cup method. [2] Brookfield viscosity, spindle no. S21 @ 50 rpm, 25 °C. [3] Measured in 10 wt% solution in IPA/water (1:1 v/v). Boiling point for all products >185°C.

COMPATIBILITY STUDIES: SOLVENTS & SURFACTANTS

ALTAHANCE sticker adjuvants are compatible with a broad range of common solvents and non-ionic surfactants and are not miscible with water. ALTAHANCE adjuvants are well soluble in paraffin oil (non-polar) which is often not compatible with polar solvents, surfactants, and can also be used as coupling agents to assist with compatibilization of paraffin oil. ALTAHANCE sticker adjuvants are miscible with commonly used types of surfactant chemistries.

Solvent	Compatibility
Water	Non-miscible
Ethanol	Miscible
Toluene	Miscible
Paraffin oil	Miscible

Solvent compatibility test: 50 wt% AltaHance, 50 wt% solvent.

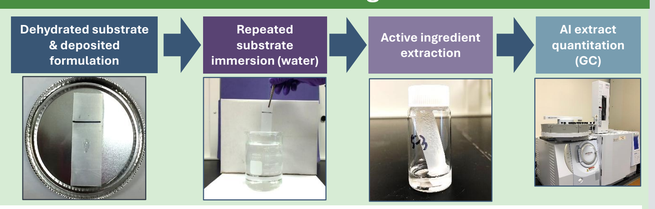


Surfactant type	HLB Value	ALTAHANCE Compatibility	Vial No.
Polysorbate	10.5	Compatible	1
Alcohol ethoxylate	10.8	Compatible	2
Castor oil ethoxylate	12.6	Compatible	3
Nonylphenol ethoxylate	13.2	Compatible	4

Surfactant mixtures stable for 2 weeks at 54 °C and no separation was observed upon freeze/thaw cycling. Anionic surfactants (sodium dodecylbenzene sulfonate) can be used to improve emulsification.

Rainfastness determination for formulation and active ingredient retention

- Based on ASTM method STP1579
- Substrate: Parafilm® M Lab Film (3 × 1 in)
- Dry film treatment: Heat lamp or no exposure
- Number of immersions



$$\text{Rainfastness } (wt\%) = \frac{Weight\ (substrate + residue\ after) - Weight\ (substrate)}{Weight\ (substrate + residue\ before) - Weight\ (substrate)} \times 100\%$$

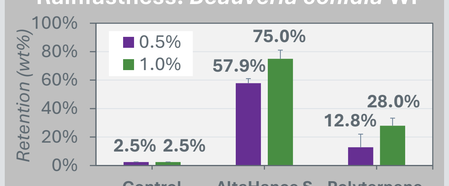
RAINFASTNESS PERFORMANCE: BIOLOGICAL ACTIVE INGREDIENTS

Beauveria conidia WP Formulation

Ingredient	Function	Wt%
*B. conidia**	Active	20
ALTABIO™ 200	Dispersant	4
Geowet HR	Wetter	5
Kaolin clay	Filler	71

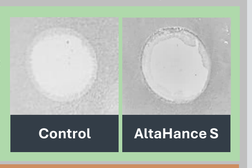
**) Contains a minimum of 2×10^{11} cfu/g.*

Rainfastness: *Beauveria conidia* WP



Sticker/spreader: ALTAHANCE S / castor oil ethoxylate (95:5 m/m) used at 0.5 wt%. WP = wettable powder.

Rainfastness test results: Dehydrated WP residue on the Parafilm M substrate following the rainfastness testing protocol.

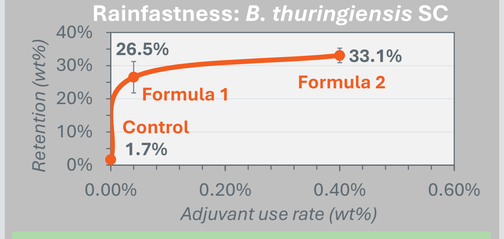


ALTAHANCE S outperformed an industry standard used at 0.5 wt% in a tank-mix wettable powder (WP) formulation.

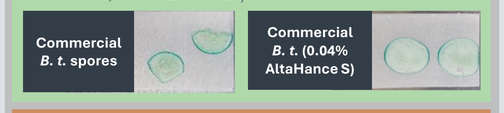
Bacillus thuringiensis SC Formulation

Ingredient (wt%)	Ctrl	Form. 1	Form. 2
BONIDE® *B. t.*[1]	2.50	2.50	2.50
ALTAHANCE S / castor oil ethoxylate (95:5 m/m)	**0**	**0.04**	**0.40**
Water (q.s. to 100)	97.50	97.46	97.10

Rainfastness: *B. thuringiensis* SC



Rainfastness test results: SC residues on the Parafilm M substrate following the rainfastness testing protocol (50 immersions, de-ionized water).

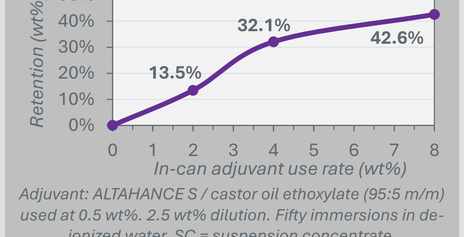


ALTAHANCE S provided improved spreading and increased retention by 25-31% in a commercial *B.t.* suspension concentrate tank-mix application.

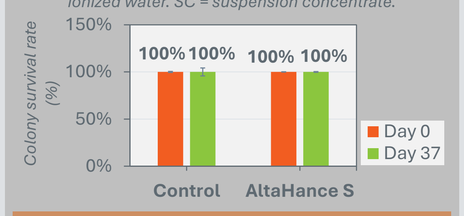
Bacillus thuringiensis In-Can SC

In-can Mix Components	0%	2%	4%	8%
MONTEREY® *B. t.* Commercial SC[2]	100	98	96	92
ALTAHANCE S: Castor oil ethoxylate (95:5)	**0**	**2**	**4**	**8**

Rainfastness: *B. thuringiensis* SC



Adjuvant: ALTAHANCE S / castor oil ethoxylate (95:5 m/m) used at 0.5 wt%. 2.5 wt% dilution. Fifty immersions in de-ionized water. SC = suspension concentrate.



ALTAHANCE S increased spore retention by 43% in a commercial *B.t.* suspension concentrate application.

[1] BONIDE is a registered trademark of Bonide Products, Inc. [2] MONTEREY is a registered trademark of Brandt Consolidated, Inc.

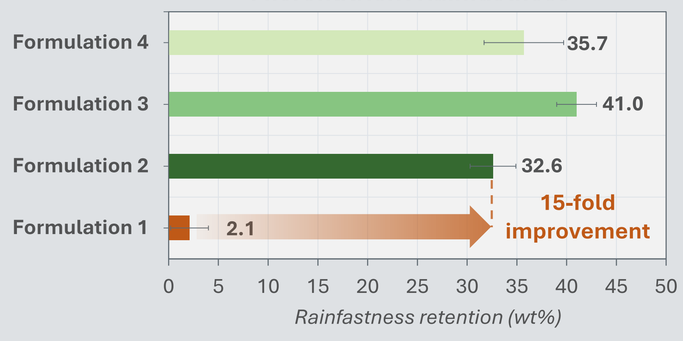
MICRONUTRIENTS APPLICATION

We demonstrated ALTAHANCE improves rainfastness performance in a manganese(II) micronutrient formulation:

		Formulation (wt%)			
Ingredient	*Function*	Form. 1	Form. 2	Form. 3	Form. 4
Manganese(II) sulfate	*Active ingredient*	4.75	4.75	4.75	4.75
Water	*Carrier / diluent*	87.88	87.88	87.88	87.88
REAX 88A*	*LS Dispersant*	2.38	2.38	2.38	2.38
Castor oil ethoxylate	*Surfactant*	0	0.50	0.50	0.50
ALTAHANCE S	*Sticker adjuvant*	**0**	**4.50**	0	0
ALTAHANCE 2S	*Sticker adjuvant*	**0**	0	**4.50**	0
ALTAHANCE 3S	*Sticker adjuvant*	**0**	0	0	**4.50**

Notes: Castor oil ethoxylate, HLB = 12.6. Substrate: Parafilm M, no light exposure. Four repetitions per formulation. *) REAX 88A is a lignosulfonate dispersant from Ingevity Corporation.

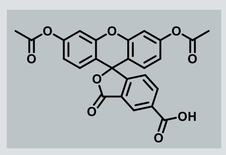
Micronutrient Rainfastness



Micronutrient rainfastness performance improved 15-fold with ALTAHANCE used in the formulation compared to a formulation without the adjuvant.

IN VIVO UPTAKE PERFORMANCE

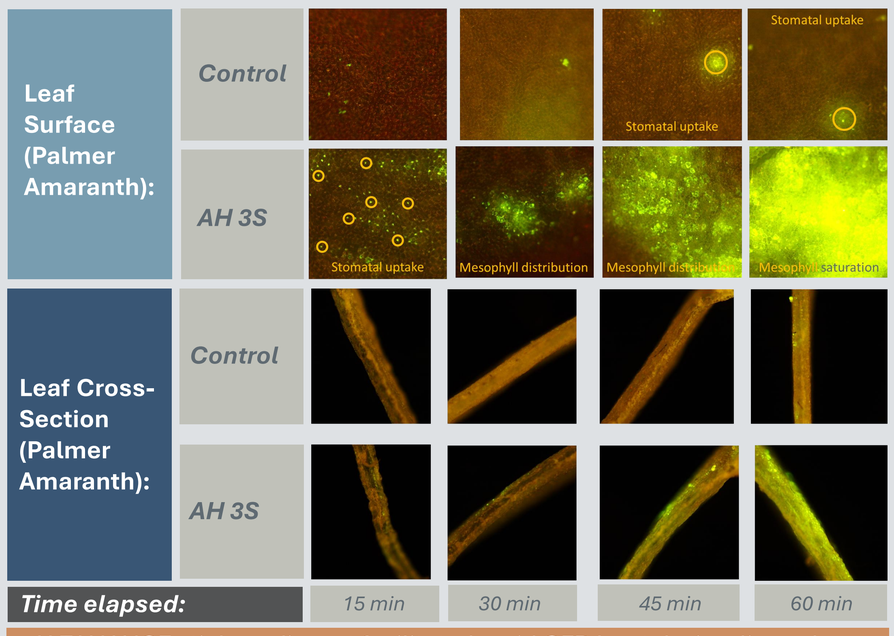
5(6)-Carboxyfluorescein diacetate (CFDA) is a non-fluorescent tracer that easily penetrates leaf stomata and diffuses into the leaf mesophyll where it undergoes non-specific hydrolysis into fluorescent carboxyfluorescein. We demonstrated that ALTAHANCE can significantly improve stomatal and cellular uptake of CFDA when applied to the leaf surface:



5(6)-Carboxyfluorescein diacetate (CFDA)
CAS RN 124387-19-5
NO FLUORESCE

Carboxyfluorescein
CFDA metabolite
GREEN FLUORESCENCE

Images taken on the Olympus BX 50 fluorescence microscope. CFDA dosed in deionized water (Control – no adjuvant), CFDA dissolved in ALTAHANCE 3S at 0.25 wt%. CFDA used at a final concentration of 100 µg/mL in water by diluting a DMSO stock solution.

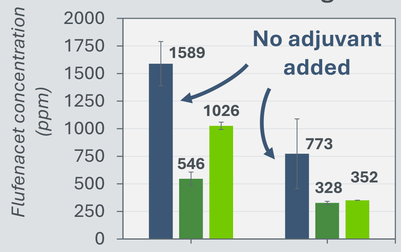


ALTAHANCE sticker adjuvant facilitated rapid CFDA uptake in a live palmer amaranth leaf through stomatal penetration followed by enhanced mesophyll diffusion when monitored *in vivo* with green emission of the CFDA metabolite.

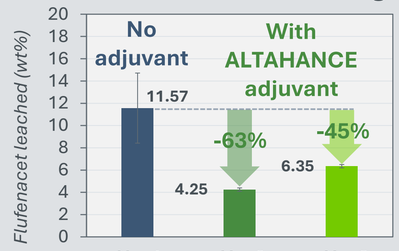
SOIL ANTI-LEACHING PROPERTIES

	Sandy soil column (200 g)		
Ingredient (wt%)	Form. 1	Form. 2	Form. 3
Flufenacet	25.00	25.00	25.00
Water	75.00	50.00	67.00
Castor oil ethoxylate (HLB 12.6)	0	1.25	0.40
ALTAHANCE 3S	**0**	**23.75**	**7.60**

Soil Leaching



Total Flufenacet Leaching



ALTAHANCE 3S, used as a soil adjuvant reduced leaching of the pre-emergence herbicide SC formulation in a sandy soil column experiment.

For additional information on ALTAHACE sticker adjuvants:

CONTACT INFORMATION

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