



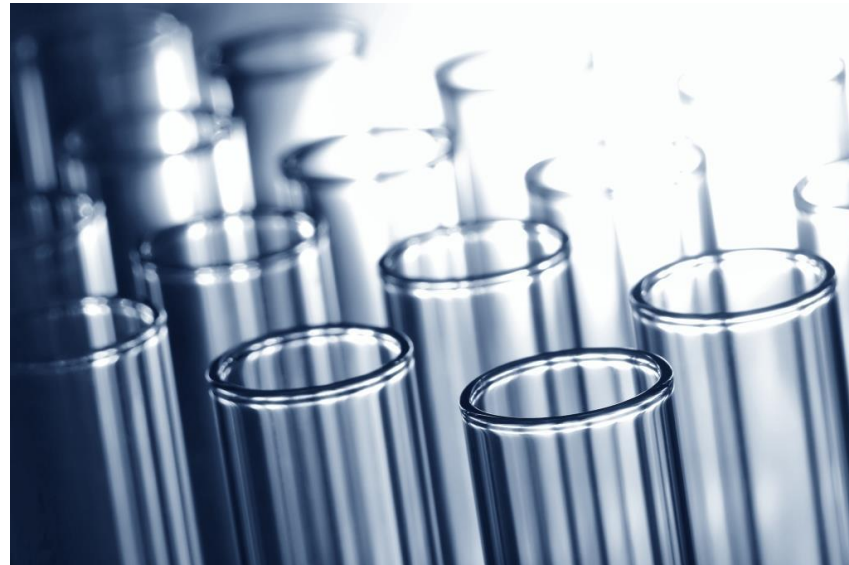
NOVEL ANTIOXIDANT SOLUTIONS FOR POLYPROPYLENE WITH ENHANCED COLOUR PERFORMANCE

Dr. Warren Ebenezer (*Research Manager / Polymer Applications*)



AGENDA

- Introducing ADDIVANT
- Colour in PP processing
- Studies with commercially available PP resins
- Future direction
- Summary



WHO WE ARE

WE INVEST IN OUR PARTNER'S PATH, PREPARING THE FIELD FOR THEIR SUCCESS



WE ARE ADDIVANT™

A new, global company created in 2013 and bringing *fresh thinking* to the polymer and rubber industries.

Headquartered in Danbury, CT, we are combining the *broadest range of Specialty Antioxidants & Stabilizers* with a world leading non-dust blend and liquid mixing capabilities.

Our promise: Create the world's fastest and most reliable innovator and solution provider to the Polyolefin market



THE BROADEST GLOBAL INDUSTRIAL FOOTPRINT IN THE ANTI-OXIDANT AND STABILIZER INDUSTRY



Asia



Europe



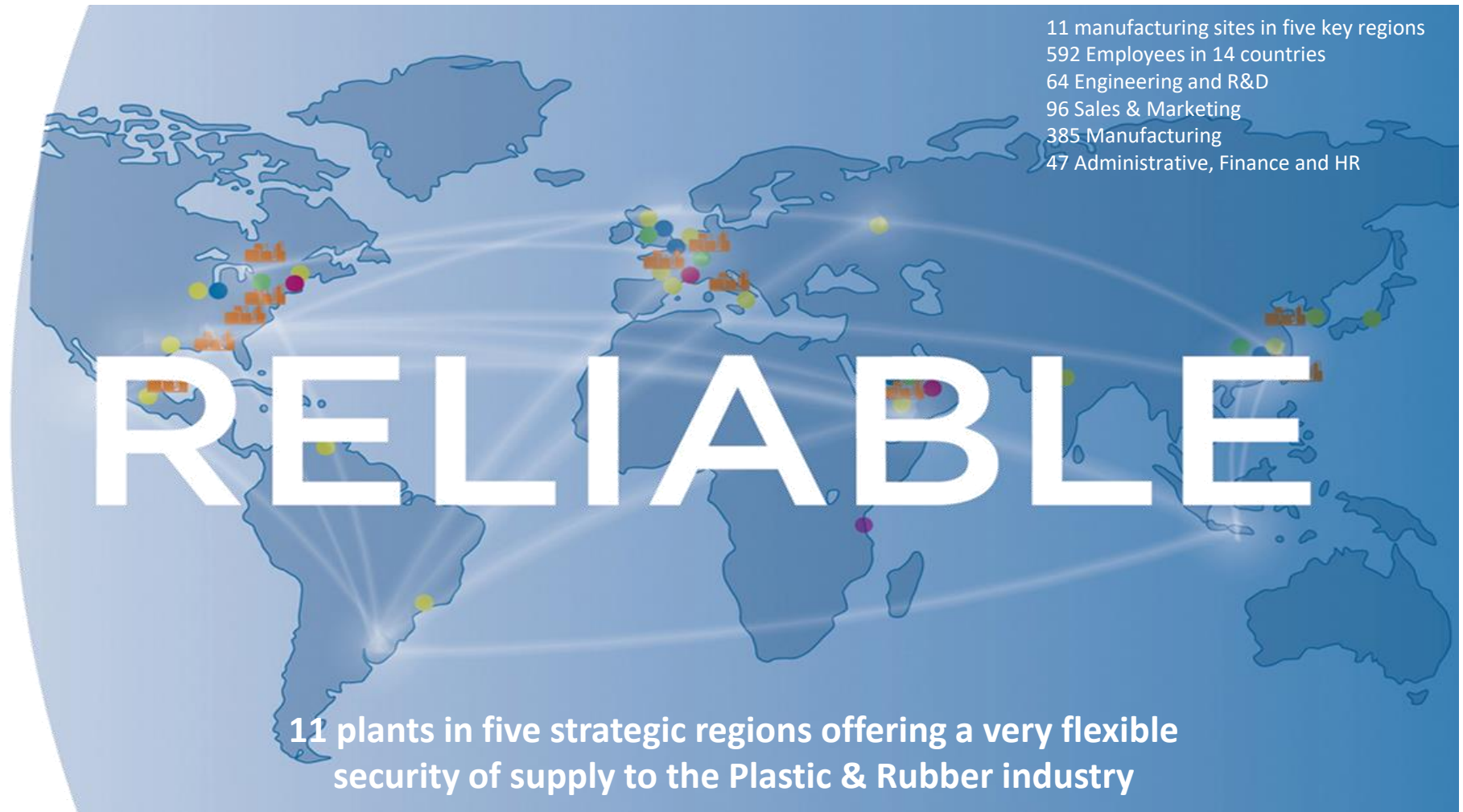
Middle East



North America



South America



OUR GLOBAL TECHNICAL CENTRE

Trafford Park, Manchester, United Kingdom

Expertise

- Addivant's global centre of excellence for formulated solutions (HMA, W&C, PP, PA, PU, Rubber *etc.* downstream applications)
- Delivered over many projects to support customers' innovation needs

Polymer Processing Capabilities

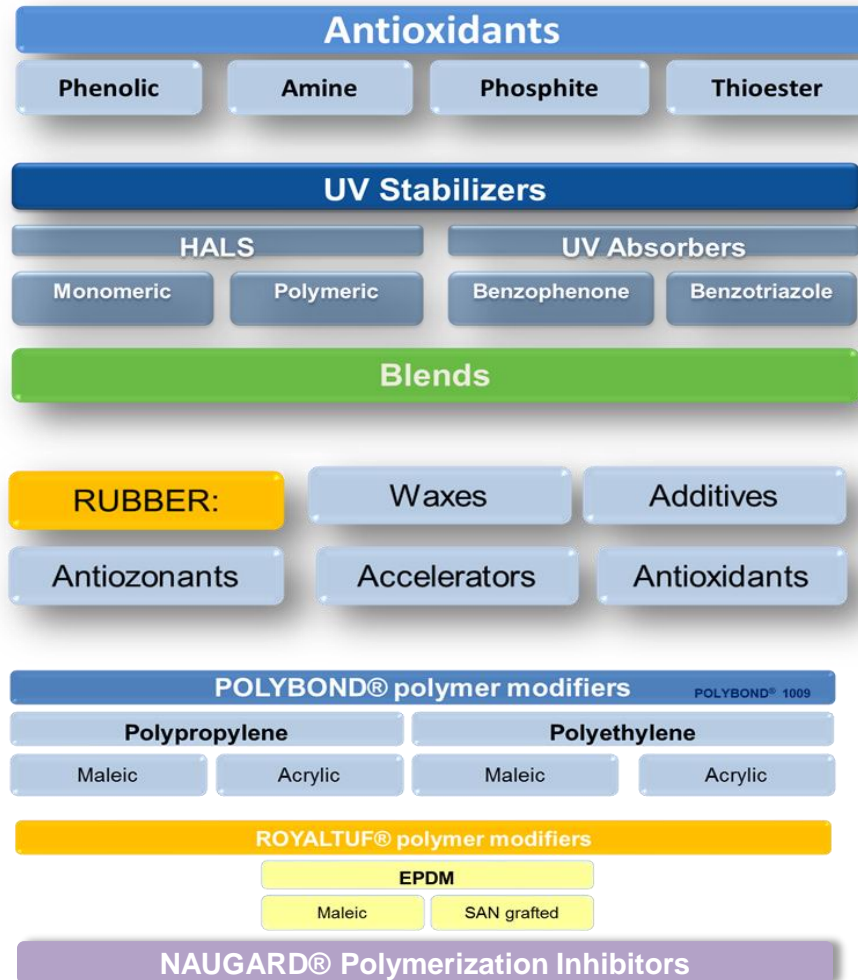
- Range of single screw and twin screw extruders
- Brabender Plastograph system
- Injection moulding
- Compression moulding
- Twin Roll mill



Polymer Characterisation Capabilities

- Materials weathering, QUV, heat, NOx
- Appearance: Xrite I7, surface smoothness,
- Rheology: Torque Rheometer, MFR, Brookfield
- Mechanical: Instron tensile tester
- Addivant Global Analytical Service

THE WORLD BROADEST RANGE IN ANTI-OXIDANTS, POLYMER STABILIZERS & POLYMER MODIFIERS



AMINOX[®]
 WESTON[®]
 LOWINOX[®]
 ANOX[®]
 ALKANOX[®]
 LOWILITE[®]
 POLYBOND[®]
 BLE[®]
 FLEXAMINE[®]
 ANOX[®] NDB[®]
 NAUGARD[®]
 NAUGAWHITE[®]
 NOVANOX[®]
 NOVAZONE[®] AS
 OCTAMINE[®]
 POLYWET[®]
 ROYALAC[®]
 ROYALTUF[®]



A set of brands proven in the world's most demanding applications

POLYPROPYLENE INDUSTRY TRENDS & CHALLENGES





Polypropylene catalysts are undergoing changes to meet the demands of customers' resin properties and regulatory needs. Additive solutions need to keep pace with the landscape change.

The stability of polypropylene is typically measured as the results of colour and melt stability determined after multipass extrusion. Both properties are critical, but colour development is a visual representation or proxy of potential stability issues.

SUPERIOR COLOR CONTROL

Extrusion processing of PP > extreme conditions > polymer damage due to chain scission

Antioxidants sacrificially protect polymer integrity

Phenolics cause discolouration *via* the formation of highly unsaturated quinonoid chemical species

PP processors use colour as an indicator of thermal history of a resin

Thus, processors want to control colour during processing for practical, economic and aesthetic reasons.



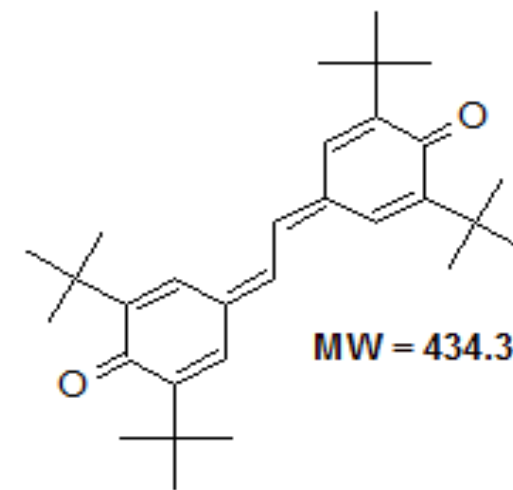
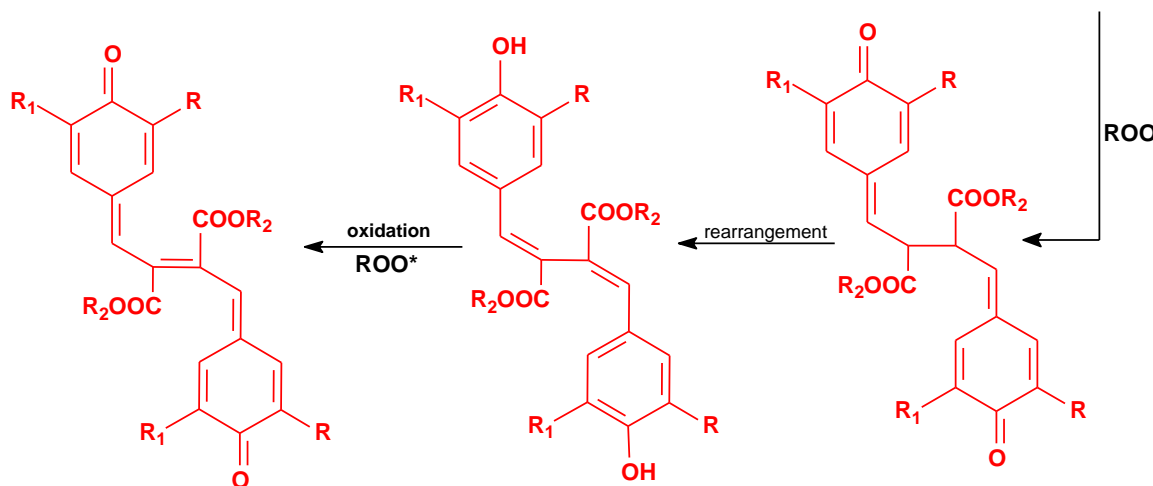
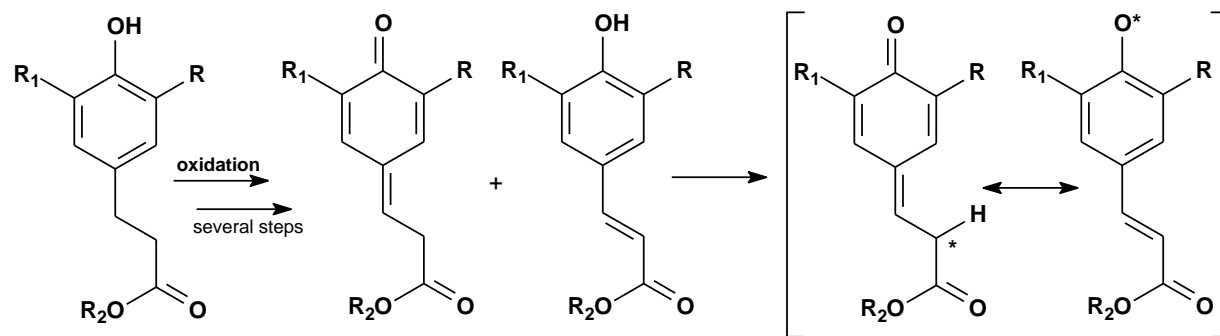
Addivant have produced new tools to allow our customers to better control colour generation during processing.

COLOUR FORMATION IN POLYPROPYLENE RESIN

Colour generation is a complex; Many coloured species > highly conjugated quinonoid structures

The stilbene quinone from BHT $\lambda_{max} = 452\text{nm}$ $\epsilon_{max} = 106000$ (bright orange)

at 4ppm it is clearly visible and stronger than a typical textile dye (poor light fastness)



stilbene quinone

EFFECT OF PH ON COLOUR FORMATION

Acid scavengers are important in PP processing to neutralize acidic catalyst residues ;

- Prevent corrosion of moulds
- Prevent catalytic damage of AOs through low pH.

But addition of acid scavengers can lead to high pH in the PP which promotes phenolic oxidation pathways *via* phenolate formation.

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Can the pH be tuned to minimize colour formation and deal with acidic catalyst residues simultaneously?

YES

Addivant has developed and patented a family of AO blended products with a new mode of pH control technology which out perform the current state of the art solutions.

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We have packages with calcium stearate and without where the bloom of a stearate is undesirable. These new products have full FDA A-H compliance and give our customers unparalleled control over colour and MFR.

SUPERIOR COLOUR CONTROL

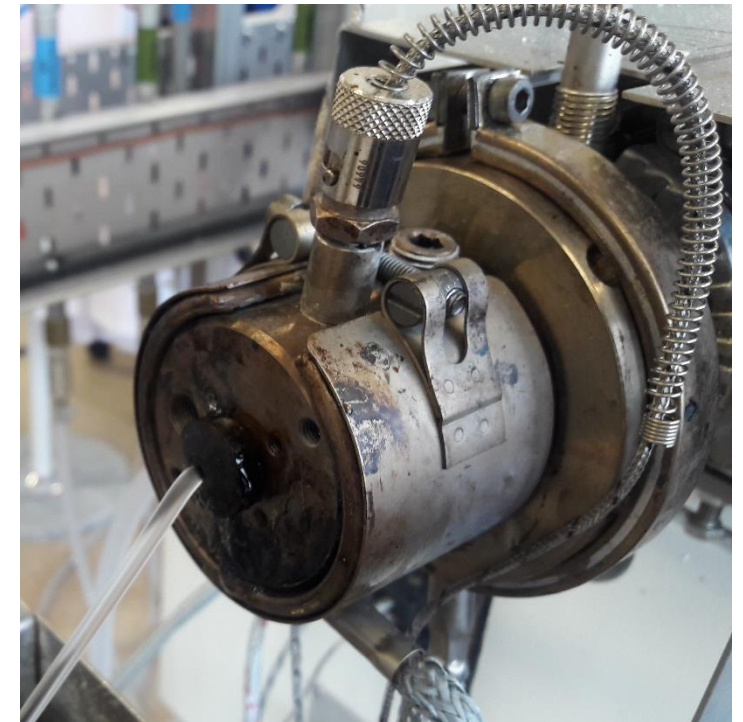
Commercial PP resins have been evaluated to understand the performance and range of the new **pH control technology** developed by Addivant;

PP	Type	MFR
PP1	homo	2
PP2	homo	12
PP3	homo	10
PP4	homo	2

Samples were exposed to compounding under N₂ at 230°C followed by 5 extrusion passes in air at 260°C. The effect on colour and the MFR of the passes was measured.

Multipass extrusion has been performed against 2 control formulations;

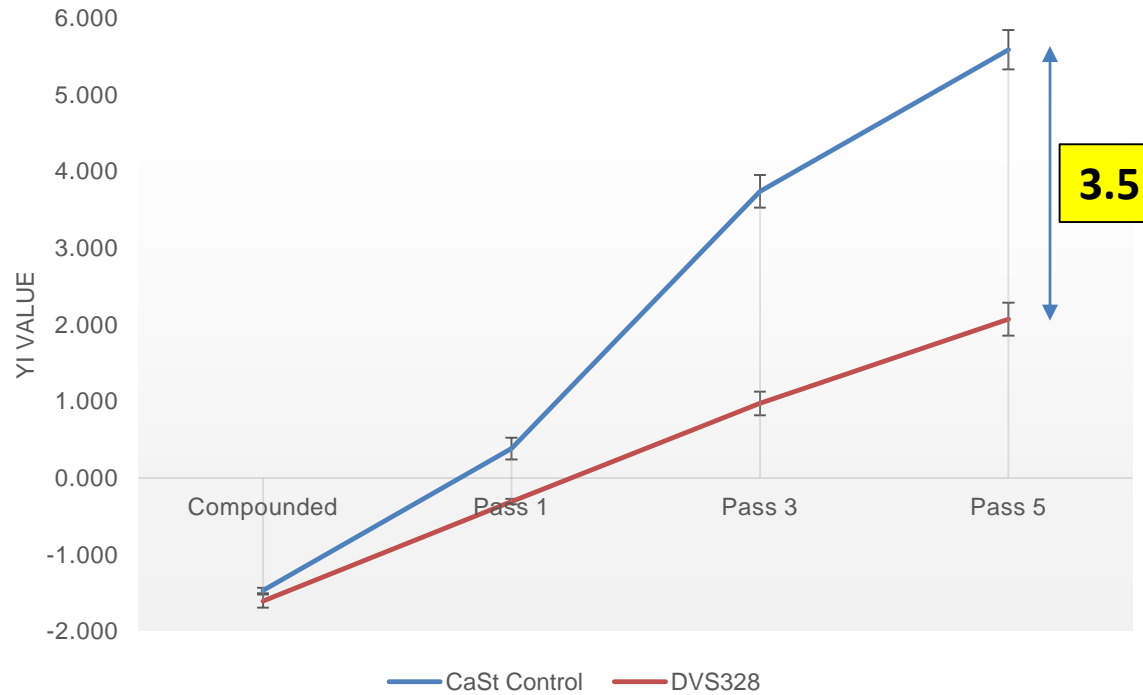
- 1) 0.12% ANOX® BB012* utilizing 0.03% CaSt as the antacid
- 2) 0.12% ANOX® BB012* utilizing 0.018% DHT4V as the antacid



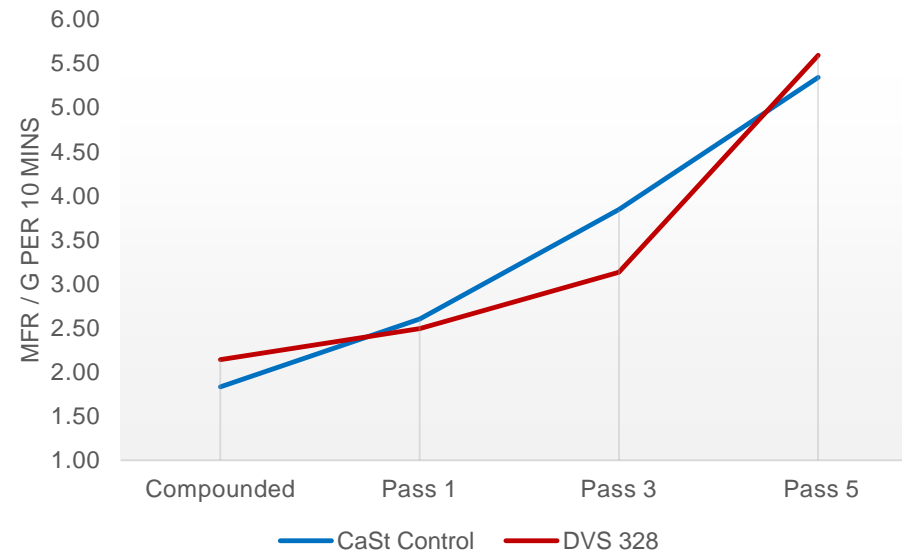
*BB012 is a blend of ANOX®20 and ALKANOX®240

SUPERIOR COLOUR CONTROL – PP1 WITH CAST

Multipass Colour Development



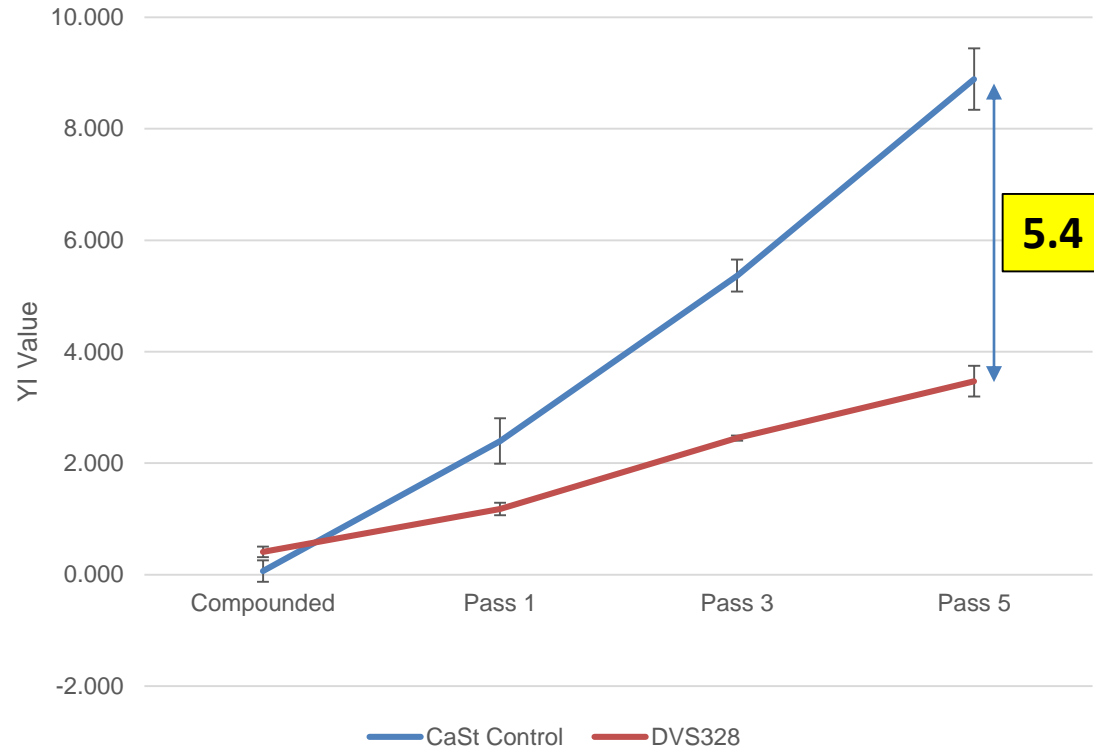
MFRs



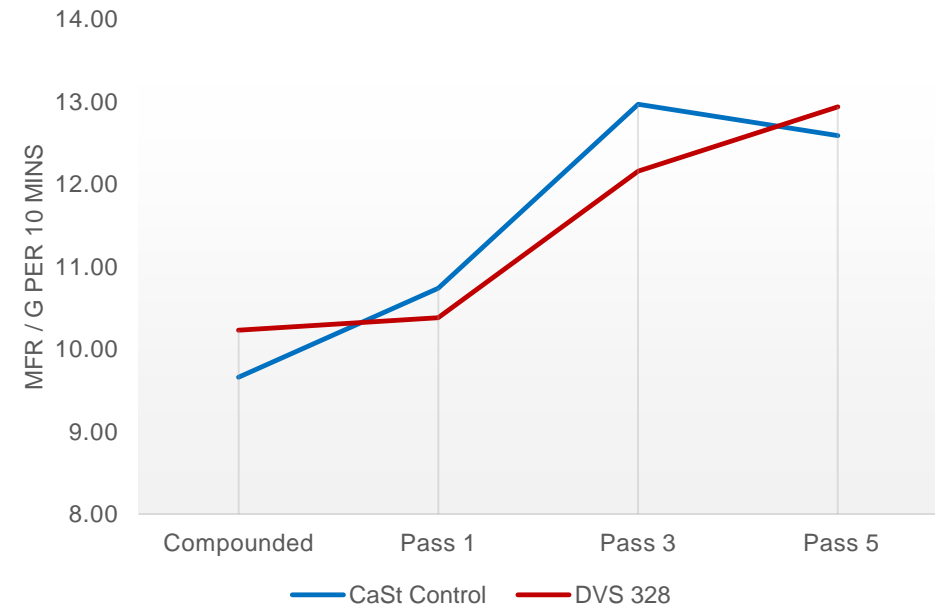
Addivant Solution DVS328 delivers lower color generation with CaSt

SUPERIOR COLOUR CONTROL – PP2 WITH CAST

Multipass Colour Development



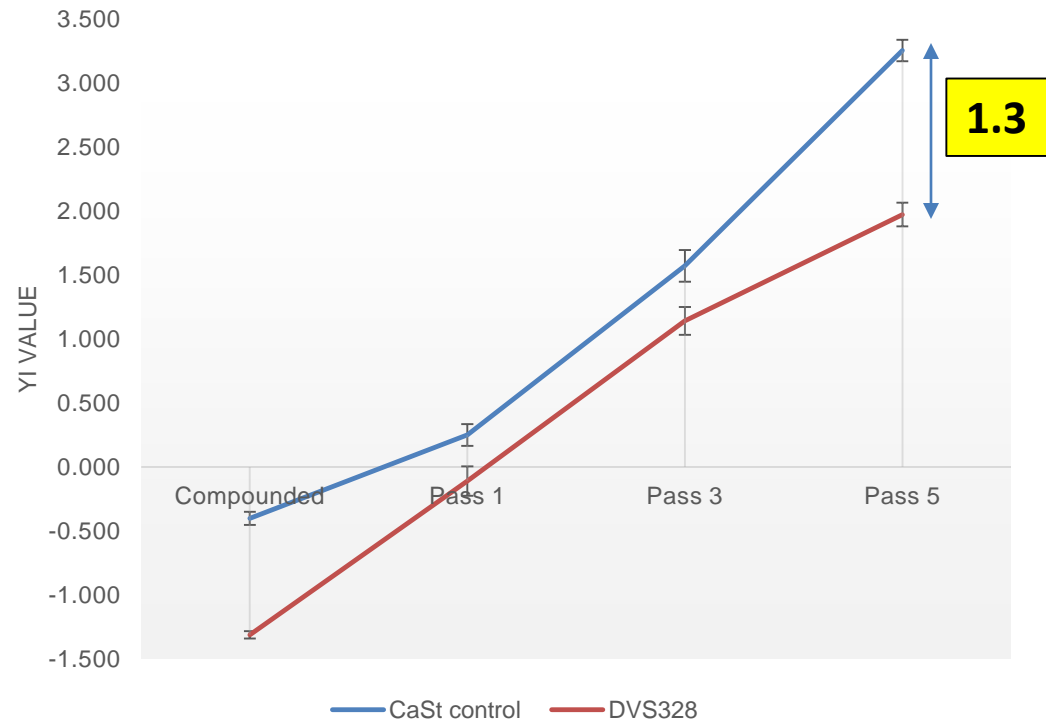
MFRs



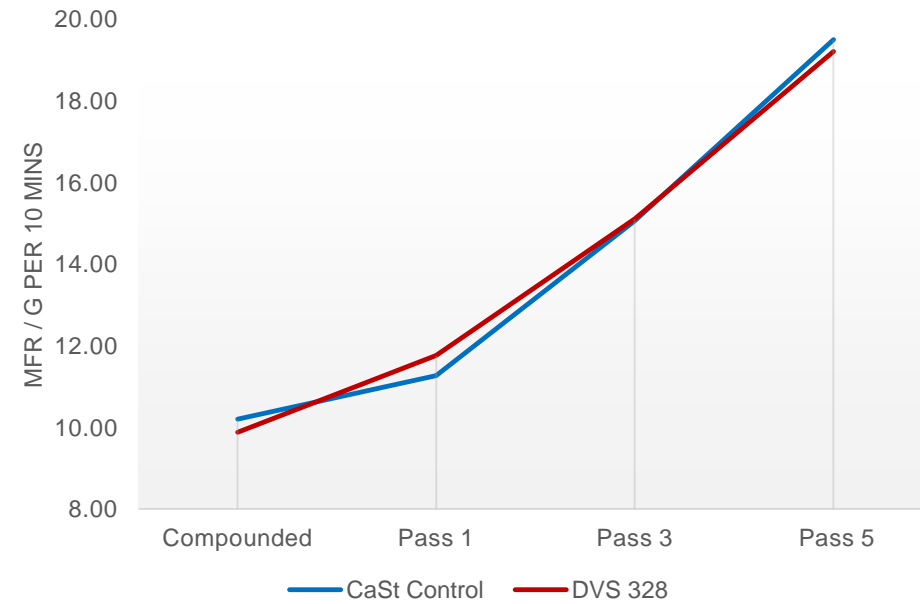
Addivant Solution DVS328 delivers lower color generation with CaSt

SUPERIOR COLOUR CONTROL – PP3 WITH CAST

Multipass Colour Development



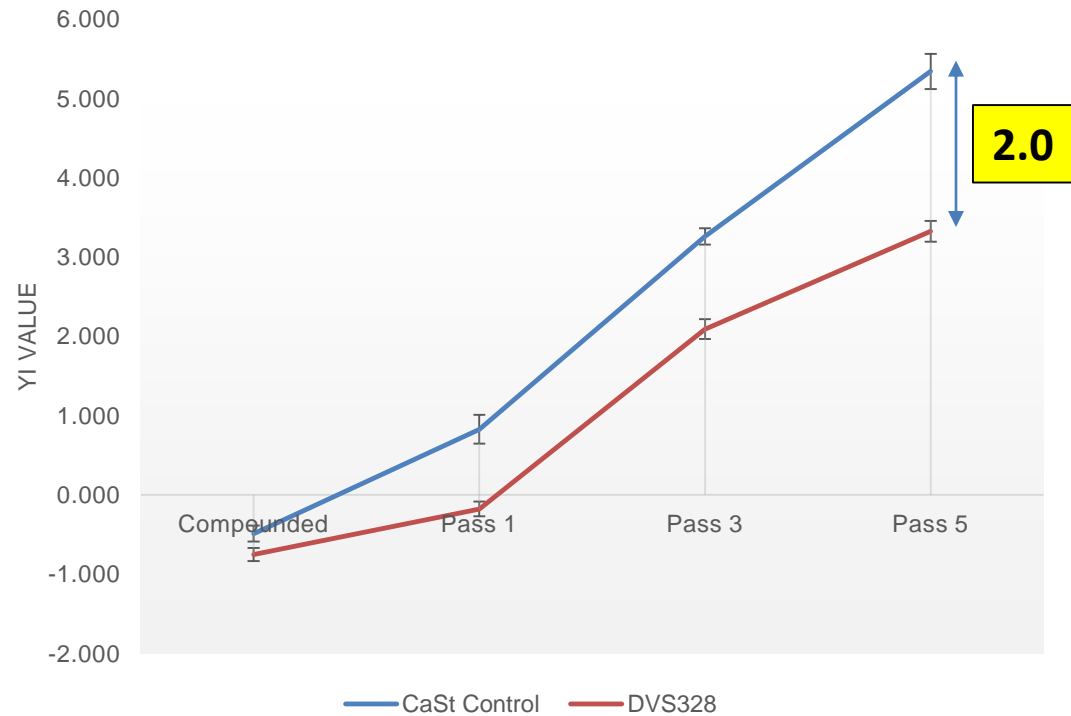
MFRs



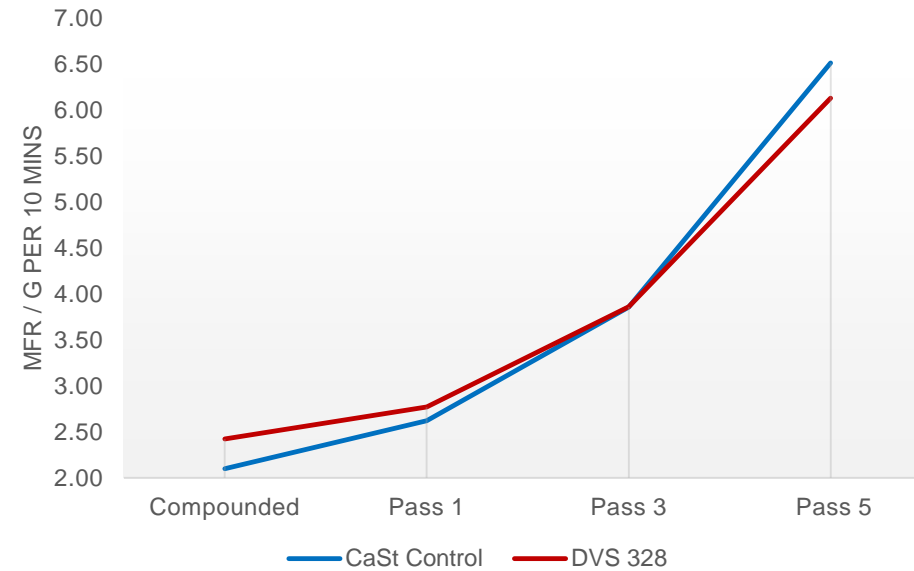
Addivant Solution DVS328 delivers lower color generation with CaSt

SUPERIOR COLOUR CONTROL – PP4 WITH CAST

Multipass Colour Development



MFRs

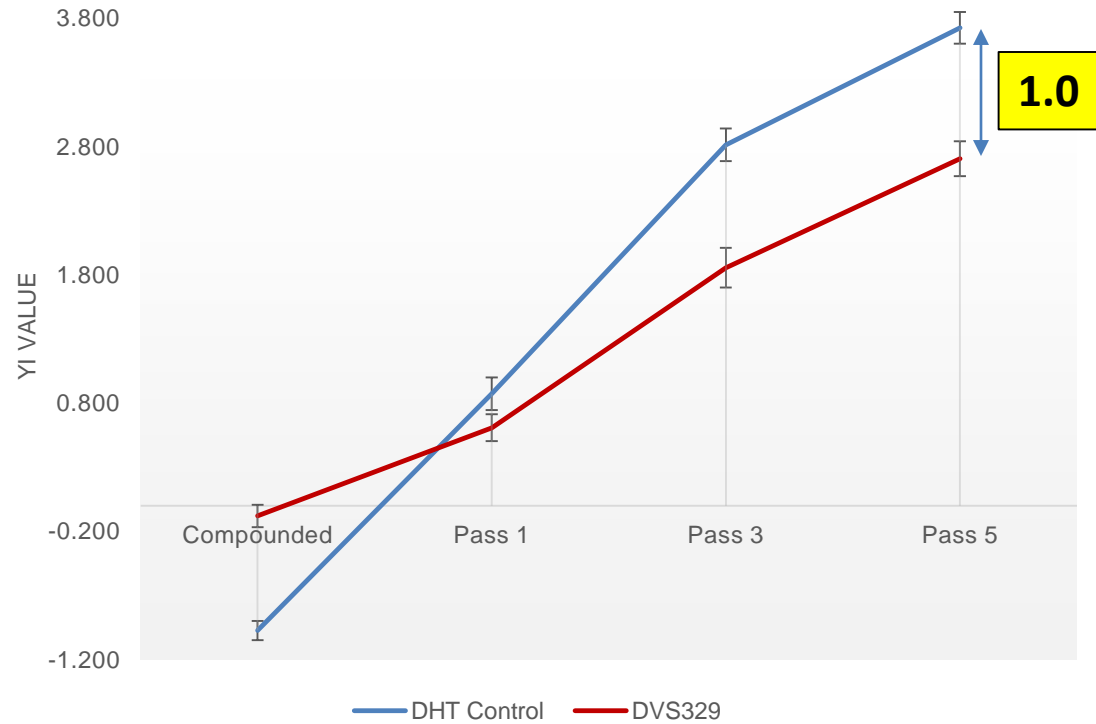


Addivant Solution DVS328 delivers lower color generation with CaSt

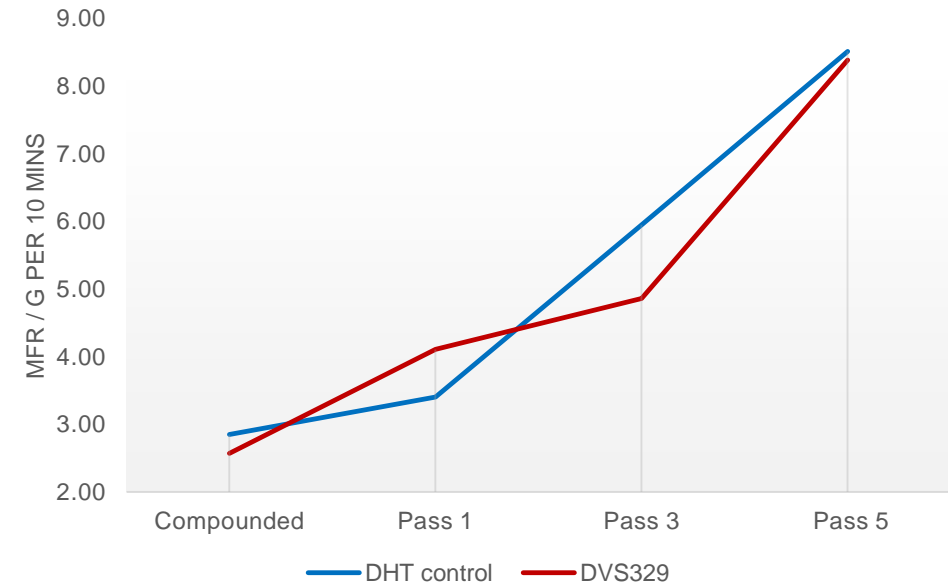
SUPERIOR COLOUR CONTROL – PP1 WITH DHT4V



Multipass Colour Development



MFRs

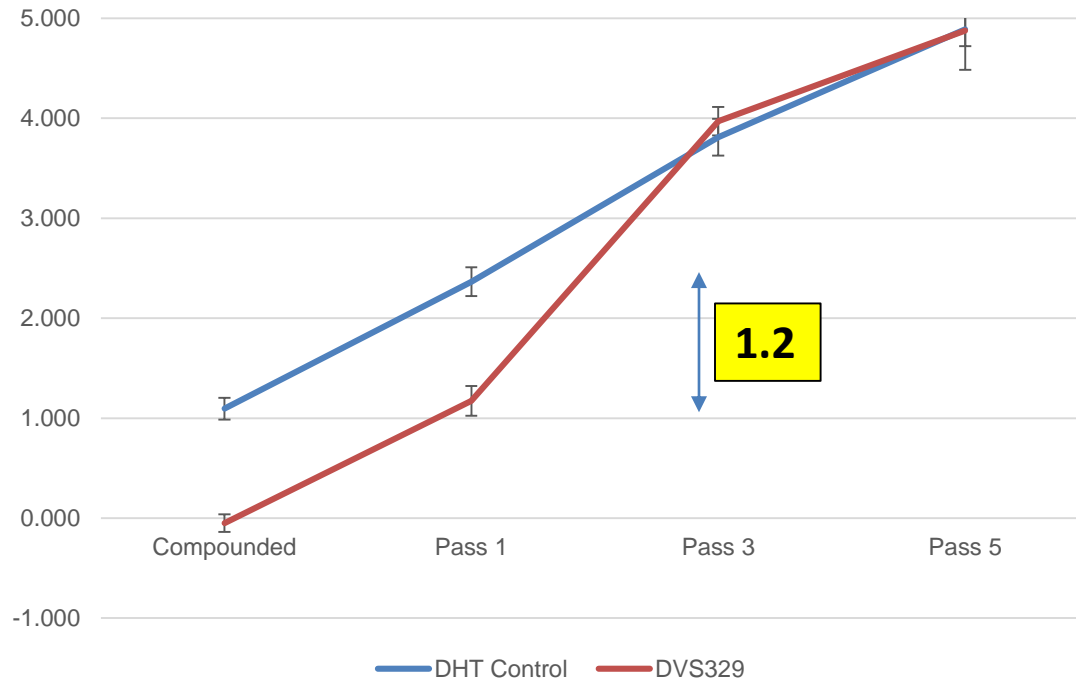


Addivant Solution DVS329 delivers lower color generation vs DHT

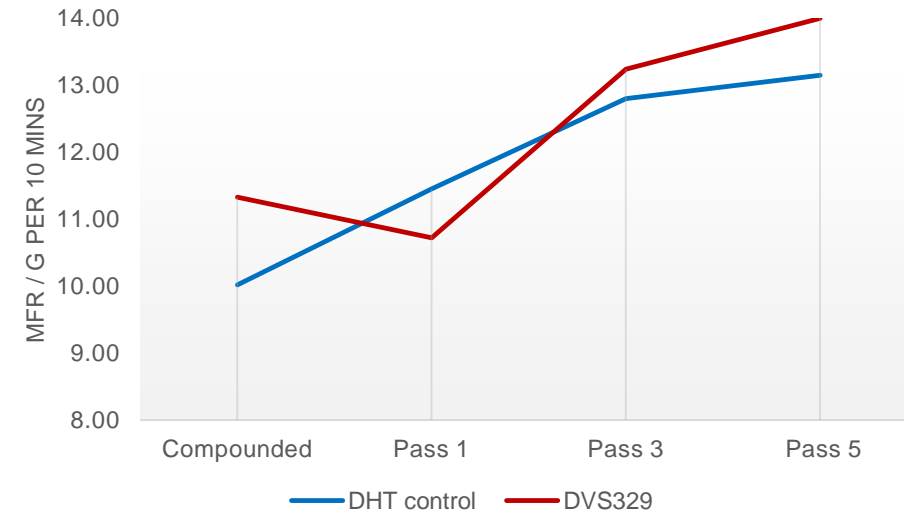
SUPERIOR COLOUR CONTROL – PP2 WITH DHT4V



Multipass Colour Development



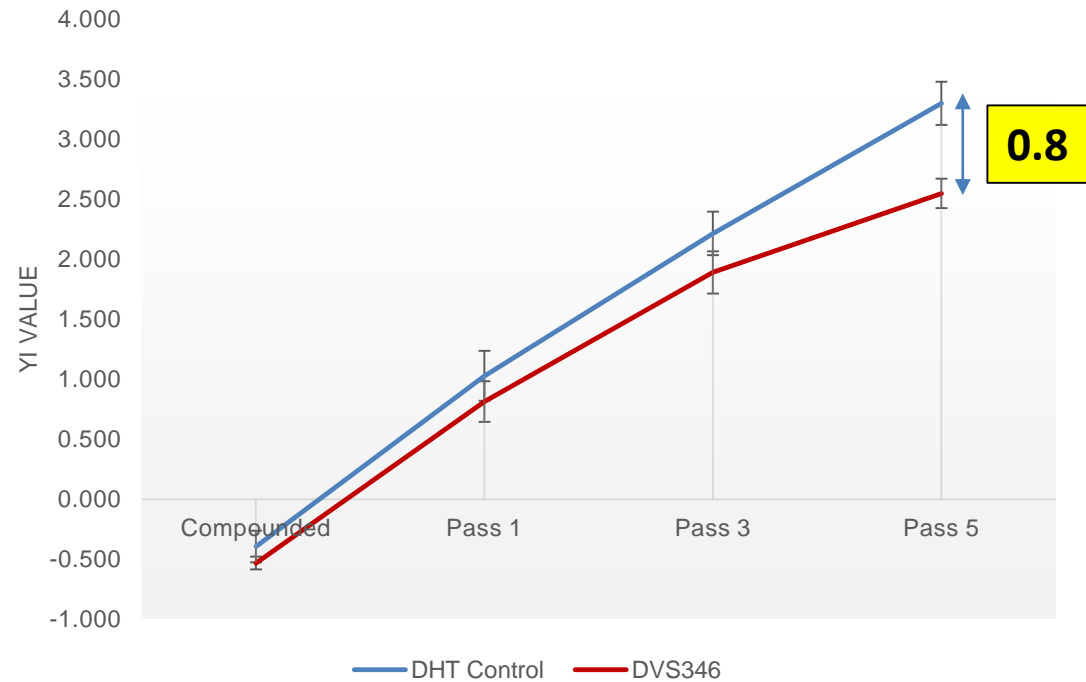
MFRs



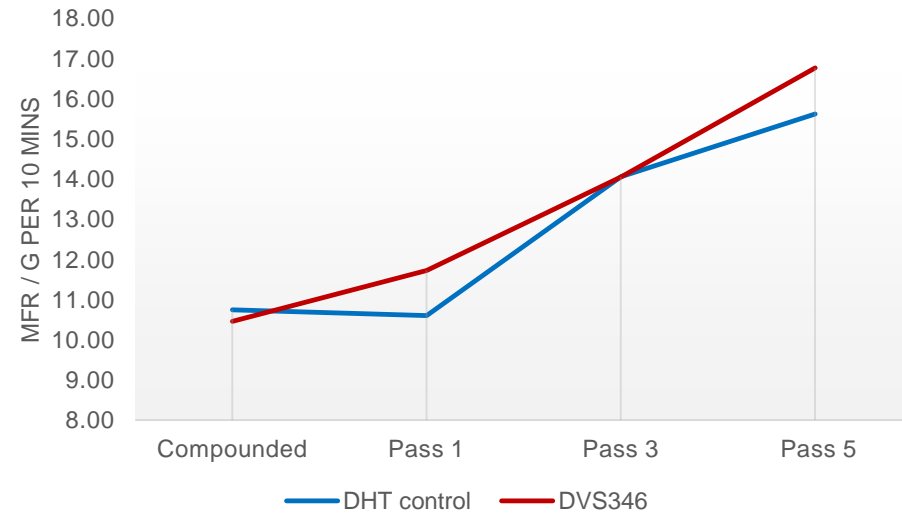
Addivant Solution DVS329 delivers lower color generation vs DHT

SUPERIOR COLOUR CONTROL – PP3 WITH DHT4V

Multipass Colour Development

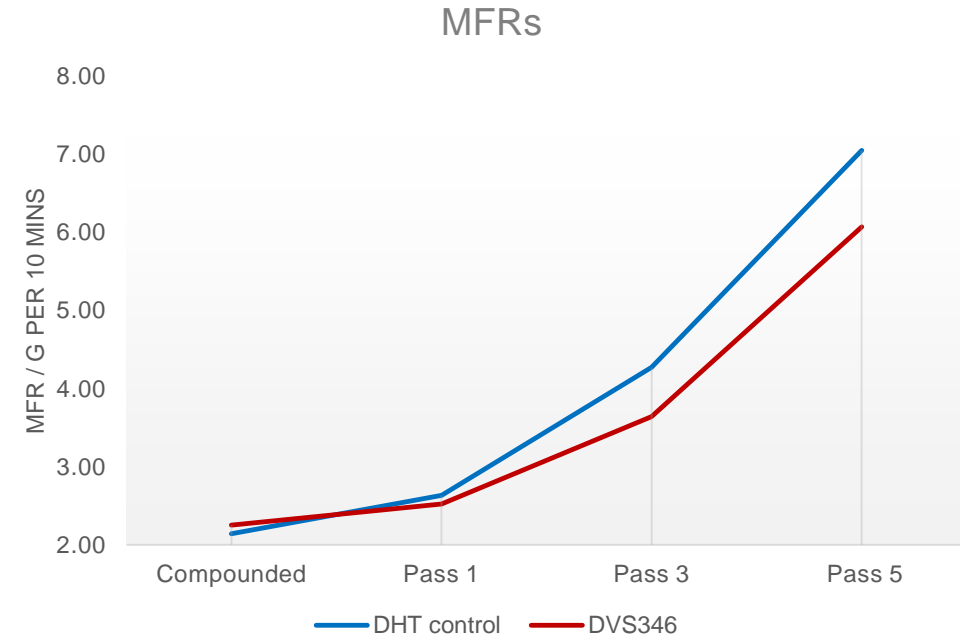
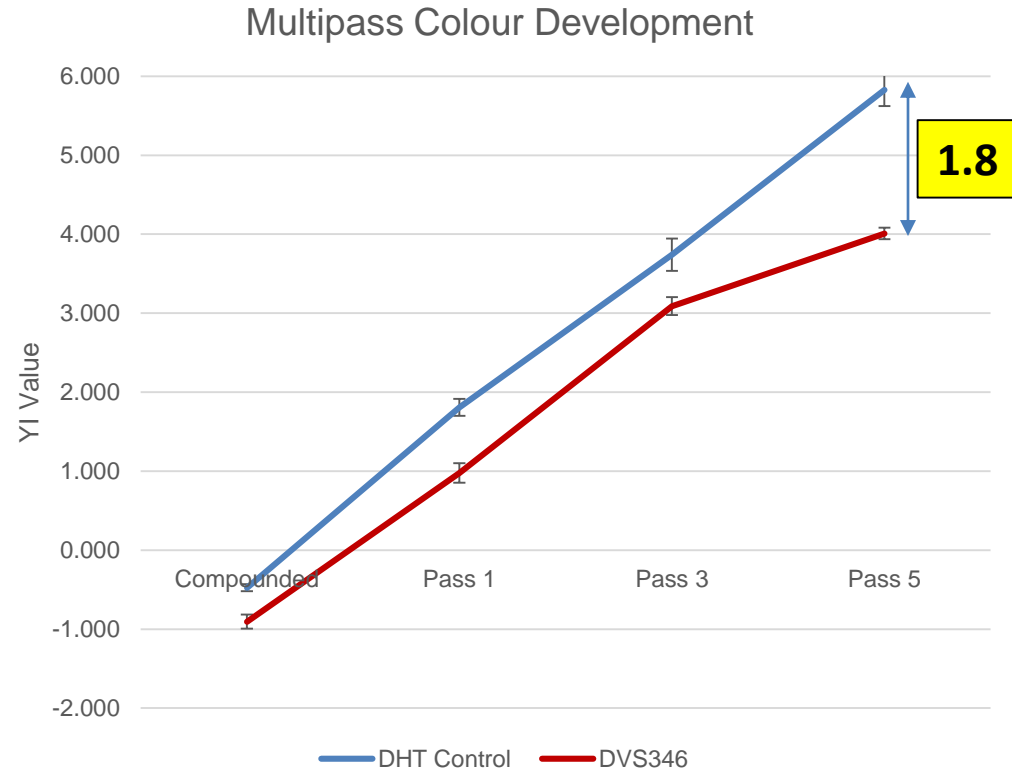


MFRs



Addivant Solution DVS346 delivers lower color generation vs DHT

SUPERIOR COLOUR CONTROL – PP4 WITH DHT4V



Addivant Solution DVS346 delivers lower color generation vs DHT

SUPERIOR COLOUR CONTROL

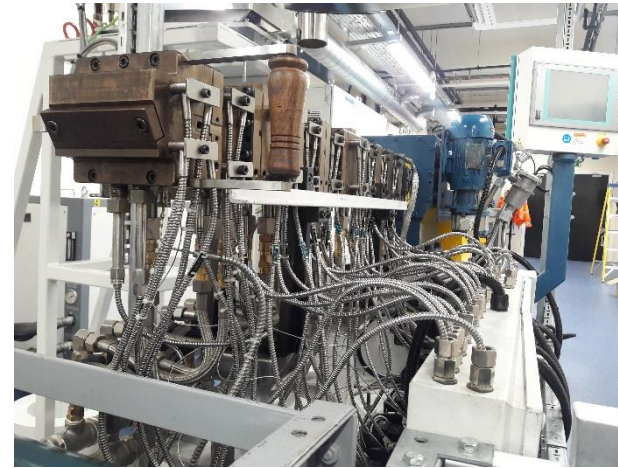
Addivant Solution	MFR	YI	Stearate Free
DVS328	=	++	No
DVS329	=	+	Yes
DVS346	=	+	Yes



NDB FORMULATION

New high efficiency FORMULATED SOLID NDB® SOLUTION designed to:

- Overcome weaknesses of existing stabilisers
- Provide excellent colour stability
- Provide higher productivity
- Improve quality consistency
- Lower costs
- Be a drop-in replacement



State-of-the-art powder-free NDB® form

Advantages of using an NDB® form

Productivity

- Process simplification
- Improved feeding, handling, storage
- Faster changeovers
- Reduced machinery down time
- Reduced working capital

Innovation

- Alloy effect
- Better additive dispersion
- Property extension
- Physical form know-how
- Performance enhancement

Quality

- Fewer human errors
- Accurate formulations
- Fewer off spec/claims
- Lower contamination risk

Cost

- Cost optimization
- Reduced QC costs
- Reduced set points
- Less waste
- Easier logistics

Health & Safety

- Lower explosion risk
- Better plant hygiene
- No worker dust exposure

FUTURE DIRECTION

- Our new **pH control technology** is being investigated throughout the polymer arena and showing promise in many additional areas such as;
 - Polyethylene
 - Engineering polymers
 - Elastomers
- **We believe that this concept will reset the baseline performance demanded by polymer compounders.**

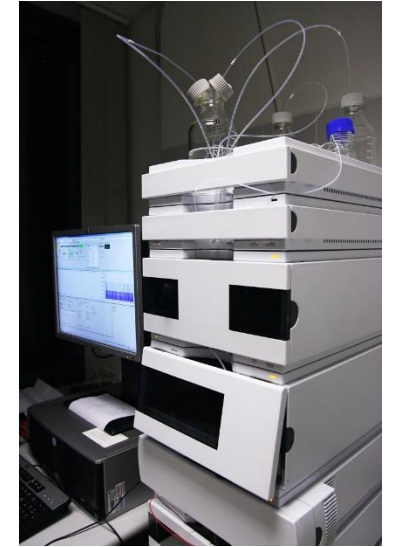


SUMMARY



SUMMARY

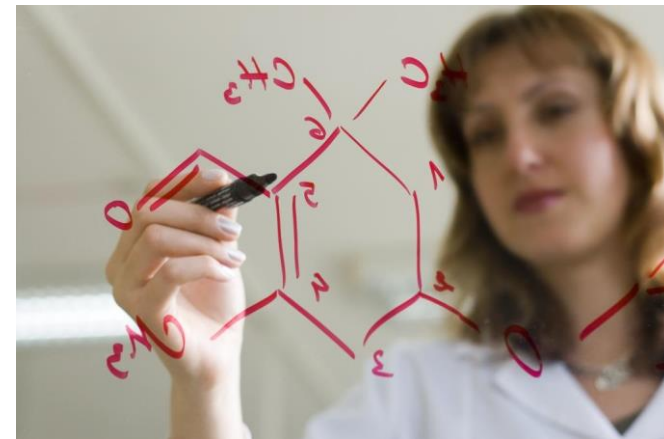
- Addivant has developed a new stabilisation system for colour control
 - Excellent colour and MFR control in a range of PP resins
 - FDA compliant for food contact A-H.
 - Controls colour through superior pH control
 - Can be used with stearate or without
 - Available in dust free NDB[®] forms
 - Commercial Introduction in 2018



ACKNOWLEDGEMENTS

Addivant:

- Mr M. Hensman
- Mr R. Becker
- Dr J. Hill



Thank You



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