



Helping to improve crop revenue and ease of harvest with cooling diffused greenhouse films



Durability



Toughness



Cooling effect



Cost optimization

Challenge:

Heavy rain and wind can limit production of tropical open field crops. While greenhouses protect against weather extremes, conventional films admit too much solar radiation, raising temperatures that limit yields.

Important considerations for greenhouse in tropical climates include:

- **Durability** - films need to be able to withstand heavy rains and typhoon winds over multiple crop cycles
- **Solar radiation levels** - Light transmission needs to be maintained at levels of between PAR 400 to 700 nm which is important for photosynthesis to take place, while limiting infrared radiation within the greenhouse.
- **Light conditions** - sunlight should be filtered and diffused to ensure uniform light distribution inside the greenhouse.

Greenhouse films developed for tropical climates can help to meet these challenges to improve productivity and extend greenhouse life.

Solution:

ExxonMobil, Ampacet, and Vis and Son Company Limited (VSC) worked together to study durable cooling diffused films designed to meet the challenges of tropical greenhouses.

Based in Thailand, VSC is one of the leading companies in the manufacture of polyethylene films and sheets. They produce an extensive range of agricultural films products from greenhouse films to mulch to grow bags.

Ampacet, a global masterbatch producer, specializes in color and additive masterbatches for plastics with a history of agriculture and plasticulture expertise.

The study combined ExxonMobil's Exceed™ XP performance polyethylene with Ampacet's HEATSCREEN 34 cooling additive and VSC's advanced extrusion technology to produce a 150 µm cooling diffused film that delivers improved durability as well as optimal light and heat transmission properties.

This cooling diffused film was put to the test in an organic watermelon greenhouse in the northern Thai city of Chiang Mai. These were the observations:

- **Durability** - The film structures have shown high retention of the tensile properties under sun exposure for more than 2 years and they continue to be in use. They are also proven to last > 5 years in accelerated aging exposure under WOMS Chamber vs market reference which drops below threshold within 2 years.

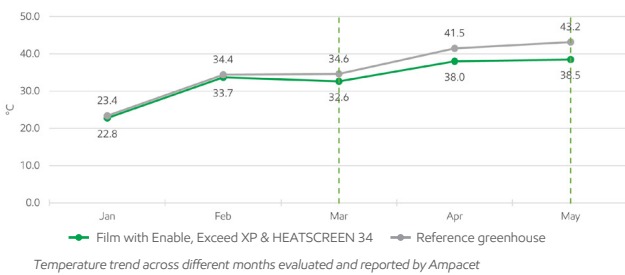
- **Toughness** – Exceed™ XP performance polyethylene enables converters to easily fabricate exceptionally tough films with very high dart impact and puncture resistance, and tensile strength at break for high-integrity greenhouse and walk-in tunnel covers.
- **Temperature** – with the cooling additive, temperatures inside the greenhouse especially during hot season is seen to be lowered by 2 to 5° C.

In addition, using Exceed XP and Enable™ performance polyethylene to replace LLDPE/LDPE blends helps converters to reduce the number of resins that need to be sourced hence reducing inventory costs. Additionally, better bubble stability and ease of extrusion further optimizes the solutions and delivers opportunities for potential high output.

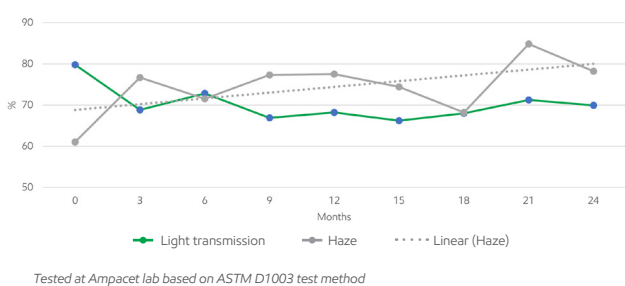
Results:

Reduced temperatures – the cooling diffused film helps to reflect infrared radiation (IR) which effectively reduces temperatures inside greenhouse when compared to conventional film by an average of 2-5° C in tropical climates. The new film also helps to provide consistent light transmission which allows better light diffusion (comfortably above 50% levels throughout the 24-month testing period) inside the greenhouse, giving excellent uniformity to crops in terms of shape, size, color, taste, as well as reducing leaf scorching.

A) Temperature is 2-5°C lower during summer months

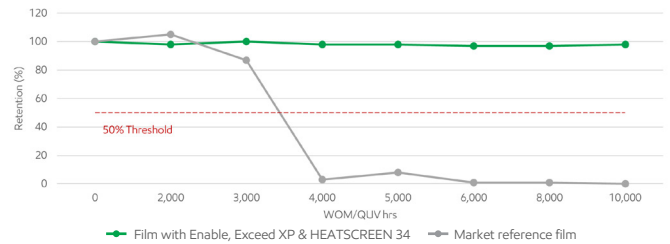


B) As film ages and haze goes up, light transmission remains constant



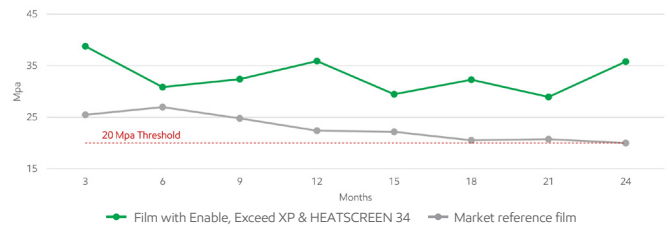
Excellent aging performance – the new film helps reduce the risk of premature breakage, extending the growing season. It is compatible with functional additives and antioxidants to retain mechanical properties and high diffusivity (through haze), which are even more critical as the film ages. It also exhibits excellent aging performance for long lasting, durable solutions, proving it can withstand the rigors of installation and extreme weather.

C) Market reference film loses tensile properties within 4000 hrs of exposure, i.e. equivalent to 2 years of sunlight aging



WOM: Weather-Ometer®
 UV Aging completed within WOM according to ISO 4892-2 using G155-05 Light Xeonor Arc in Ampacet lab.
 WET aging: Rain cycle: 102 min dry followed by 18 min water spray & repeated the cycle for the whole aging.
 Irradiance: 0.35 W/m² nm @ 340 nm; Exposed films were tested at ExxonMobil lab based on ASTM D-882-18 test method.

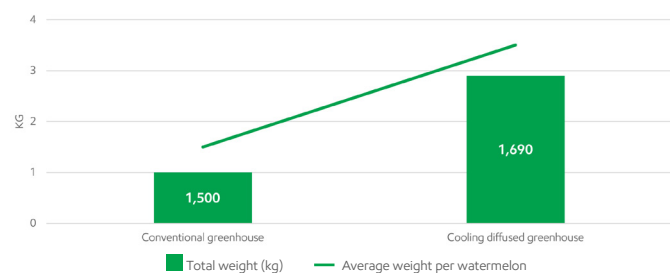
D) Market reference film MD tensile at break drops to 20 MPa threshold mechanical properties within 2 years of sun aging



Tested at ExxonMobil lab based on ASTM D-882-18 test method

Mr. Montchai and Mrs. Pimwalan, owners of the organic watermelon farm, are very satisfied with the results after replacing the conventional film with the new cooling diffused film for two crop cycles. They said, "Our crop yield has increased after using this film. The average weight of our watermelons increased from 1-2 kg to 3-4 kg with one melon going up to 6 kg. The average harvest time has been reduced and we can now harvest watermelons in 45-50 days compared to 60-70 days previously. With all this, we are especially pleased that our average income per 13m x 30m greenhouse has increased by 35%."

E) Harvest per greenhouse



Estimates provided by VSC

"Ampacet and VSC have been valuable partners in this project," said Tan Wee Long, Head of Market Development, ExxonMobil Asia Pacific Pte Ltd. "VSC's insights of the Thai agricultural industry and their state-of-the-art processes and Ampacet's advanced portfolio of additives and extensive community outreach were critical to the success of the trial of this film formulation. Through each party's insight, we hope to improve farmers' livelihoods."

Benefits for other crops – The new cooling diffused greenhouse film provides the same benefits for capsicum, cannabis*, sweet pepper, tomato, chrysanthemum flower, and hemp.

*Only where permitted by law

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