BRINGING LIFE TO PLASTICS

Additives for Greenhouse Films

Products for Mono- and COEX Films

GABRIEL-CHEMIE GROUP

Greenhouse Films

FOREWORD

Gabriel-Chemie continuously invests in the research and development of new additives to improve the performance of agricultural films. Our expertise and technical resources are dedicated for designing new functional additives that fulfil the needs without neglecting the film's influence on the crops.

Gabriel-Chemie own a long term experience in the field of agricultural film applications.

Greenhouse crops are one of the most innovative examples of modern agriculture and it is predictable for them to expand more and more in future, especially in areas with unfavourable climatic conditions. They are one of the highest man-made forms of agricultural activity, because of the intense technological and bio-agronomic inputs in confined portions of the agricultural environment.

Greenhouses are a means to grow crops by overcoming adverse weather conditions; they exploit solar radiation to condition indoor micro-climatic parameters, also with the use of additives in plastic films, aimed at optimising crop production in areas or in periods of the year, not suitable for open field cultivation.

In the last decade, greenhouses covered over 220,000 ha world wide, of which 80,000 ha in the EU, whereas small tunnels and mulched areas in the world amount to 250,000 ha and 4,000,000 ha respectively, and future increases are expected both in developed and in developing countries. In the Mediterranean Countries the greenhouse covered area amounts to more than 70,000 ha, where the so-called mediterranean greenhouses or "cold greenhouses" have got established.

In all countries horticulture under cover is a profitable branch of agriculture involving considerable industrial activities with high technological level.

With this information, Gabriel-Chemie want to lead your attention to many innovations and applications, which can be applied for the present day greenhouses.

We offer a variety of products for mono- or coextruded greenhouse films, offering a number of functional additives. With this brochure we want to give both, a product survey as well as specific instructions for use.

The practice showed that leading manufacturer of greenhouse films - in Middle East, North Africa, and Central Europe - working in a close co-operation with Gabriel-Chemie, following our product and recipe recommendations, were able to increase considerably their home market shares and to step on the export markets in Europe and USA with superior quality and novelties in this specific area of application.

Greenhouse Films

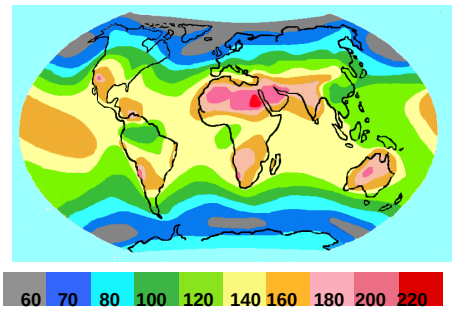
LIFESPAN EXPECTATION OF A GREENHOUSE FILM

A good UV-stabilisation of a greenhouse film should enable that after desired lifetime at least 50% of initial tensile strength is present at the film. It has to be taken into account that each UV-stabilisation must be designed regarding to maximum possible annual sun radiation energy which is typical to geographic area of application.

The annual sun radiation energy depends on meteorological conditions and can show absolutely different values according to place of the exposure.
The sun radiation energy is usually expressed in kLy (Kilolangley) units. A conversion to other energy units is possible, the conversions in other units can be done as follows:

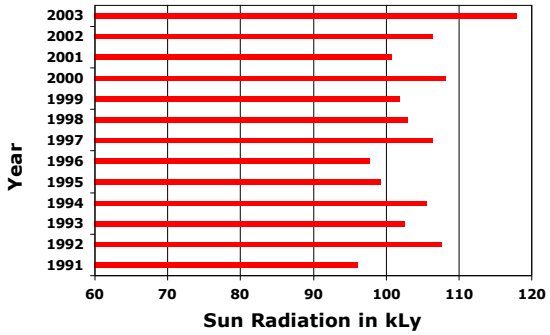
- 1 kLy = 1000 Ly Langley
- 1 kLy = 4187,5 J/cm2 = 4,19 kJ/cm2
- 1 kLy = 1,11632 Wh/cm2 = 11,63 kWh/m2
- 1 hour of sunshine (average value) = 45 Ly (from 33 Ly to 77 Ly !)

GLOBAL RADIATION IN KLY/YEAR



In the past, the yearly sun radiation energy in Central Europe was assumed with an average of 80 kLy per year. Latest measurements of the Austrian Central Meteorological Institute show that the annual sun radiation energy has risen due to climatic alterations to an average of approximately 110 kLy in Austria, even in some areas about 120 kLy. Diagram shows as an example the alteration of the sun radiation energy in Vienna/Austria relating to the year of measurement:

ANNUAL SUN RADIATION IN VIENNA/AUSTRIA



A suitable UV-stabilisation of a greenhouse film must refer to geographical area(s) of exposure and their average sun radiation energy. We want to inform, that the actual life span highly depends on use of chosen polymer type, use of further additives and processing-conditions during manufacture and is influenced by environmental and exposure conditions at end use.

Greenhouse Films

LIGHT STABILISATOR EVOLUTION

Until the end of the 1970's, the usual UV-stabilisation for greenhouse films was a combination of organic nickel compound (Ni-Quencher) with an UV-Absorber **(1st Generation)**. Nowadays in some areas these formulations are still in use, but Ni-Quencher systems have experienced a considerable recession due to the fact that elementary nickel was found to be dangerous to the environment especially in case of inadequate disposal.

At the beginning of the 1980's HALS-Stabiliser (Hindered Amine Light Stabiliser) came on the market **(2nd Generation)**. These stabiliser are often proven to be more effective in preventing polymer degradation, due to heat and UV radiation.

Later on there was developed a blend of HALS grades providing improved chemical resistance **(2nd Generation Plus)**. This system is clear transparent, without colouring characteristic to the film

Stabilising Greenhouse Films, we have to consider another important parameter: the influence of acid separating substances and sulphur containing or halogenated agricultural chemicals (as pesticides and insecticides or other agrochemicals). Therefore it was decided to study and develop a new generation of HALS-Stabiliser **(3rd Generation)**, which has less sensitivity to these chemicals and is performing better under difficult conditions. This stabiliser is often combined with inhibitors which should neutralise the negative influences of chemicals as far as possible. This system is still sensitive against elemental Sulphur as used for incineration sticks or as powder, used for disinfections inside Greenhouses.

In 2000, the non interacting light stabilisator system **(4th Generation)** with excellent light and thermal stabilisation was introduced. It has a high chemical resistance in general, is not reactive with most pesticide chemicals, also not with elemental sulphur applications. As all new developments, it is of higher costs and is used at valuable cultivations, where severe use of pesticide chemicals lead to early damage of greenhouse films. Main application of this light stabilisator system is mainly for cultivation of ornamental plants and roses. Despite of higher costs for this light stabilisation, producer might save costs, because this system provides long term service life of greenhouse films under severe pesticide use. This system offers best possible resistance of higher levels of agrochemicals and also enables superior life time exposures (> 3 years) depending on area of application.

For the time being latest development is an economisation alternative to 4th Generation NOR HALS Masterbatch providing excellent resistance to agricultural chemicals and also enables long life time exposures (> 2 years) depending on area of application. This system provide economical cost calculations at greenhouse film, this system is called **3rd Generation Plus**. It is clear transparent, without colouring characteristic to the film.

Greenhouse Films

LIGHT STABILISATOR SYSTEMS 1ST TO 4TH GENERATION

1ST GENERATION: **MAXITHEN® HP79141/168UVAO** - Conventional Ni-Quencher stabiliser in combination with UV-Absorber. It has yellow-green colouring characteristic of films.

2ND GENERATION: **MAXITHEN® HP72630UVAO -** high molecular HALS-stabiliser in combination with UV-Absorber-clear transparent. It is clear transparent, without colouring characteristic to the film.

2ND GENERATION PLUS: **MAXITHEN® HP792850UV -** Blend of HALS with improved chemical resistance. It is clear transparent, without colouring characteristic to the film.

3RD GENERATION: **MAXITHEN® HP72910UVAO** - New HALS-system in combination with inhibitors – less sensitive to pesticides. It has whitish colouring characteristic of films - diffused light radiation in Greenhouses.

3RD GENERATION PLUS: **MAXITHEN® HP7AA2600UV -** light stabiliser masterbatch for the UV stabilisation of agricultural films. This product is an economical alternative to our NOR HALS Masterbatch (4th Generation) providing excellent resistance to agricultural chemicals and also enables long life time exposures (> 2 years) depending on area of application. It is clear transparent, without colouring characteristic to the film.

4TH GENERATION: **MAXITHEN® HP7AA1220UV -** Non interacting NOR HALS light stabilisator system, not reactive with pesticide chemicals, in combination with UV Absorber, for greenhouse cultivation of ornamental plants, where severe pesticide use is applied even under intense sunlight. MAXITHEN® HP7AA120UV offers best possible resistance of higher levels of agrochemicals and also enables superior life time exposures (≥ 3 years) depending on area of application. It is clear transparent, without colouring characteristic to the film.

COMBINATION PRODUCTS LIGHT STABILISER / ANTIOXIDANT / IR BARRIER

1ST GENERATION: **MAXITHEN® HP7AA3650UVAOIR** - Ni-Quencher stabiliser in combination with UV-Absorber and Infrared Additive for thermic greenhouse films, it has yellow-green colouring characteristic of films.

2ND GENERATION: **MAXITHEN® 7AA3640UVAOIR** - high molecular HALS-stabiliser in combination with UV Absorber and IR Additive for thermic greenhouse films - clear transparent.

3RD GENERATION: **MAXITHEN® HP7AA3630UVAOIR** - New HALS-system in combination with inhibitors for thermic greenhouse films, less sensitive to pesticides. It has whitish colouring characteristic of films - diffused light radiation in Greenhouses, enhancing advanced crop growth for earlier harvest.

Greenhouse Films

GREENHOUSE FILM CATEGORIES

At a greenhouse film, there is seldom used a light stabilisator system only. In most cases there are used functional additives in addition for optimised crop production.

Frequently used features at greenhouse films are:

UV-STABILISED 1ST TO 4TH GENERATION

These films are applied where there is little saving on heat inputs and where condensation is not a problem.

UV-STABILISED 1ST TO 3RD GENERATION / THERMIC FILMS

Formulated to improve heat retention by use of additional IR-Barrier additives. When using IR-Barrier additives, the capability of the greenhouse film to reflect during night infrared radiation back into the greenhouse directly saves energy losses, keeping the thermal energy inside.

UV-STABILISED 1ST TO 3RD GENERATION / ANTIFOG / THERMIC FILMS

Have thermic properties by use of IR-Barrier additives and Antifog additives to control the condensation of water on the film. If properly installed, water will condense uniformly on the film transforming to a water film. This improves light transmission and reduces the risk of water falling on plants. Best for crops which respond well to high direct light levels and warm temperatures.

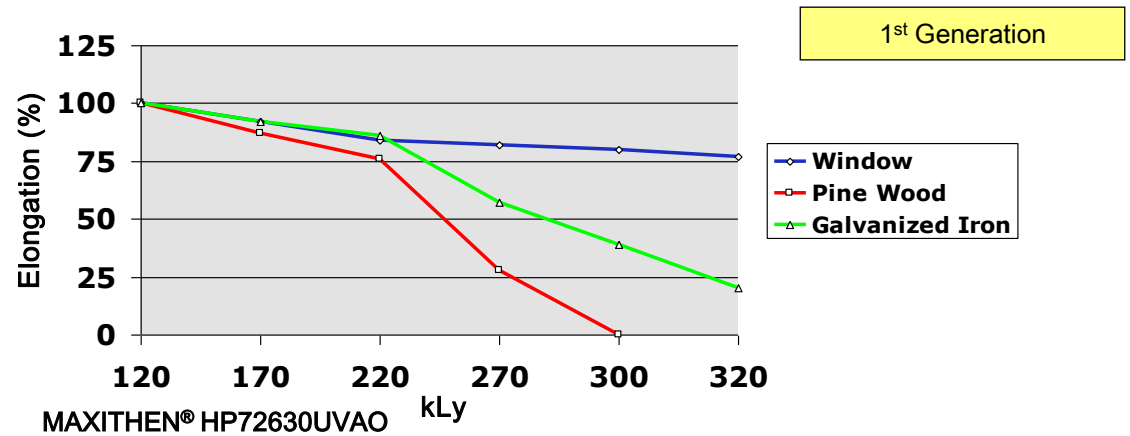
Please contact us to get dosage recommendations to your particular application.

Greenhouse Films

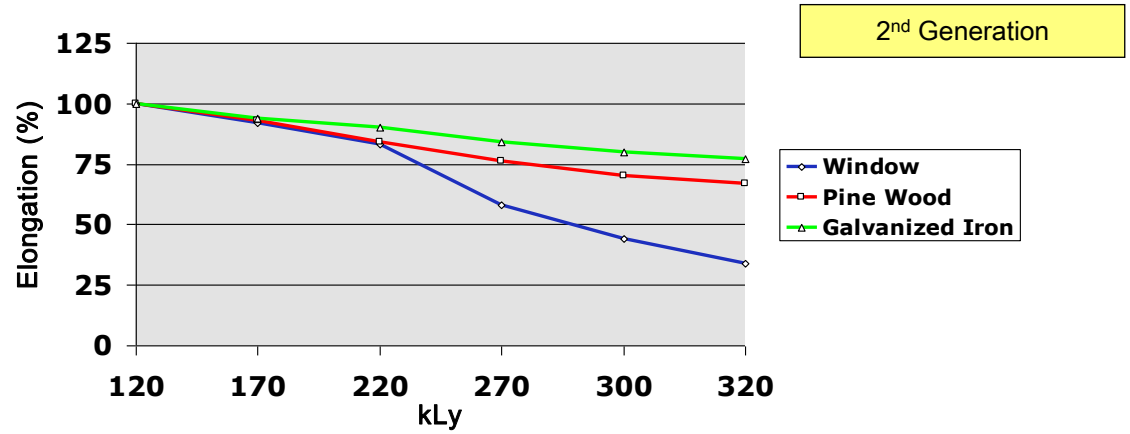
INFLUENCE OF PESTICIDES ON UV-STABILISATION AT GENERATIONS 1-3

Greenhouse Film LDPE (200µ)

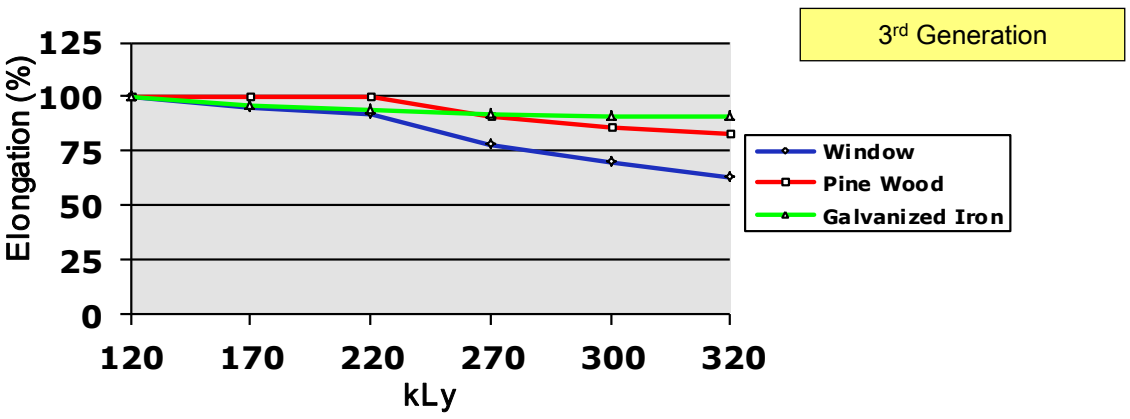
MAXITHEN® HP79141/168UVAO



MAXITHEN® HP72630UVAO



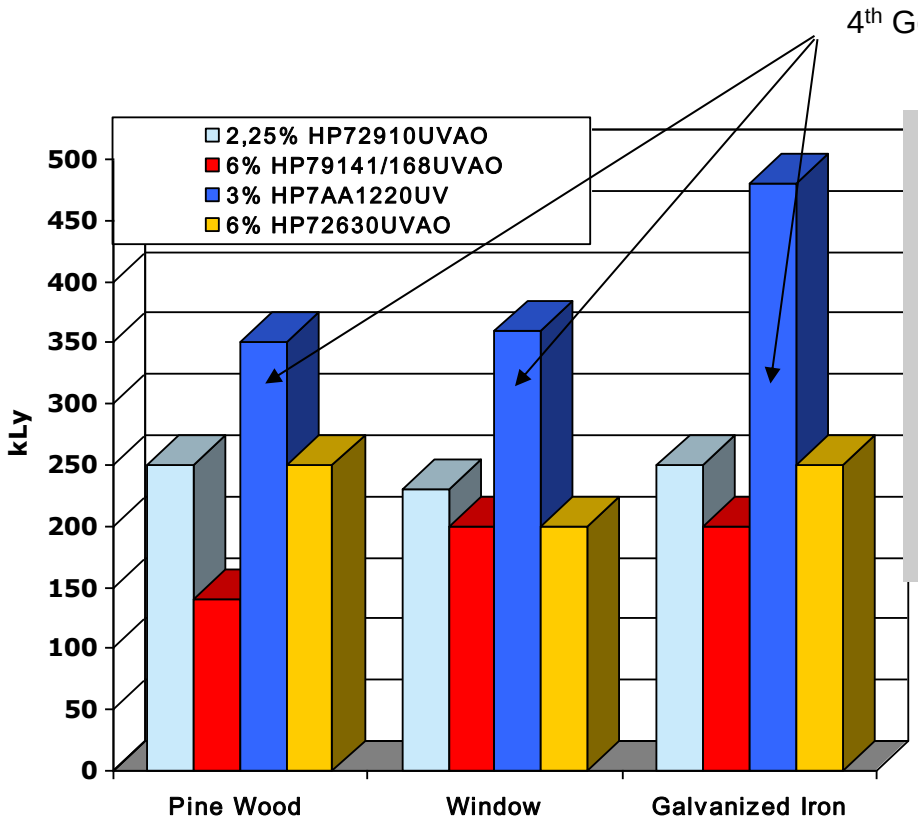
MAXITHEN® HP72910UVAO



Greenhouse Films

THE PERFORMANCE OF THE 4TH GENERATION AGAINST USE OF PESTICIDES

Greenhouse Film LDPE (200µ)



Remarks to Diagram:

50% residual elongation in Greenhouse exposed in Italy, having sun radiation at approx. 140 kLy per year.

In the Greenhouse, there was monitored the light stability performance of additives in the window sections (no frame) and in contact with the support (wood or galvanized iron) under real, practical pesticide conditions. Metham-Sodium (Sulphur) was applied twice a year and Permethrin (Chlorine) was applied once a year.

1st Generation – MAXITHEN® HP79141/168UVAO

2nd Generation – MAXITHEN® HP72630UVAO

3rd Generation – MAXITHEN® HP72910UVAO

4th Generation – MAXITHEN® HP7AA1220UV

CONCLUSION:

4th Generation MAXITHEN® HP7AA1220V - Non interacting light stabilisator system clearly showed superior performance at pesticide use and still kept 50% of elongation up to 350 kLy (30 month, areas 140 kLy/Year).

Greenhouse Films

ANTIFOG ADDITIVES

ANTIFOG BASICS

The term fog is used to describe the condensation of water vapour on the surface of a transparent plastic film in the form of small to large droplets. The reason we see the water in the form of condensed water droplets on the surface of the plastic film is, beside humidity and temperature differences, due to the difference between the surface tension of the water and the surface tension of the polymer.

The antifog additive is incorporated into the polymer matrix during the extrusion process. Upon extrusion, the additive migrates to the surface of the polymer, where the additive is increasing the surface tension of the polymer. A small quantity of the antifog additive dissolves in the water droplet and decreases the surface tension of the water. At one point the surface tension of the polymer and the surface tension of the water “droplet” are equal so that the water droplet is spread into a continuous layer of water, which is transparent.

Using Antifog additives will improve light transmission of greenhouse films,
enabling following results:

- higher plant grow rates
- higher crop yield per plant
- earlier crop maturity and hence the date it may be sold
- will reduce burning of plants and crop spoilage
- will reduce constant water dripping.

MAXITHEN® HP790470AF ANTIFOG - FOR USE AT GREENHOUSE MONO- AND COEX FILMS

For conventional greenhouse polyethylene Monofilm, in order to obtain a 6-month Antifog effect, a dosage rate of 2% HP790470AF is sufficient. For longer lasting Antifog effects, targeting periods of up to max. 1 ½ years, dosages up to 6-7% MAXITHEN® HP790470AF are necessary.

Antifogging additives will migrate to both surfaces of the Monofilm, having the possibility of loss of additive to external rainfall. This has negative implications to the long-term antifog effectiveness of the film.

In order to get best possible long lasting Antifog effects of up to 2 years, we recommend a special three COEX layer-build up, as shown in this brochure.

Greenhouse Films

MAXITHEN® HP790470AF ANTIFOG – for use at 3 Layer coextruded greenhouse films (COEX)

In COEX applications attention has to be paid that Antifog is a migrating additive and is able to migrate in the polymer layer matrix. The layer build up and the polymer selection has to take this into account. For superior long lasting effects, beside use of MAXITHEN® HP790470AF Antifog MB, it is additionally necessary to reformulate the polymer selection in the layer build up in order to get more migration potential to inner side of greenhouse, to achieve a saturation of antifog ingredient to film surface inside the greenhouse.

TYPICAL FILM STRUCTURE

for a 200µm 3-layer COEX film with unidirectional migration inside the greenhouse to get long lasting Antifog effects up to 2 years:

Sun

external layer (25%):
crystalline LDPE as
“BARRIER”

core layer (50%):
EVA (about 14%VA) as
HP790470AF, dosage 4-5%
“RESERVOIR”

inner layer (25%):
EVA (about 4-5%VA)
HP790470AF, dosage 1-2%

CROPS

Greenhouse film with unidirectional migration to the inside
The external layer of the film use a crystalline LDPE with no antifog additive, acting as a protective barrier layer and represents about 25% of the overall film thickness. The inner layer also represents about 25% of the overall film thickness and is typically a ethylene-vinyl-acetate (EVA) copolymer with a low level of VA-vinyl acetate (4-5%VA) and around 1-2% MAXITHEN® HP790470AF to provide immediate starting antifogging effect. The core layer, being around half of the overall film thickness, is again an EVA copolymer, but with a higher level of VA (14%VA) and a higher level of MAXITHEN® HP790470AF (4-5%). The core layer effectively acts as a long-term reservoir for the film as the antifogging additive is most compatible with the more amorphous polymer. As antifog additive is consumed to the internal side, the core layer slowly releases replacement additive through unidirectional migration to the inner side only.

Greenhouse Films

ANTIFOG …..CONTINUED

IMPORTANT NOTE TO ALL ANIFOG MB´S
It is imperative that selected base polymers are free from slip additives! Regardless if Mono or COEX film, use of any migrating slip additive can inhibit the Antifog effect totally down to zero, because of contradictory functional effects to film surface! Use of Light Diffuser additives, Antiblock additives based upon natural or synthetic silica, or mineral based IR Barrier additives, will deteriorate the Antifog effect in a certain way, because these additives are able to adsorb on their particle surface certain amounts of Antifog active substance itself. When such additives have to be used, the dosage of the Antifog MB must be adapted in order to compensate the adsorption effect.

At COEX films, the Antifog effect is considerably influenced by the choice of polymers in the respective layers. Antifog MB's use migrating additives, lower or no VA Copolymer content in the chosen polymer slow down the migration property and/or the reservoir capability of the system itself. This is the reason why superior antifog effects can be achieved at speciality COEX films with right polymer selection corresponding to the layer build-up.

Since the Antifog effect also depends to a big extent on the agricultural end use conditions inside and around the greenhouse and should therefore be tested under practical conditions on geographical area of application, before taking an antifog greenhouse film formulation on commercial scale.

Greenhouse Films

INFRARED (IR) BARRIER, BASICS
Radiation of long wavelength infrared energy can pass through the greenhouse film.
At night, the warm plants, soil and components within the greenhouse loose energy by transmission of long wave (infrared) radiation to the cold sky above. The rate of this loss depends, not only on the temperature of the plants, and the atmospheric conditions (clouds, carbon dioxide, and ozone content), but also on the properties of the greenhouse film cover material.
The composition of the film, the polymer selection and the use of suitable additives influence this property significantly, and ensure by use of proper additives to keep the greenhouse warm inside at night at cold seasons, enabling earlier cultivations in springtime's and prolonging cultivations at autumn. Heat retention is achieved by choosing the correct polymers for the film or by using special additives like IR Barriers. The thickness of the film will also have an effect - thinner films will tend to give inside colder night-time and winter temperatures.

When using IR-Barrier additives, the capability of the greenhouse film to reflect during night long wavelength infrared radiation back into the greenhouse directly saves energy losses, keeping the thermal energy inside.

Amongst other methods, there are two main methods to give IR Barrier properties to LDPE greenhouse films.

1. Use of mineral IR Barrier additives in LDPE films especially, but not limited, applied for Monofilms, the thinner the film, the more addition rate is necessary.

2. Use of ethylene-vinyl-acetate (EVA) copolymer, applied most often at COEX films, because EVA has certain IR Barrier property by itself, in relation to VA content and thickness of the film.

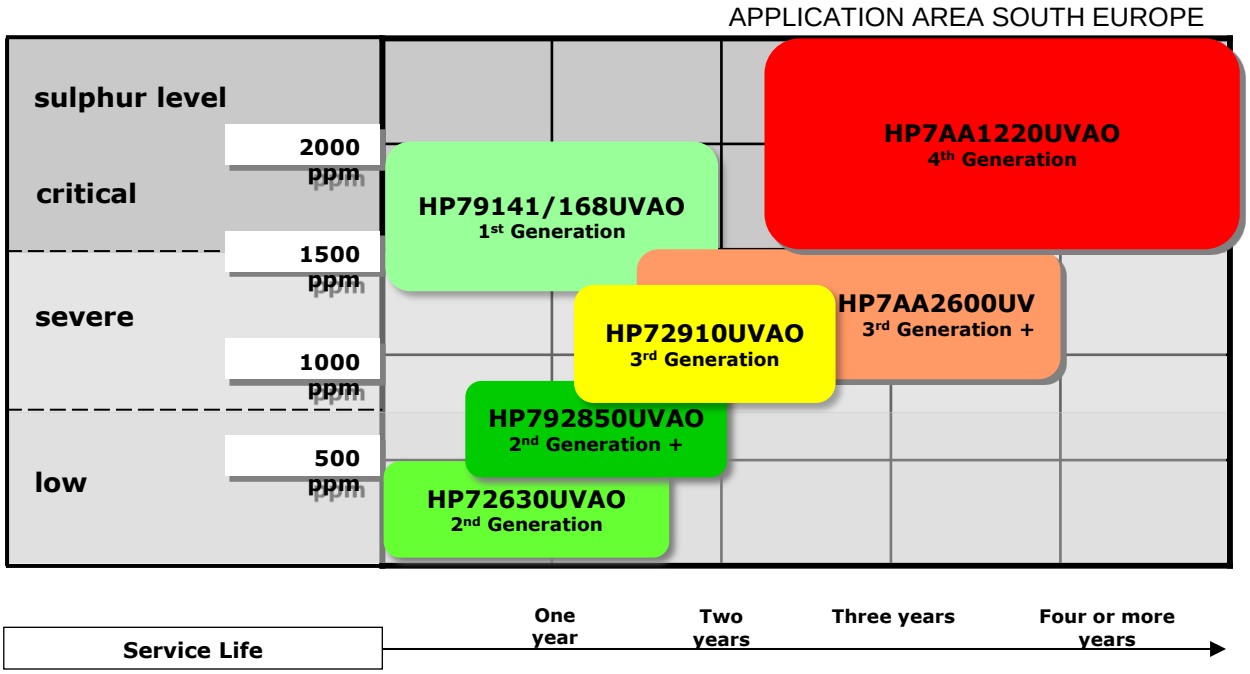
IR-BARRIER MASTERBATCH

MAXITHEN® HP7AA0410IR BARRIER ADDITIVE MB
Contain special grade mineral filler with high effectiveness and purity to generate excellent IR-barrier properties at the greenhouse film for improvement of thermal properties inside the greenhouse.
When using LDPE, or blends LDPE/LLDPE, a dosage of 4% MAXITHEN® HP7AA0410IR for 200µm film has to be added. For 150µm films, an higher addition rate of 8-10% would be necessary. For thin gauge films, lower than 150µm, we do not recommend the use of IR-Barrier additives.

Active substance in our MAXITHEN® HP77AA0410IR is of high chemical purity, compared to other IR Barrier existing in the market our product give high safety against deteriorating catalytic photo degradation, which ensure best possible service lifetime results.

Greenhouse Films

POSITIONING OF DIFFERENT KIND OF HALS SYSTEMS



The light stabilisator evolution is commented on page 4 of this brochure.
Gabriel-Chemie introduced a categorisation expressed as Generations. Depending on climatic locations and given environmental surrounding conditions at greenhouse location, the growers have to adapt the pesticide evaluation and the frequency of treatments corresponding to particular selected crops cultivation.

Since the use of aggressive agrochemicals is a worldwide trend to increase crop production, the chemical stability of the applied light stabilisator system is important in order to get optimum service life's at greenhouse films.

Above Graph inform about the positioning of various light stabilisator masterbatches, offered from Gabriel-Chemie, relative to their chemical stability (referencing the sulphur resistance) and resulting service life expectation.

Greenhouse Films

PRODUCT OVERVIEW

Product Name	Composition details	Description/Application
MAXITHEN® HP79141/168UVAO	Ni-Quencher / UVA / AO 1st Generation	Greenish colour, good sulphur resistance, for greenhouse films 150-200µm up to 33 months (2 summers).
MAXITHEN® HP7AA3650UVAOIR	Ni-Quencher / UVA / AO / IR 1st Generation	Greenish colour, good sulphur resistance, combination product with IR Barrier, for thermic greenhouse films 150-200µm up to 33 months (2 summers).
MAXITHEN® HP72630UVAO	HALS / UVA / AO 2nd Generation	Transparent, low agrochemical resistance, for cultivations having low or no agrochemical use. For greenhouse films (150-200µm) up to 33 months (2 summers).
MAXITHEN® HP7AA3640UVAOIR	HALS / UVA / AO / IR 2nd Generation	Transparent, low agrochemical resistance, for cultivations using low or no agrochemical use. For thermic greenhouse films (150-200µm) up to 33 months (2 summers).
MAXITHEN® HP792850UVAO	HALS / AO 2nd Generation Plus	Transparent, improved chemical resistance. For greenhouse films (150-200µm) up to 33 months (2 summers).
MAXITHEN® HP72910UVAO	HALS / AO 3rd Generation	Achieve whitish diffused films, outstanding chemical resistance, enable earlier harvest. For greenhouse films (150-200µm) up to 36 months (3 summers).
MAXITHEN® HP7AA3630UVAOIR	HALS / AO / IR 3rd Generation	Achieve whitish diffused films, outstanding chemical resistance, enable earlier harvest. For thermic greenhouse films (150-200µm) up to 36 months (3 summers).
MAXITHEN® HP7AA2600UV	HALS Blend / UVA 3rd Generation Plus	Transparent, superior agrochemical resistance, typical application greenhouse films (180-200µm) ≥ 24 months.
MAXITHEN® HP7AA1220UV	NOR HALS / UVA 4th Generation	Transparent, best available resistance to high levels of agrochemicals. For greenhouse films with severe pesticide use (180-220µm) ≥ 36 months.
MAXITHEN® HP790470AF	Surface active Antifog / Antidrip Masterbatch	Antifog/ Antidrip masterbatch for greenhouse films. Effective at dosage rate 2% for 6 month and 6-7% for up to 18 months. At COEX applications long lasting antifog effects up to 24 months.
MAXITHEN® HP7AA0410IR	IR Barrier Masterbatch	IR Barrier for transparent films, enable IR effectiveness to thermic greenhouse films, typical dosage rate 4% at 180-200µm films.

HALS= Hindered Amine Light Stabilizer; NOR= NOR HALS; AO= Antioxidant; UVA= UV Absorber; IR= Infrared

Greenhouse Films

All indications in this product information were elaborated for support and service to our customers. All data's and statements in this product information have been obtained from laboratory tests under ideal and closely controlled conditions. The information should act as a guide only and should not be construed as guaranteeing specific properties or suitability for a particular application. Therefore, trials by customers using their polymers and their conditions must confirm the suitability of our product for the intended application.

BUSINESS UNITS OF GABRIEL-CHEMIE GROUP:

Building & Agriculture

Home & Lifestyle

Packaging for Industrial & Consumer Goods

Cosmetics Packaging

Food & Beverage Packaging

Medical

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