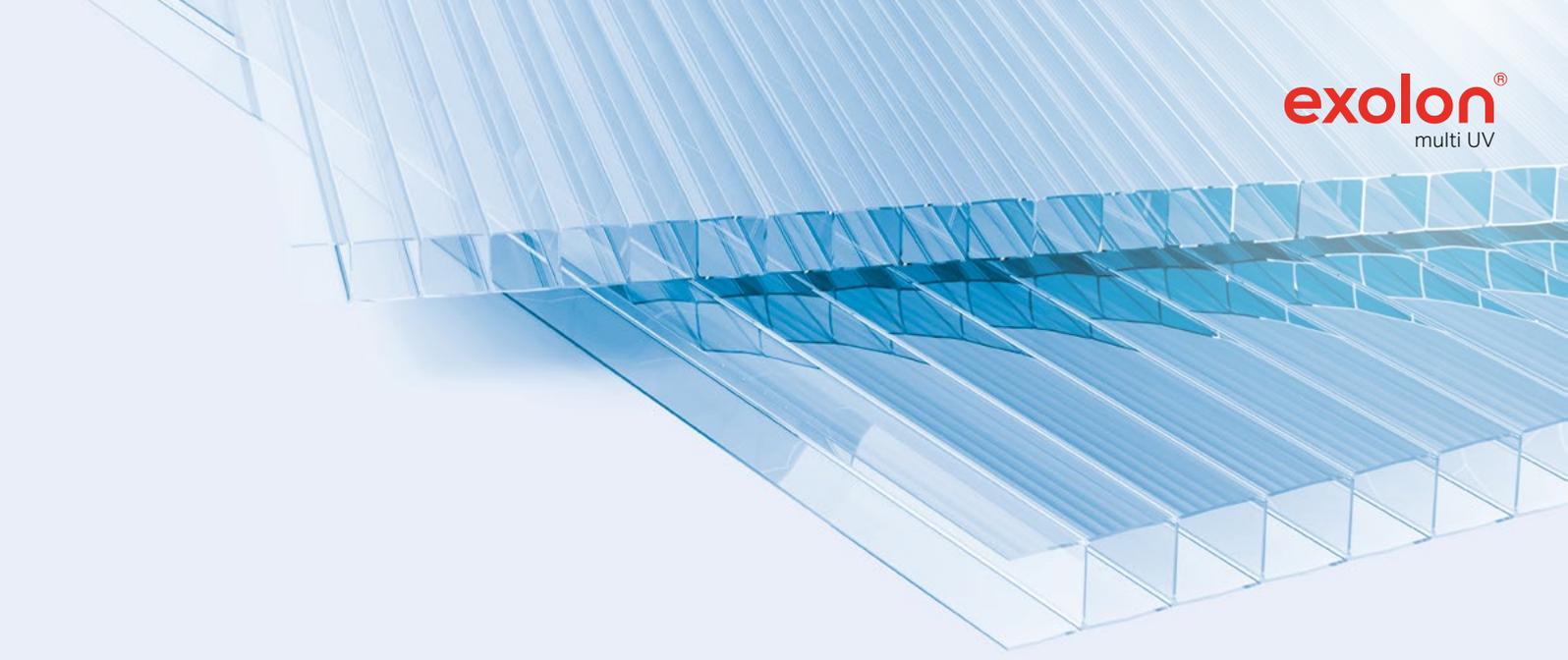




WHITE PAPER

## Maximize greenhouse yields with polycarbonate multiwall sheets



# Polycarbonate multiwall sheets.

A building material with significant added value for greenhouses.

Exolon Group is the leading manufacturer of polycarbonate multiwall sheets used in a wide range of building sectors. Especially for greenhouses, we develop innovative solutions that are proven to maximize yields and minimize negative impacts on the environment. Compared with glass or polymethyl methacrylate (PMMA), our polycarbonate multiwall sheets offer a multitude of benefits, making them the ideal solution for high-tech and highly productive greenhouses.

## At a glance: 9 reasons for polycarbonate instead of glass or PMMA

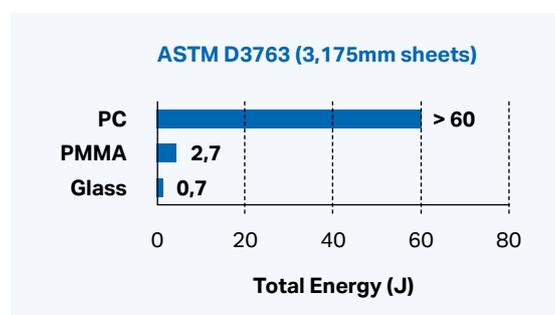
- ✓ High robustness
- ✓ Maximum light transmission
- ✓ Minimal UV radiation
- ✓ Unique appearance and performance
- ✓ Optimum light diffusion
- ✓ No condensation
- ✓ Reliable temperature control
- ✓ Reduced costs and CO<sub>2</sub> emissions
- ✓ Easy processing and assembly

## High robustness



As polycarbonate (PC) is virtually unbreakable, it is the perfect material for greenhouses, which usually have to withstand adverse conditions. It is nearly twenty-five times more impact-resistant than polymethyl methacrylate (PMMA), and more than a hundred times stronger than glass. The increased resistance of polycarbonate makes it particularly suitable in areas where severe conditions or extreme weather events such as storms, strong winds and snow can occur, as well as desert areas.

Exolon<sup>®</sup> multi UV multiwall sheets have a ten-year warranty, thanks to the unique protective layer that prevents damage from ageing caused by ultraviolet (UV) light. Another important advantage: in construction, polycarbonate is preferred to other translucent plastic materials, such as PMMA, as it is self-extinguishing (B-s1, d0 in accordance with EN13501-1).



In accordance with ASTM D3763, polycarbonate has a much higher puncture resistance than polymethyl methacrylate and glass.

## Maximum light transmission



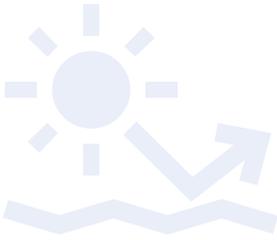
Sunlight is crucial for plant growth and crop yields. It is generally assumed that a 1% increase in light transmission increases the yield by the same amount. Exolon<sup>®</sup> multi UV polycarbonate sheets are designed to provide greenhouse operators with multiple benefits without compromising on light transmission.

Thanks to advanced extrusion techniques developed in the production processes, and to the development of high-tech geometries, Exolon Group can supply polycarbonate multiwall sheets with exceptionally high light transmission values. Exolon<sup>®</sup> multi UV 2/8-10.5 and 2/10-10.5 sheets, for instance, have thicknesses of 8 mm and 10 mm, respectively. The 10.5 mm rib distance maximizes light transmission, which reaches values of 81% and 80%, respectively.

PRODUCT	THICKNESS (mm)	PITCH (mm)	LIGHT TRANSMITTANCE clear (%)	LIGHT TRANSMITTANCE white (%)	THERMAL TRANSMITTANCE (W/M <sup>2</sup> K)
Exolon <sup>®</sup> multi UV 2/4-8	4	8	82	77	4,0
Exolon <sup>®</sup> multi UV 2/6-8	6	8	82	76	3,5
Exolon <sup>®</sup> multi UV 2/8-10,5	8	10,5	81	78	3,3
Exolon <sup>®</sup> multi UV 2/10-10.5	10	10,5	80	70	3,0
Exolon <sup>®</sup> multi UV 2/16-30	16	30	77	57	2,8

Exolon<sup>®</sup> multi UV twin-wall sheets provide excellent light transmission in greenhouses.

## Minimal UV radiation



Exolon<sup>®</sup> multi UV sheets block UV rays. This creates an environment in the greenhouse that is not only safer for workers, but also better for plant growth.

Extensive research has proven that plants grow better in the absence of UV rays. Comparative studies<sup>1</sup> have shown that aubergines grow 21% taller and produce 17% more leaves. An increase in height and leaf production was also observed in tomato cultivation, without affecting pollination by insects<sup>2</sup>. Studies have also shown an increase in the growth of lettuce and pepper plants<sup>3</sup>.

The importance of UV deprivation becomes even clearer when comparing the performance of polycarbonate to glass. Very high light transmission values can be obtained with the latter, but it does not filter the ultraviolet part of solar radiation. Tests<sup>4</sup> have shown that compared to glass roofing, courgette plants grow taller with polycarbonate and produce more leaves and biomass. Moreover, yield losses are reduced in tomato crops with polycarbonate.

It has also been shown that the absence of UV rays prevents the spread of viruses and other pathogens transmitted by insects<sup>5</sup>. Improved control over the proliferation of fungi can be achieved by inhibiting sporulation<sup>6</sup>. These effects make polycarbonate an ideal material for integrated pest and disease control management, so that pesticide use can be minimised.



<sup>1</sup> Kittas C, Papaioannou C, Obeid D, Katsoulas N, Tchamitchian M. Effect of two UV-absorbing greenhouse-covering films on growth and yield of an eggplant soilless crop. *Scientia Horticulturae* 2006;110:30-7

<sup>2</sup> Kittas C, Papaioannou C, Obeid D, Katsoulas N, Tchamitchian M. Effect of two new UV-absorbing greenhouse-covering films on growth and yield of a soilless tomato crop, International Symposium of the eCIGR in New Trends in Farm Buildings, May 2-6, 2004, Evora, Portugal

<sup>3</sup> Paul ND, Jacobson RJ, Taylor A, Wargent JJ, Moore JP. The use of wavelength selective plastic cladding materials in horticulture: understanding of crop and fungal responses through the assessment of biological spectral weighting functions. *Photochemistry and Photobiology* 2005;81:1052-60

<sup>4</sup> Joon Kook Kwon, Bekhzod Khoshimkhujaev, Jae Han Lee, In Ho Yu, Kyoung Sub Park, and Hyo Gil Choi, Growth and Yield of Tomato and Cucumber Plants in Polycarbonate or Glass Greenhouses

<sup>5</sup> Antignus Y. Manipulation of wavelength-dependent behaviour of insects: an IPM tool to impede insects and restrict epidemics of insect-borne viruses. *Virus Research* 2000;71:213-20

<sup>6</sup> Lammatau Chr., Chemisana D., solar radiation manipulations and their role in greenhouse cladding, 2012

## Unique appearance and performance



Exolon<sup>®</sup> multi UV sheets can be used in greenhouses, but also for more complex buildings, such as nurseries or exhibition areas. They are perfect for realizing the most demanding and innovative designs, where appearance is combined with performance.

Exolon<sup>®</sup> multi UV 2/16-30 is a special polycarbonate sheet that is particularly suitable when high light transmission and a clean appearance are both important. The sheet has a thickness of 16 mm, which is good for thermal insulation, and has a 30 mm rib distance to ensure high light transmission. Additionally, Exolon<sup>®</sup> multi UV 2/16-30 is produced with an innovative surface treatment that gives the sheet outstanding transparency and gloss.



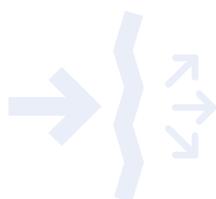
**Common Sheet**



**Exolon<sup>®</sup> multi UV 2/16-30**

Exolon<sup>®</sup> multi UV 2/16-30 has a special surface treatment to give unrivaled transparency and gloss compared to other polycarbonate sheets.

## Optimum light diffusion



Light transmission and the spread of light are important for many crops, especially plants with broad or dense leaves. Exolon Group uses specially developed diffuser masterbatches to ensure high light transmission with maximum distribution. For example, Exolon<sup>®</sup> multi UV 2/8-10.5 in opal has a light transmission of 78%, which is only three points less than a transparent sheet.

With diffuse light, however, the plants use the radiation more efficiently. Plant damage caused by direct sunlight is avoided, as is direct shading, which can reduce yields. The benefits of diffuse light can increase photosynthesis by up to 7 %<sup>7</sup>.



**Direct light**



**Diffused light**

Diffused light prevents leaves from shading.

<sup>7</sup> T. Li, E. Heuvelink, T. A. Dueck, J. Janse, G. Gort and L. F. M. Marcelis. Enhancement of crop photosynthesis by diffuse light: quantifying the contributing factors

## No condensation



Condensation is an undesirable effect that occurs very frequently in greenhouses. Water droplets negatively impact growth as they reduce light transmission, increase the risk of disease and pesticide consumption, and can damage flowers if they fall.

Exolon<sup>®</sup> multi UV sheets are available with a special 'No-Drop' treatment that prevents drops forming, so condensing water flows off the walls quickly as a thin film without negatively affecting light transmission. The 'No-Drop' treatment provides improved control over plant and flower growth, particularly in damp or cold environments.



Standard



No drop

The special 'No-Drop' treatment prevents water droplets forming and encourages them to flow in a thin film of water.

## Reliable temperature control

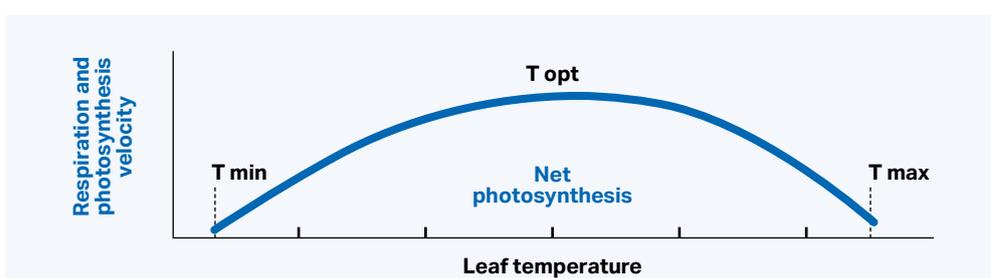


Temperature plays a vital role in the growth of plants. Thus, temperature control is a key factor for ensuring maximum yield, providing the correct humidity values and minimizing fungal growth. That's why more and more greenhouses have climate control systems that maintain the environment at the desired conditions.

Thanks to their multiwall structure, polycarbonate sheets are the most suitable material for providing thermal insulation with good light transmission. Exolon Group offers a range of multiwall sheets to maximize thermal insulation and ensure optimum growth temperatures for plants.

PRODUCT	THICKNESS (mm)	PITCH (mm)	LIGHT TRANSMISSION (%)	THERMAL TRANSMITTANCE (W/M <sup>2</sup> K)
Exolon <sup>®</sup> multi UV 5X/8-25	8	25	71	2,8
Exolon <sup>®</sup> multi UV 5X/10-25	10	25	68	2.5
Exolon <sup>®</sup> multi UV 5X/16-25	16	25	64	2,0
Exolon <sup>®</sup> multi UV 5X/20-25	20	25	60	1,8

Exolon<sup>®</sup> multi UV 5X multiwall sheets combine thermal insulation with good light transmission.



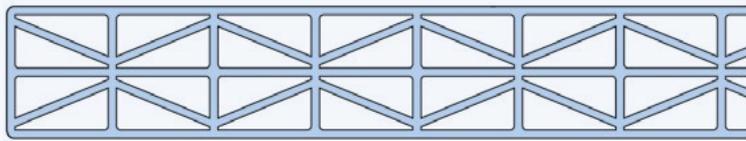
Optimum growth temperature of a plant.

## Reduced costs and CO<sub>2</sub> emissions



Exolon<sup>®</sup> multi UV can also significantly reduce energy consumption and greenhouse management costs. The X-structure of Exolon<sup>®</sup> multi UV 5X/8-25 reduces the thermal transmittance value, increasing the obtainable insulation. This reduces energy used for climate control in the greenhouse, reducing costs and emissions.

The X-geometry provides increased rigidity in order to facilitate the wall application and optimize the required structure and the corresponding costs.



With their X-geometry, Exolon<sup>®</sup> multi UV 5X sheet provide increased rigidity while reducing energy costs and emissions.

### Calculation example

Consider a typical greenhouse where the cover area is about 1,85 times the cultivated area, Exolon<sup>®</sup> multi sheet can halve energy consumption compared to common glass.

As can be seen from the values shown in the table below, compared to 4 mm glass, the Exolon<sup>®</sup> multi UV 2/8-10,5 sheet reduces consumption by 51%, as the double wall provides a thermal transmittance value equivalent to half than that of glass. Thanks to Exolon<sup>®</sup> multi UV 5X/8-25, consumption can be reduced by a further 15%, because the X-structure provides even lower transmittance.

Data per m <sup>2</sup> cultivated	POWER REQUIRED (W)	CO <sub>2</sub> EMISSIONS (kg/year)
4 mm glass	309	731
Exolon <sup>®</sup> Multi UV 2/8-10,5	152	360
Exolon <sup>®</sup> Multi UV 5X/8-25	129	306

Assuming a typical temperature difference of 25 °C between outside and inside and zero solar radiation

## Easy processing and assembly



Polycarbonate multiwall sheets are easily processed. They are lightweight and can be cut with common circular saws, which makes installation much easier. Additionally, they can be cold bent, allowing for semi-circular or elliptical coverage to maximize sunlight throughout the day.

For more information,  
please contact us by e-mail at  
[sales@exolongroup.com](mailto:sales@exolongroup.com)



## Summary

# Exolon® multi UV provides a multitude of crucial benefits

Exolon® multi UV are polycarbonate multiwall sheets that are ideal for optimizing greenhouse yields. Thanks to their superior light transmission, they guarantee protection and an adequate supply of light.

Increasingly high thermal insulation values can be achieved with the 5X structure which is also available for the first time as 8 mm, minimizing costs and the impact on greenhouse climate control.

These features make Exolon® multi UV sheets the best choice for greenhouses where temperature control is crucial, or for climates that are too hot or cold. The best possible climate for plant growth can be recreated and protected with Exolon® multi UV, minimizing consumption and maximizing yields.



**exolon**  
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GOING BEYOND

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