Neuburg Siliceous Earth Improves the Performance of PE Greenhouse Film

# A Rich Harvest with the Right Earth

Greenhouse film should transmit visible light but trap infrared radiation inside the greenhouse. Unfilled PE film cannot wholly accomplish the latter. With the right filler, however, the film can be a strong IR blocker. Just how well it performs depends very much on the particle size of the additives, as shown in tests on Neuburg siliceous earth.

**The films must promote photosynthesis while retaining heat in greenhouses.** © Adobe Stock; Kasparart

Greenhouses create the optimum climate for plant growth, enabling earlier harvests and longer growing seasons. This is achieved by ensuring that the film transmits the maximum-possible amount of light in the photosynthetically active region (PAR). In the infrared range (IR), on the other hand, it is desirable for the film to act as a good thermal barrier.

Sunlight supplies radiation extending from 290 nm (UV) through the visible to the near infrared range (approx. 3000 nm). The visible range spans 380 to 720 nm. It is used by plants for photosynthesis. Hence this radiation is also called photosynthetically active radiation (PAR). Measurements, however, often only consider the range from 400 to 700 nm.

The second major spectral range for greenhouses is the mid-infrared wavelength range spanning 7 to 13 µm. It represents the thermal radiation emitted from the earth's surface, and is also known as terrestrial radiation. This is radiated into the atmosphere and is lost, especially at night. These losses cannot be prevented by a film made of polyethylene (PE), as it is largely transparent to IR radiation in the required wavelength range. PE/EVA copolymer, for example, goes some way toward improving on this by virtue of its vinyl acetate content. Much better results, though, can be achieved with mineral additives that act as an IR blocker.

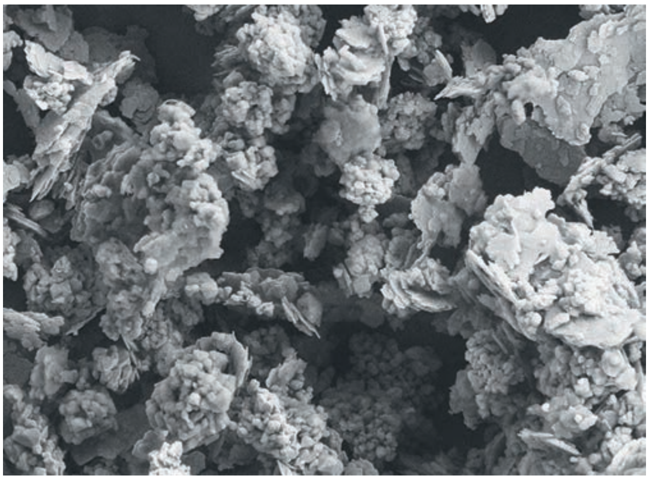

**Fig. 1.** Neuburg siliceous earth has long served as a filler for plastics intended for various applications, such as tubing, floor coverings and coatings. © Hoffmann Mineral

## IR Blocker with Neuburg Siliceous Earth

Fine-particle mineral fillers are used as additives that specifically target a reduction in transmission in the film's IR range and thus improvements in heat retention. It is important that they do not appreciably reduce transmission in the PAR. Hoffmann Mineral studied the suitability of Neuburg siliceous earth as an IR absorber for greenhouse film. The company investigated blown film made of LDPE (low density polyethylene) or PE/EVA containing Neuburg siliceous earth to assess its optical properties and transmission in the PAR and IR ranges. It also compared the film's IR efficiency with that of unfilled film containing no IR absorber.

Neuburg siliceous earth is a natural combination of corpuscular Neuburg silica and lamellar kaolinite; it is a loose aggregate that cannot be separated by physical methods. The silica fraction has a round grain shape and consists of aggregated primary particles about 200 nm in diameter (**Fig. 1**).

Two filler variants were tested. Sillitin V 88 (color values L* 94; a* 0.1; b* 3.8) and Sillitin Z 89 puriss (color values L* 94, a* 0.1, b* 4.0) are both relatively color-neutral representatives of Neuburg siliceous earth. Sillitin V 88 is a coarser grade (particle size d50: 4.0 µm; d97: 18 µm), while Sillitin Z 89 puriss (particle size d50: 1.9 µm; d97: 9.0 µm) is a finer grade that is particularly easy to disperse.

Besides polymer and filler, an antioxidant and calcium stearate were added in typical dosages encountered in practice to stabilize the tested film. The recipe structure was the same for both film types:

- 92.1 % polymer,
- 7.5 % filler,
- 0.2 % calcium stearate,
- 0.2 % antioxidant.

The compounds were converted into blown mono-film having a thickness of about 100 µm. The LDPE grade employed was Riblene FM 34 F (manufacturer: Versalis; density: 0.924 g/cm$^3$; melt flow rate (MFR): 3.5 g/10 min.), which is suitable for blown-film applications.

## Wider-Ranging and More Uniform Light Scattering

Light transmission in the 400 to 700 nm spectral range is an important property of greenhouse film. As mentioned, this is the wavelength range in the solar spectrum that plants use for photosynthesis. Transmission in this range therefore needs to be as high as possible. What is more, it matters whether the light is direct or indirect (diffuse). Too much direct light is detrimental to plant growth, especially in areas of strong sunlight. Mineral fillers offer more extensive and more uniform light scattering, a fact which benefits plant growth.

As expected, the unfilled film exhibits the highest overall transmission. Adding filler reduces light transmission only slightly, however. The fine filler Sillitin Z 89 puriss is somewhat less effective at reducing transmission than the coarser grade Sillitin V 88. The unfilled film produces a diffuse fraction of about 8 %. With the fine filler Sillitin Z 89 puriss, »


**Fig. 2.** Filler addition renders the LDPE films much milkier. The larger the particles of Neuburg siliceous earth, the milkier the film appears. © Hoffmann Mineral

## Info

### Text

**Siegfried Heckl** is Key Account Manager at Hoffmann Mineral; siegfried.heckl@hoffmann-mineral.com
**Petra Zehnder** works in the Applications Technology department at Hoffmann Mineral.
**Hubert Oggermüller** is Head of the Applications Technology department at Hoffmann Mineral.

### Service

For more information, please visit: ***www.hoffmann-mineral.de***

### Digital Version

A PDF file of the article can be found at ***www.kunststoffe-international.com/archive***

### German Version

Read the German version of the article in our magazine ***Kunststoffe*** or at ***www.kunststoffe.de***

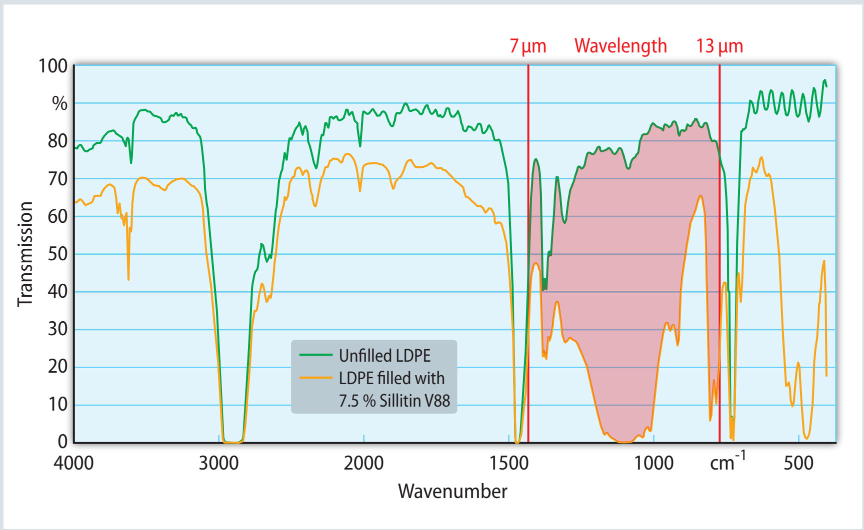


**Fig. 3.** Transmission curves for the mineral-filled and unfilled film: the differential area is shown in red and illustrates the IR blocking properties conferred by the filler. Source: Hoffmann Mineral; graphic: © Hanser

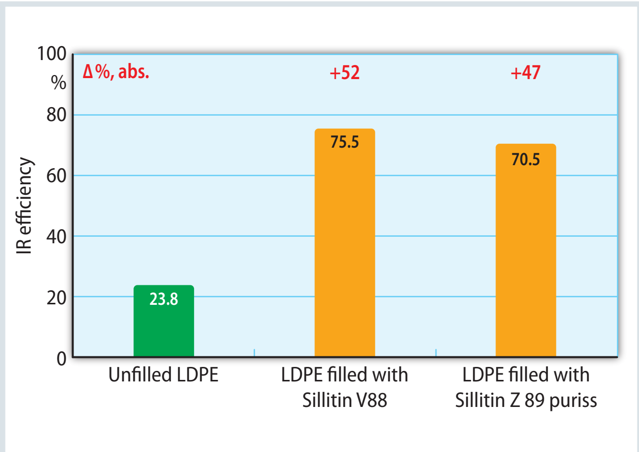


**Fig. 4.** The IR efficiency of the film rises markedly with addition of Neuburg siliceous earth. To an extent depending on the filler, the increase is 47 to 52 %. Source: Hoffmann Mineral; graphic: © Hanser

this figure rises to about 28 %. The coarser Sillitin V 88 yields the highest diffuse fraction of about 32 %, and thus produces the strongest light scattering.

## *Particle Size Influences Haze and Optical Impression*

Film haze behaves in a manner similar to that of diffuse transmission. While the unfilled film, as expected, is relatively clear with a haze value of 10 %, the latter figure increases strongly with the addition of filler. The fine filler particles of Sillitin Z 89 puriss, at 35.8 %, produce less haze than the 42.9 % produced by the coarse particles of Sillitin V 88.

The optical impression of the LDPE film fits well with the haze readings. When the same object is viewed through the film, the film filled with Sillitin Z 89 puriss produces the clearest images, whereas those produced by Sillitin V 88 are the milkiest. The reason for this is the particle size of the fillers. Coarser particles cause stronger light scattering and the film appears milkier than in the case of finer particles (**Fig. 2**).

Gloss was determined at an angle of incidence of 45°. It drops by about 30 gloss units (GUs) as a result of filler addition. Filled film is more matte than unfilled film. Here, Sillitin Z 89 puriss yields the higher gloss value, 36 GU, and thus has a lower matting effect. This correlates well with the lower haze.

As for transmission in the IR range, the focus is on the 7 to 13 µm wavelength range, equivalent to the wavenumbers 1430 to 770 $cm^{-1}$. The wavelength range around 10 µm corresponds to the maximum energy radiated from the Earth's surface (terrestrial radiation at 15 °C or 288 K).

## *IR Efficiency Increased by over 50 %*

The unfilled LDPE film has only a low blocking effect on IR radiation in the required wavelength range. By comparison, Sillitin V 88 lowers transmission significantly in the near- and mid-infrared ranges (**Fig. 3**). A marked blocking effect on IR radiation is also observed in the case of Sillitin Z 89 puriss. Unlike Sillitin V 88, however, Sillitin Z 89 puriss boosts the blocking effect in the somewhat shorter wavelength range < 9 µm. This is due to the finer grain size of the filler.

IR efficiency, as defined in EN 13206, is the percentage fraction that is blocked by the film in the wavenumber range 1430 to 770 $cm^{-1}$. Unlike the unfilled PE film, which has an efficiency of just 24 %, the blocking effect arising from use of the mineral filler is 70 to 75 %. Filled film thus has considerably higher heat-retention capacity.

Relative to the unfilled PE film, the fine product Sillitin Z 89 puriss improves IR efficiency by about 47 %, with the coarse Sillitin V 88 improving it by about 52 % (**Fig. 4**). The material thus has the greatest blocking effect on infrared radiation and accordingly leads to the lowest heat loss. Theoretically, the IR efficiency could feasibly be boosted further by a higher film thickness or higher mineral concentration.

## *Do PE/EVA and Neuburg Siliceous Earth Complement Each Other?*

The PE/EVA films were made with the polymer Escorene Ultra FL 00909 (manufacturer: ExxonMobil; density: 0.928 $g/cm^3$; MFR: 9 g/10 min.; vinyl acetate content: 9.4 wt.%), which is suitable for blown film. As with the results obtained for the LDPE film, the unfilled PE/EVA film showed the highest overall transmission. The light transmission is only slightly reduced by the addition of filler, with the finer grade Sillitin Z 89 puriss again exhibiting the lower losses. The diffuse fraction increases from about 3 % for the unfilled film to about 30 % for the fine filler. In PE/EVA film, too, the coarser Sillitin V 88 gives rise to the highest diffuse fraction of about 35 % and thus to the strongest light scattering.

As expected, the unfilled film is clear, having a haze value of only about 4 %.

The haze increases sharply as filler is added, with the finer filler particles of Sillitin Z 89 puriss again producing less haze, at 36.6 %, than the coarser particles of Sillitin V 88, at 43.4 %.

For the PE/EVA films, the optical impression is more or less as would expected on the basis of the haze readings. Of the filled film, that filled with Sillitin Z 89 puriss again has the clearest appearance while that filled with Sillitin V 88 is the milkiest (**Fig. 5**). Gloss at a 45° angle of incidence drops by 20 to 30 GU as a result of the added filler. The filled film is more matte than the unfilled film.


**Fig. 5.** The fillers also confer a milkier appearance on PE/EVA film. In these cases, too, the appearance and haze depends on the size of the filler particles. © Hoffmann Mineral

## *Over 80 % IR Efficiency*

Even the unfilled PE/EVA film typically has a certain blocking effect in the required IR range of 7 to 13 µm. Filler addition markedly increases the film's blocking properties even further (**Fig. 6**). As with the LDPE film, the fine-particle Sillitin Z 89 puriss reduces transmission more strongly in the < 9 µm range than does the coarser Sillitin V 88.

The IR efficiency of unfilled PE/EVA film is inherently around 50 %. Through the addition of fillers, it can be improved to 80 to 85 %. Compared with the unfilled film, this means that the finer filler improves IR efficiency by about 30 % and the coarser one by about 35 % (**Fig. 7**). Sillitin V 88 is thus the best blocker for infrared radiation and correspondingly exhibits the least heat loss. Theoretically, the IR efficiency could feasibly be boosted further by using a higher film thickness or mineral concentration.

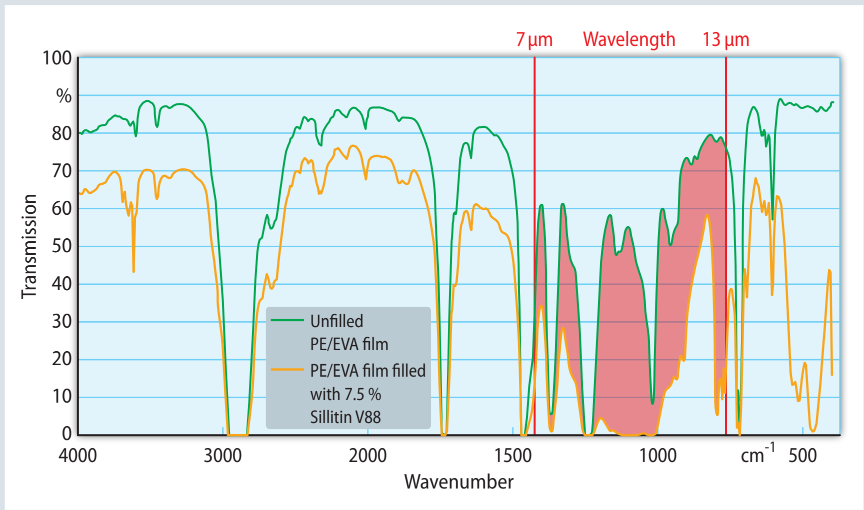


**Fig. 6.** Comparison of mineral-filled PE/EVA film and unfilled film: Neuburg siliceous earth also markedly raises the IR barrier properties of these films. Source: Hoffmann Mineral; graphic: © Hanser

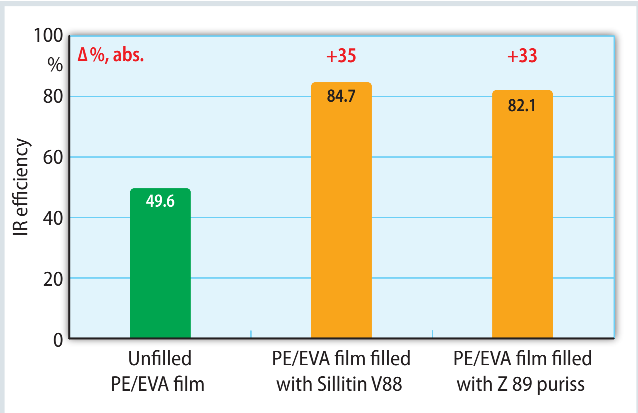


**Fig. 7.** The IR efficiency of filled PE/EVA films reaches values greater than 80 %. However, the increase is lower than that obtained with LDPE films, owing to the higher inherent efficiency in the unfilled state. Source: Hoffmann Mineral; graphic: © Hanser

## *Summary*

Neuburg siliceous earth makes a suitable IR absorber for greenhouse film made both with PE and with PE/EVA. Compared with unfilled films, light scattering is markedly enhanced in the photosynthetically active wavelength range, with almost no change occurring in overall transmission – this benefits plant growth. In addition, IR efficiency is significantly increased and heat loss is thus markedly reduced.

The two tested products from the Neuburg siliceous earth range differ slightly in this respect. The finer Sillitin Z 89 puriss offers good light scattering and good IR blocking in combination with less optical haze. The filler with the coarser particles, Sillitin V 88, produces the strongest light scattering and the strongest IR blocking, but also exhibits more optical haze.

Other modifications of Neuburg siliceous earth offer scope for further optimization of greenhouse film. Products surface-treated with special additives, for example, are likely to have a positive impact in the form of extended film life and improved weatherability. ■