MiNBLOC® HC

High-Clarity Antiblock Additive for Films

An improved film additive based on nepheline syenite with engineered particle size distribution

MINBLOC® high-clarity antiblock film additives exhibit superior thermal and optical properties and provide unique benefits relative to other film additives. A comparison is made between MINBLOC and calcined kaolin, a very commonly used filler for horticultural thermal films. MINBLOC is made of nepheline syenite, a naturally occurring silica deficient*, sodium-potassium alumina-silicate. The unmatched optical properties are due to its low transition metal content, and a refractive index which closely matches that of polyethylene resins commonly used for thermal films. Due to its precisely engineered particle size distribution, films with a very high loading of up to 20% by weight (wt%) can be produced without a decrease in tensile strength properties. Total light throughput is insignificantly affected, even at these extremely high filler loadings of 20% by weight (wt%). At high loadings, the film gives highly diffused light as measured by the haze. Moreover, these high additive loadings provide very good thermicity, which is the measurement of the thermal energy loss by the greenhouse through the film.

Materials and methods

The additives studied and their characteristic properties are shown in Table 1. Particle sizing was measured with a Beckman Coulter LS 13 320 laser diffraction particle size analyzer. Compounds with LyondellBasell Petrothene® NA345-013 LDPE (MFI: 1.8; specific gravity: 0.921) resin were prepared using a 32 mm twin screw compounder. The compounds were processed in a ¾ inch single screw extruder, equipped with a 2 ½" blown film die. Filler loadings ranged from 0% (barefoot) to 20% by weight (wt%).

*The new OSHA standard which reduces the respirable crystalline silica permissible exposure limit (PEL) from 0.10 mg/m3 to 0.05 mg/m3 over an 8 hour time weighted average (TWA), and sets an action limit of 0.025 mg/m3 (eight hour TWA) has been enforced. Silica deficient nepheline syenite is compliant with the new standards hence does require engineering controls to limit worker exposure. Engineering controls require large footprint, specific equipment, maintenance and capital investments.

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Table 1: Typical properties of MINBLOC compared with calcined kaolin

Filler	D50, LS (µm)	Surface Area, BET (m_2/g)	Refractive Index	Fe_2O_3 (%)
MINBLOC	10.0	1.0	1.53	0.06
Calcined kaolin (*)	3.7	8.5	1.56	0.65
(*) Data taken from technical datasheet of producer.				

Film properties were characterized with a range of techniques. Thermicity, the measurement of thermal performance, was determined from FTIR spectroscopy using a Nicolet Magna-IR. Optical properties were measured with a HazeGard Plus hazemeter produced by BYK Gardner, which measures total transmittance and haze according to ASTM D1003 and clarity. UV-Vis spectra were measured with a Shimadzu UV mini-1240 spectrophotometer. Color measurements were made with a Color i5 colorimeter by X-Rite; yellowness was determined according to ASTM E313. Tensile strength was measured with a COM-TEN instrument according to ASTM 882. In a simple greenhouse experiment, the air temperature was monitored in a box made of polystyrene foam filled with sand and covered with film for 12 days.

Thermal properties

Thermal film reduces heat loss from a greenhouse during nighttime by trapping the infrared heat radiation from the soil and plants that is normally lost. This helps to maintain optimum plant growth conditions by keeping the average temperature higher plus it extends the growing season by allowing crops to be planted earlier in the spring season and to grow longer into the autumn. In regions requiring space heating, fim additives help to reduce energy requirements by maintaining more heat in the greenhouse. The improvement of a highly loaded film compared to a barefoot film is illustrated by the greenhouse experiment where the air temperature is monitored; this is shown in Figure 1.

To keep thermal loss to a minimum, thermicity should be as low as possible. Thermicity is a measure of the heat radiation that is lost through the thermal film. This property is determined by FTIR spectroscopy as the fraction of mid-IR radiation from 700 to 1400 cm-1, or 14 to 7 microns, over the total IR radiation passing through the film. The FTIR spectra of typical barefoot and filled films are shown in Figure 2, where the thermicity for the filled film is given by the hashed area.

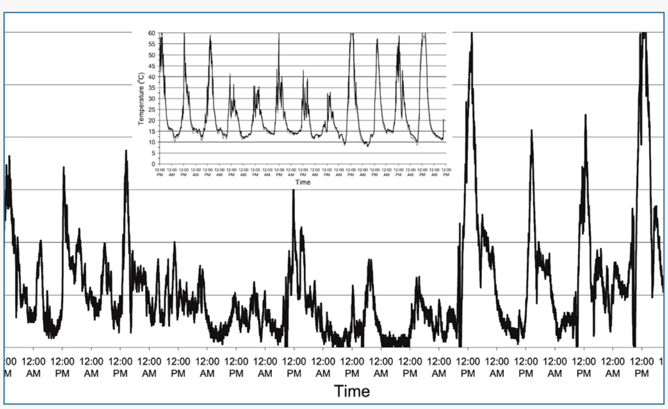

Figure 1: Improvement in air temperature of a filled thermal film compared to barefoot as measured in a simple greenhouse experiment of 12 days. Nighttime temperatures in the box with filled film are a few degrees higher. The inset shows the actual air temperatures.

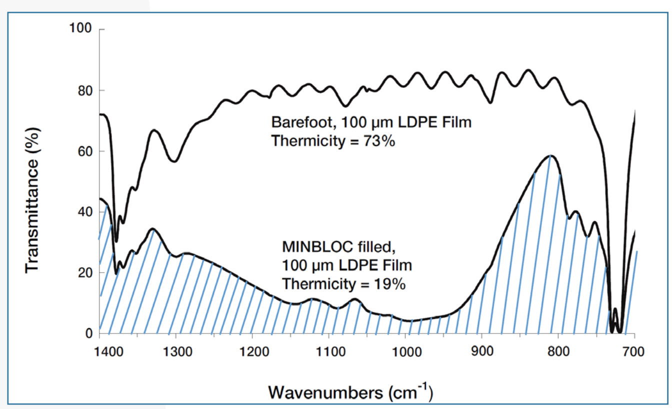

Figure 2: Determination of thermicity by FTIR spectroscopy. Thermicity is a measure of the radiation passing through the film from 700 to 1400 cm-1 (hashed area for the filled film).

Table 2: Comparison of thermal and optical properties of MINBLOC and calcined kaolin additives studied at 10 wt% loading in 6 mil* films.

Additive	Thermicity (%)	Transmittance (%)	Haze (%)	Clarity (%)
Barefoot	64	92	27	96
MINBLOC	10	91	64	24
Calcined Kaolin	8	86	71	41

Polyethylene film by itself is very transparent to infrared radiation in the range where most heat is leaked. Addition of fillers substantially limits the transparency to infrared radiation by reflecting the infrared radiation back into the greenhouse via a phenomenon called Mie scattering. The effect depends on the filler loading and on film thickness; the effect of filler loading is shown in Figure 3. It also depends on the difference in refractive index between the additive and the resin, and on the particle size. Thermicity of filled thermal film is improved significantly compared to barefoot, as shown in Table 2 for films with 10 wt% loading. The particle size of MINBLOC is engineered to optimize scattering in the critical range of 700 to 1400 cm-1 to obtain the best thermicity possible.

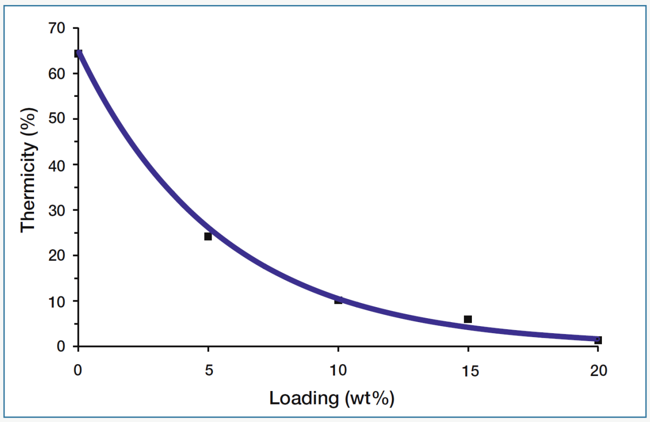

Figure 3: Measurements of thermicity values of 6 mils LDPE films obtained for barefoot and four different MINBLOC loadings.

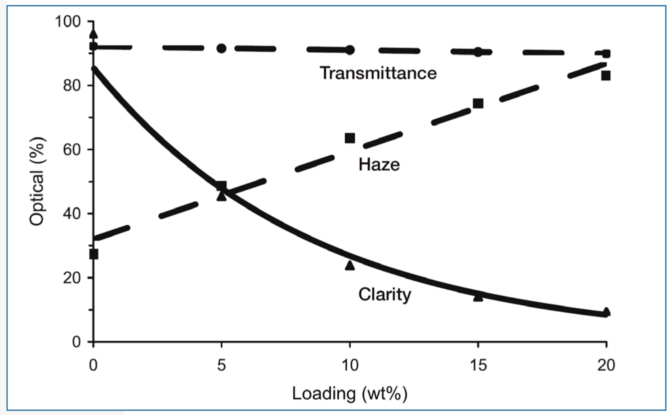

Figure 4: Measurements of optical properties – transmittance (T), haze (H), and clarity (C) – of 6 mils LDPE films obtained of barefoot and four different MINBLOC loadings.

Optical properties

Optical properties of the thermal film are important for crop growth. It is generally accepted that total visible light transmittance must be at least 80%. Table 2 compares transmittance values at 10 wt% filler loading. Fillers help to diffuse the light by scattering, which is beneficial for most crops. Haze and clarity are measures of wide and narrow angle scattering, respectively; diffused light has high haze and low clarity. With higher filler loading, haze increases and clarity decreases as shown in Figure 4. Good additives have very high transmittance and high haze, even at high loadings. A comparison of optical properties for different additives is made in Table 2.

*1 mil = one thousandth of an inch = 25.4 micron

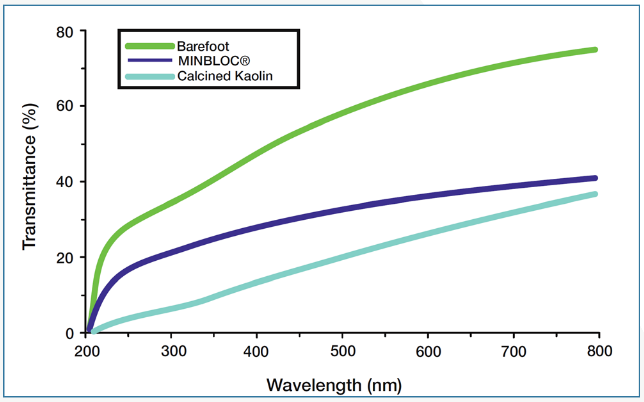

Figure 5: UV-Vis spectra of thermal films filled with different additives at 10 wt% loading. The PAR range is from 400 to 700 nm.

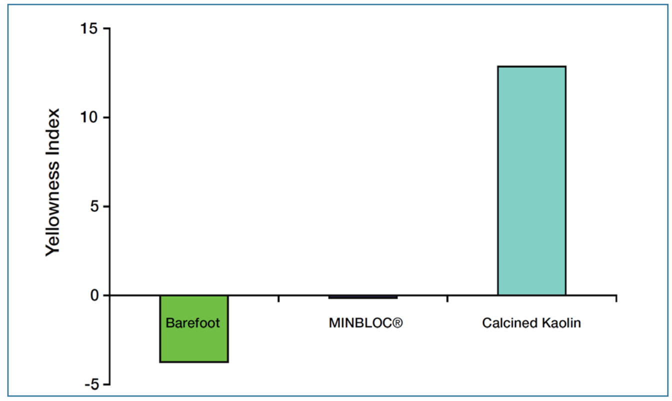

Figure 6: Yellowness Indices measured according to ASTM E313 for film rolls (roll color). Film with calcined kaolin is much more yellow than the other films.

Crops require that sufficient PAR light (Photosynthetically Active Radiation, i.e., 400 to 700 nm) passes through the film. The amount of visible light passing through the film at each wavelength is affected by the additive. Figure 5 shows the UV-Vis spectra of barefoot, MINBLOC and calcined kaolin filled films. With longer wavelength, transmittance increases. This is observed as relatively less blue light passing through the film causing the film to appear more yellow-brownish as can be measured by the Yellowness Index. Measurements of roll colors are shown in Figure 6. Discoloration is caused at least in part by the iron content. Calcined kaolin has relatively high iron content which produces films that appear yellowish. It should be noted that discoloration is often due to degradation of organics, such as additives, surface treatment, or resin. In this study, there was no degradation of organics, as verified by FTIR.

Resistance to breakdown

It is generally believed that service life of a film is affected by the concentration of transition metals in the film. Additives with high transition metal content, such at calcined kaolin, are expected to reduce the service life. In contrast, MINBLOC has very low transition metal content. Iron oxide content is listed in Table 1.

Greenhouse cover films must be mechanically strong to withstand long term environmental exposure, sometimes extending over several years of service. Moreover, films must have sufficient mechanical strength to be processed during film blowing without bubble breakage. Due to the unique engineered particle size distribution, MINBLOC can be added at a very high loading, up to 20 wt%, without degrading the tensile properties of the film as shown in Figures 7 and 8. This allows for the manufacturing of thermal films with exceptionally good thermal and optical properties.

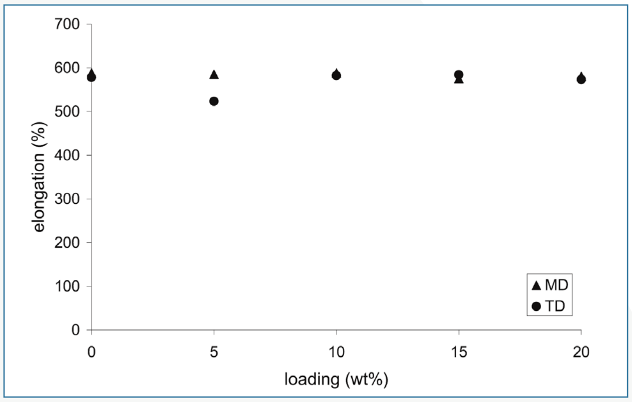

Figure 7: Elongation at break for 6 mils films containing MINBLOC.

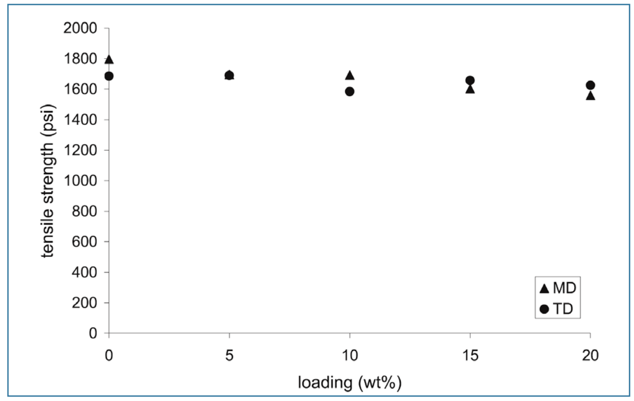

Figure 8: Tensile strength at break for 6 mils films containing MINBLOC.

Advantages of MINBLOC

MINBLOC offers a unique balance of optical and thermal properties as compared to the industry's best film additives. As a result of its engineered particle size distribution, very high loadings that provide excellent thermal properties are possible without degrading physical performance. Due to its low surface area, low porosity and general chemical inertness MINBLOC does not absorb, interfere with or diminish the effectiveness of other expensive formulation components such as antioxidants, processing aids, and light stabilizers. The narrow particle size distribution of MINBLOC minimizes large particles, thereby reducing abrasion of plastics processing equipment as confirmed by the Einlehner abrasion test. MINBLOC also contains very low levels of residual iron, a known prodegradant, which not only reduces yellowness but also helps extend service life.

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