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Quality Compounds Require Premium Talc Grades and Sophisticated Formulations

by

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Summary

Talc is a natural mineral, occuring with different mineralogy, chemical analysis, and morphology. These paramaters have a big influence on mechanical and stabilization properties. Heat stabilization systems using different talc sources in the world were investigated in order to identify their influence of heavy metals and morphology. The testwork had been done by IMI-Fabi (Italy), in cooperation with Superlab (Italy), as well as by CIBA Additives(Switzerland).

The thermal stability depends on the crystallinity of a talc, its specific surface and its heavy metal content. The influence of heavy metals, e.g. Fe, Cr, Mn, on the degradation values of a PP compound heavily depends on where the metal ion is linked to, either at the inner silicate lattice, bound as a carbonatic bymineral, or as sulfide or magnetite. In addition, the crystallinity of a talc has the strongest impact, as some high purity talc products show a significant decrease in thermal stability.

This paper discusses the differences of the world's talc grades, their suitability for PP-compounds, and it offers some proposals for stabilization.

There are many types of talc

The term "**talc**" does not express the diversity of this mineral in nature. On the one hand "talc" is a pure magnesium-hydrate-silicate, on the other hand, it is a general term for a polymineralic rock. **Pure talc** has the chemical formula: $Mg_3[Si_4O_{10}(OH)_2]$. Purest talc grades are available in China, India, and Australia. Talc is most frequently accompanied by "chlorite", where the Mg^{2+}-ion has been substituted by Al^{3+} - or Fe^{3+} - ions (France, Austria, Italy, USA, etc). To compensate the different loadings of the Al^{3+} - or Fe^{3+} -ions compared to the Mg^{2+}-ion, an additional Brucite-layer is added at the Chlorite modification. The Fe^{3+}-ion of a chlorite talc is mainly linked to the chlorite-layer where a part of the Al^{3+} is substituted. Nevertheless, this Fe^{3+} is not available for any chemical reaction or interchange as many studies have certified. **Chlorite** has a lamellar structure as well, with similar properties as pure talc in most of the typical applications. Its theoretical formula is $(Mg,Al,Fe)_{12}(Si,Al)_8O_{20}(OH)_{16}$. The typical color is green (chloros=light green) to opaque.

Other by-minerals are Carbonates, Mica, Serizit, Quartz, and in some rare cases Tremolite. Apart from the mineralogy, talc and chlorite deposits are classified by brightness and platy structure (aspect ratio). The lamellar talc is the most common modification. The more compact talc is extremely rare in Europe (Germany, Spain), but can be found in Australia and the USA. The industrial talc grades used in automotive polypropylene compounds contain chlorite & talc in most cases. Electro- and domestic appliances require high purity talcs for reasons of brightness.

[1] HiPro Trading is the export organization of IMI-Fabi, Italy.

White talcs have a low content of impurities. The European talc mines do not contain a lot of white talc showing brightness levels above 90. Their volume is not exciting compared to the importance of white talc for the plastics industry. As the European market has a much higher demand for white talc grades, the talc mining industry has been importing material from overseas' countries, most of it arriving from China (Liaoning, Guangxi), as well as Australia (Mt.Seabrook). However, we have to mention that not all talcs arriving from China are of good quality, as the industry is too fragmented. Only few of the more than 100 mines have suitable qualities available.

Differences of Talc Grades in Practice

Talc de Luzenac pioneered the development of talc grades in PP during the 70's and 80's. Owing to the good quality and availability of the French source and the ambitious development work, a range of medium and high purity talc products were offered to the compounding industry. Compared to some other Western European countries, a quite different development took place in Italy: IMI-Fabi started initially as a supplier of lower brightness talc grades with a low carbonate content, but higher iron content and they developed a special range of products with a high cost performance in PP. Their customers at the compounding industry enabled and supported the use of those grades by utilizing more sophisticated stabilization systems. Today, markets became more uniform, more competitive, and these IMI Fabi talcs are used all over Europe, as well as in overseas countries, due to high cost performance.

Thermal Stability - the big issue

Following a common, yet inprecise argumentation, mineralogy and iron-content are responsible for thermal stability. The general slogan was : "the purer the talc, the better the heat stability". Unfortunately, the experience showed that the story is not as simple as it had been explained by some parties. Only in some cases a conformity with practical results could be found.

MINERALOGICAL PURITY

Looking at different products with high talc content, we find that purity alone is not the decisive factor.

	1	2	3	4	5	6
	Australian Talc	Mount Seabrook Australia	India	Italy	China	Italy
D-98	20 my	20 my	10my	15 my	20 my	30 my
talc [%]	98	98-99	97	92	99	60-65
chlorite	2	1	2	5	1	20-25
carbonate	0	0-1	1	2	0	10-15
morphology	microcrystalline	platy	platy	platy	platy	mixed
Fe [%]	1	0,7	0,6	0,9	0,2	2,8
BET [m^2/g]	13-15	9-10	10	7	9-10	3-4
stability at 150 °C [d]	8	40	28	40	40	26

formulation : 60 % PP-Homopolymer (Moplen C30G); 40 % Talc; 0,10 % Irganox 1010; 0,15 %; Sandostab PEPQ, 0,25 % DSTDP, 0,25 % Ca-stearat

In this case, one of the theoretically pure Australian talcs shows very poor thermal stability values for a white & pure talc. The higher Fe-content of Talc 4 in comparison to Talc 5 does not seem to have any influence on standard compounds.

Another test-serie came up with similar results:

Talc source	France	South Korea	India	Norway	Norway
D 98	45 my	70 my	10 my	70 my	10 my
talc [%]	80	90	97	55	55
chlorite	18	8	2	13	13
carbonate	2	3	1	33	33
Fe [%]	0,7	0,5	0,2	5,0	5,0
degradation [d] at 150 °C	70	64	29	28	12

formulation : 60 % PP-Homopolymer, MFI 2-3, 40 % Talc, 0,1 % Ca-stearat, 0,1 % Irganox 1010, 0,3 % DSTDP;0,5 %Araldite ST 7072

The chemical analysis alone does not allow any conclusions as to the thermal degradation behavior of different talc grades. The cristallinity of the talc and the resulting specific surface have a strong influence. The fineness of the talc grades also have important effects on degradation properties. Micronized talcs with similar BET show similar results. The higher specific surface and the subsequent higher absorption of stabilizers seem to overweigh the differences in iron-content.

CHEMICAL PURITY - THE Fe-CONTENT

The Fe^{3+}-ions can be located within the crystal-lattice of the mineral, forming a solid solution within the dolomite and/or magnesite. The major part of the Fe-ions in a chlorite-talc is linked to the crystal-lattice of the chlorite. Fe as magnetite, pyrite, etc., can be separated by magnetic separation. IMI-Fabi ran intensive testing programs to identify the type and the liberation size of the iron. As a suitable testing material, IMI-Fabi provided industrial scale talc products, with about 85-90 % talc content, some chlorite, and about 10 % of carbonates. The total iron content is about 4 %. The aim was the identification of a material in which all magnetics are liberated, but the lowest possible content of talc is included. We could identify a 1% separation to be the optimum, containing the whole amount of the magnetic constituents. This magnetic-separable mass of 1 % consists of approx. 20-40 % magnetite (that makes 0,3 to 0,4 % of the talc). The balance is intergrown chlorite-talc and carbonate.

Talc before magnetic separation	20		20	
Talc after magnetic separation		20		20
CarbonBlack Batch 50% in PE[2]	0	0	1,50	1,50
Irganox 1010			0,21	0,21
Irgafos 168			0,07	0,07
Irganox PS802			0,40	0,40
hours at 150 °C	72	144	1030	1030

formulation : Eltex 658, 20 % filling rate

[2] Type Schulman 1850

In addition to these testings, a French talc was included because of its low iron content in order to check its influence concerning thermal stability in relation to the standard talc.

Talc before magnetic separation, 20 my	20		
Talc after magnetic separation, 20 my		20	
French Talc, 20 my			20
Loss on ignition	10-11 %	10-11%	9%
Fe-content	3,5-4 %	3,5-4 %	< 2 %
Masterbatch Black	1,50	1,50	1,50
thermal degradation 150 °C [h]	570	565	555

Formulation : Moplen T30G, 20% filling rate, 0,14 % Irganox 1010, 0,07 % Irgafos 168, 0,3 % PS802

Considering the standard deviations of the tests, those results show that there are no differences between those talc grades in regard to thermal stability !

The conclusion of these testings are :

- the iron content has an influence concerning thermal stability; in case the Fe-ion is bound to the magnesite, its influence is big. If it is bound to the chlorite lattice, there is little influence.
- the texture of the talc product has a much stronger impact; microcrystalline talc types (Yellowstone-USA, Three Springs-Australia) with high surfaces reduce thermal stability significantly
- carbon black has a similar effect due to its high specific surface.

CIBA Additives investigated different stabilization systems using a homologous range of talc products provided by IMI-Fabi :

- industrial talc products of IMI-Fabi's Italian mine with increasing fineness
- high purity talc from Liaoning (China), ground and micronized by IMI-Fabi

IMI-Fabi investigated a further type

- high purity talc from Mt.Seabrook (Australia), micronized by IMI-Fabi

	unit	talc	chlorite	carbonates	Fe-content	source
grey talc	%	70-75	15-20	10-12	3	Italy
white talc	%	99	0,5	0,5	0,4	China
white talc	%	99	0,5	0,5	0,7	Australia

		grey 1	grey 2	grey 3	China 1	China 2	China 3	Australia
D-98	microns	15	10	8	14	10	8	8
D-50	microns	2,5	2,2	1,8	2	1,8	1,4	1,4
BET	m^2/g	7	10	11	10	11	12	12
w/o CarbonBlack								
0,4% Chimasorb	150 °C, d	33	33	27	52	47	45	46
0,3 % Irganox 1010 0,6 % Irg.PS 802	150 °C, d	24	19	10	32	39	38	39
0,3 % Irganox 1010 0,6 % Irg.PS 802 0,5 % Araldit GT 7072	150 °C, d	66	64	57	121	127	118	120
+1 % Flammruß 101								
0,4% Chimasorb	150 °C, d	33	27	27	41	45	38	40
0,3 % Irganox 1010 0,6 % Irg.PS 802	150 °C, d	17	18	10	24	38	24	28
0,3 % Irganox 1010 0,6 % Irg.PS 802 0,5 % Araldit GT 7072	150 °C, d	45	45	39	62	63	60	63

Base formulation : Profax 6501, 20 % Talc, 0,15 % Irganox B215, 0,05 % CaSt., 0,03 % DHT-4A

The addition of Araldit improves the thermal stability significantly for both, the pure and industrial talc grades. The sensitivity concerning carbon black still exists.

The introduction of the Chimasorb stabilizers reduces sensitivity concerning Fe-content and carbon black to a minimum, also compensating most of the influence of the increasing specific surface. In addition, Chimasorb systems implement a UV-resistance.

We are aware that these formulations contain a certain rate of stabilizers as we targeted to reach best possible spread of the results. In practice these dosage rates must be adopted to the standard demands of the industry.

Ciba Additives

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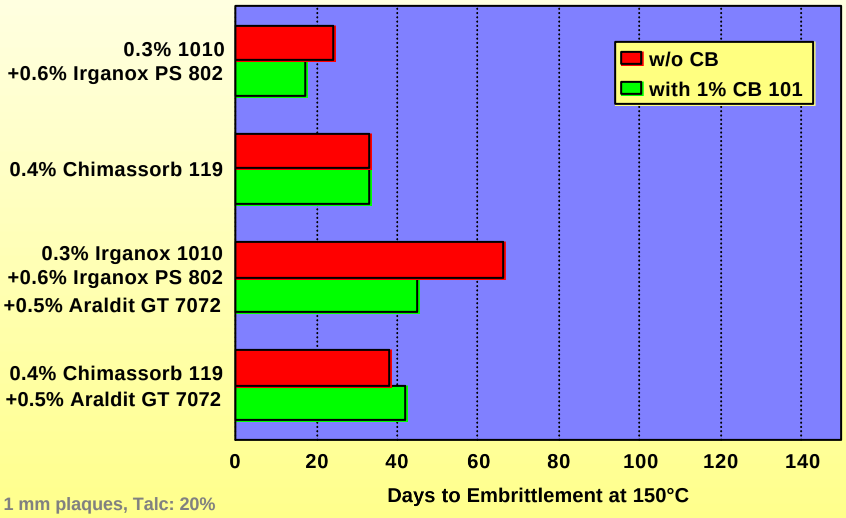
Thermal Stability of Talc Filled PP
IMI - Fabi, Italy

Talc CM2



1 mm plaques, Talc: 20%
Polymer: PP, Profax 6501
Base stabilization: 0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A

Fig. 1

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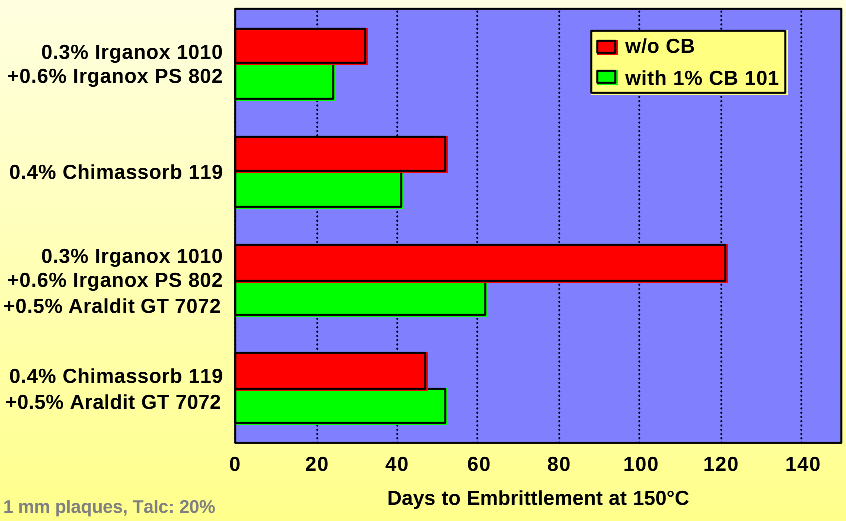
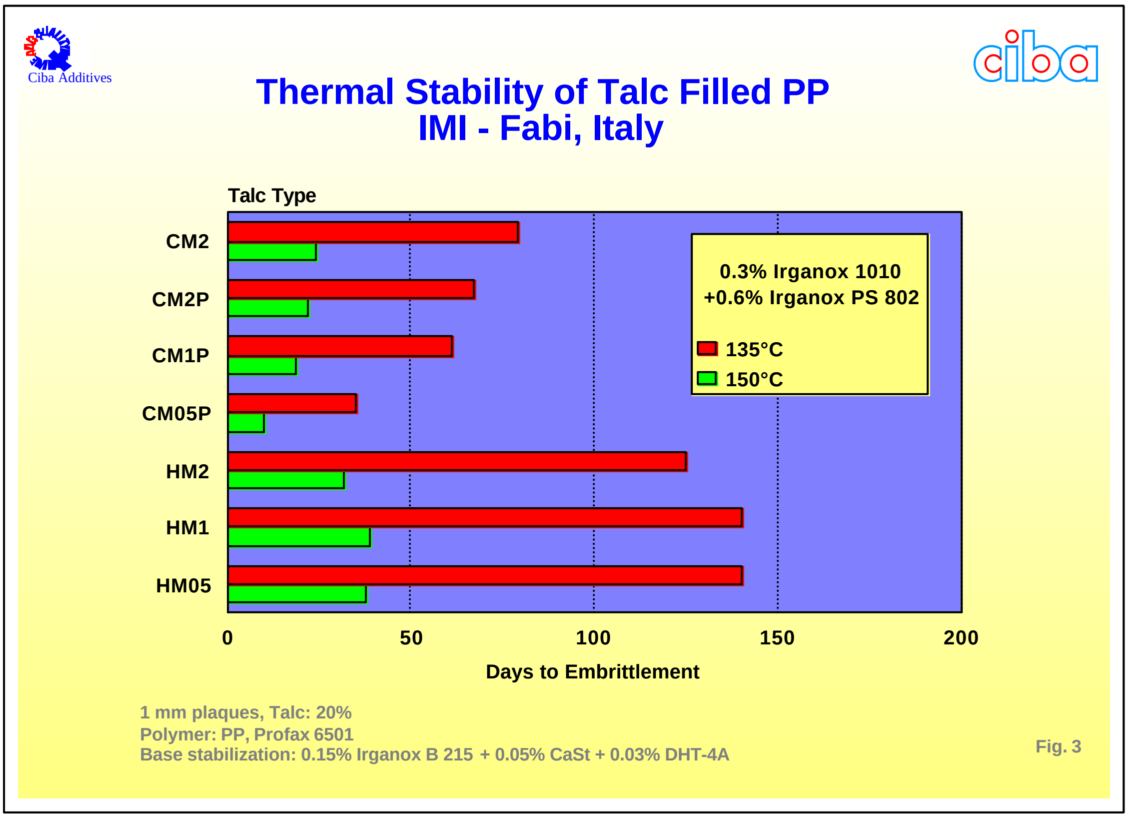
Thermal Stability of Talc Filled PP
IMI - Fabi, Italy

Talc HM2



1 mm plaques, Talc: 20%
Polymer: PP, Profax 6501
Base stabilization: 0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A

Fig. 2



Ciba Additives
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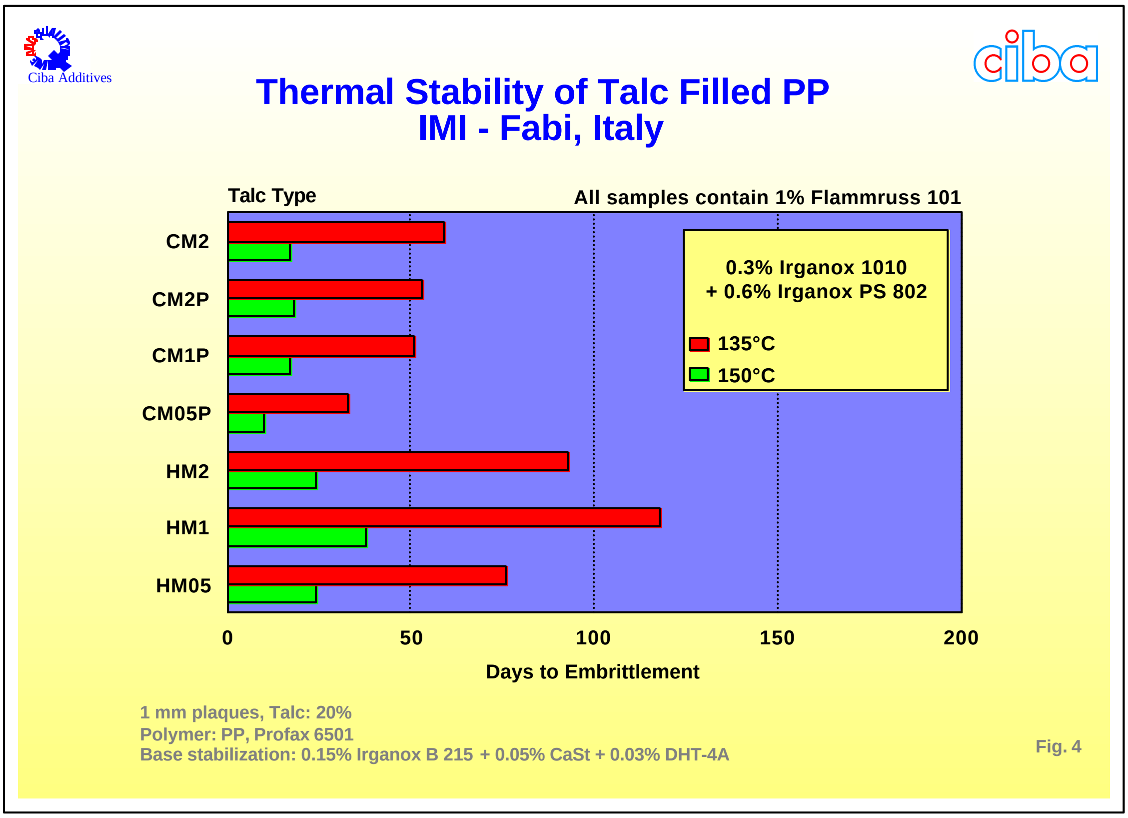
Thermal Stability of Talc Filled PP
IMI - Fabi, Italy
Talc Type
CM2
CM2P
CM1P
CM05P
HM2
HM1
HM05
0.3% Irganox 1010
+0.6% Irganox PS 802
135°C
150°C
0
50
100
150
200
Days to Embrittlement
1 mm plaques, Talc: 20%
Polymer: PP, Profax 6501
Base stabilization: 0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A
Fig. 3



Ciba Additives
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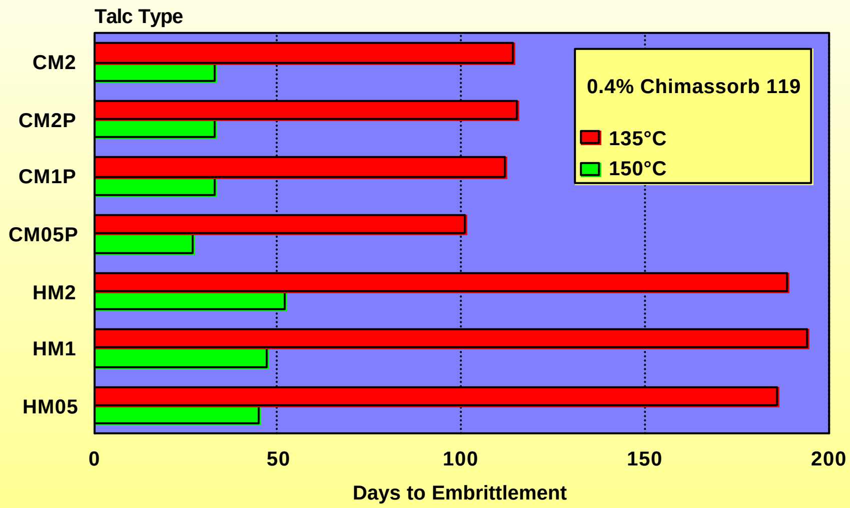
Thermal Stability of Talc Filled PP
IMI - Fabi, Italy
Talc Type
All samples contain 1% Flammruss 101
CM2
CM2P
CM1P
CM05P
HM2
HM1
HM05
0.3% Irganox 1010
+ 0.6% Irganox PS 802
135°C
150°C
0
50
100
150
200
Days to Embrittlement
1 mm plaques, Talc: 20%
Polymer: PP, Profax 6501
Base stabilization: 0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A
Fig. 4

Ciba Additives

Thermal Stability of Talc Filled PP
IMI - Fabi, Italy

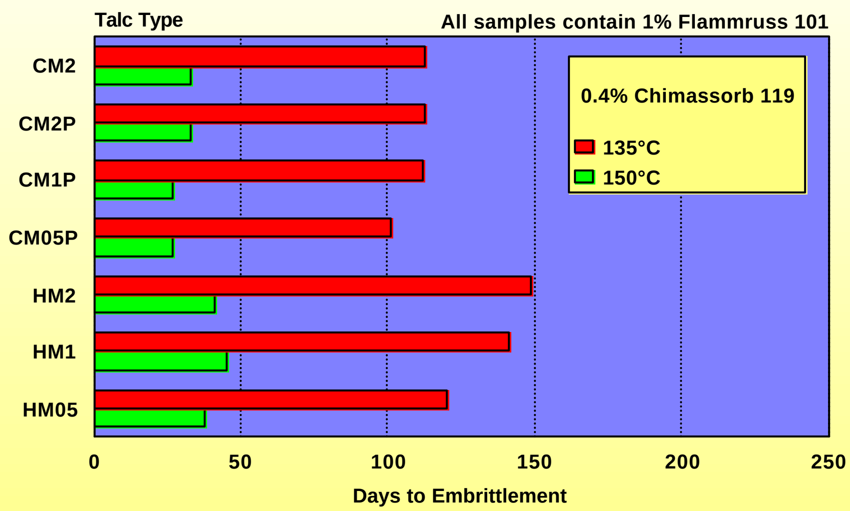


1 mm plaques, Talc: 20%
Polymer: PP, Profax 6501
Base stabilization: 0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A

Fig. 5

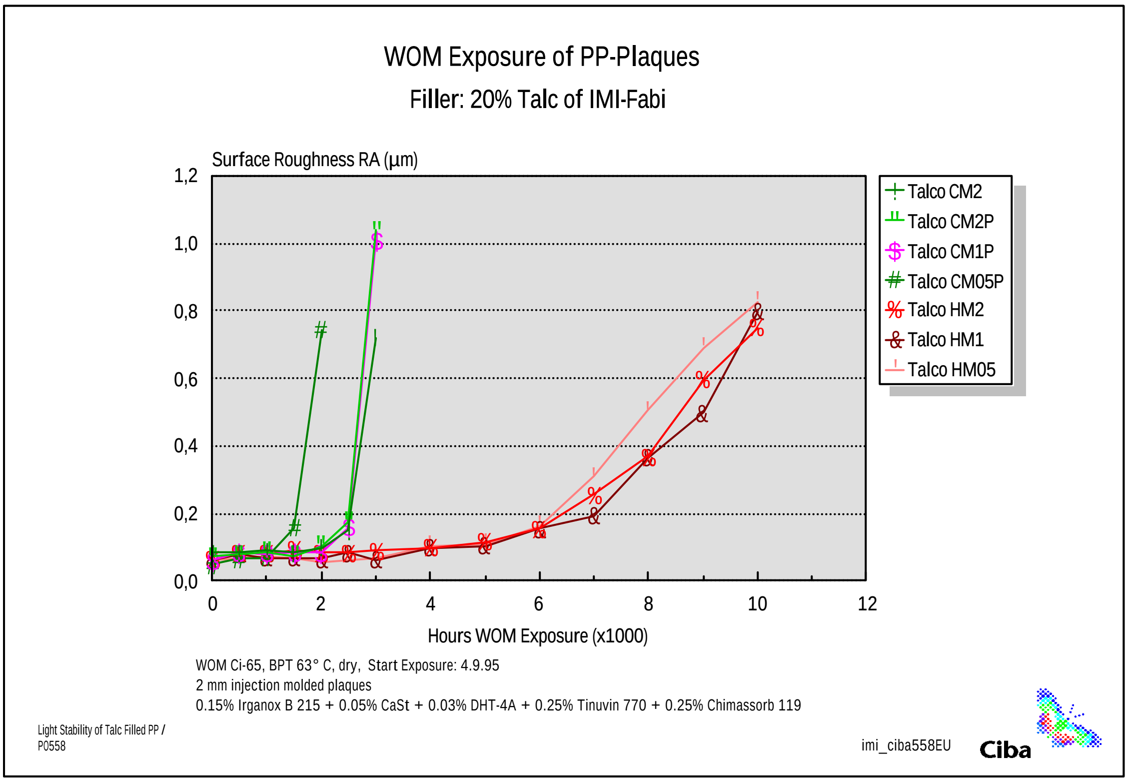
Ciba Additives

Thermal Stability of Talc Filled PP
IMI - Fabi, Italy

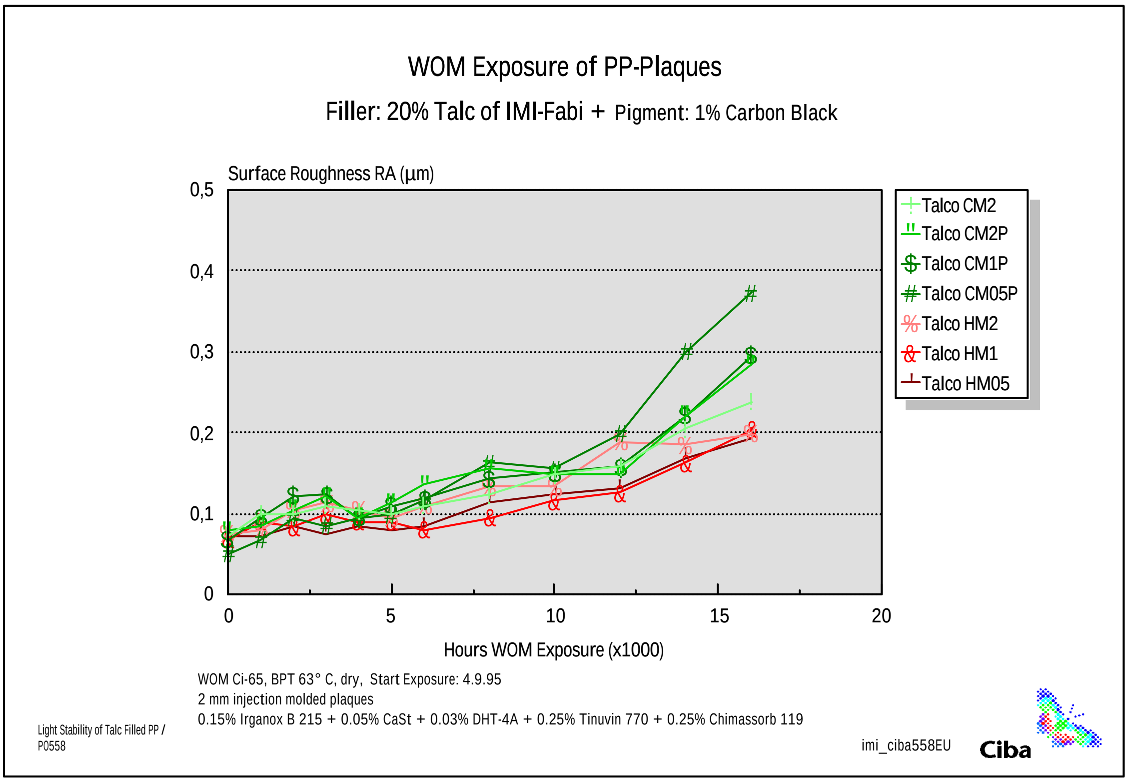


1 mm plaques, Talc: 20%
Polymer: PP, Profax 6501
Base stabilization: 0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A

Fig. 6



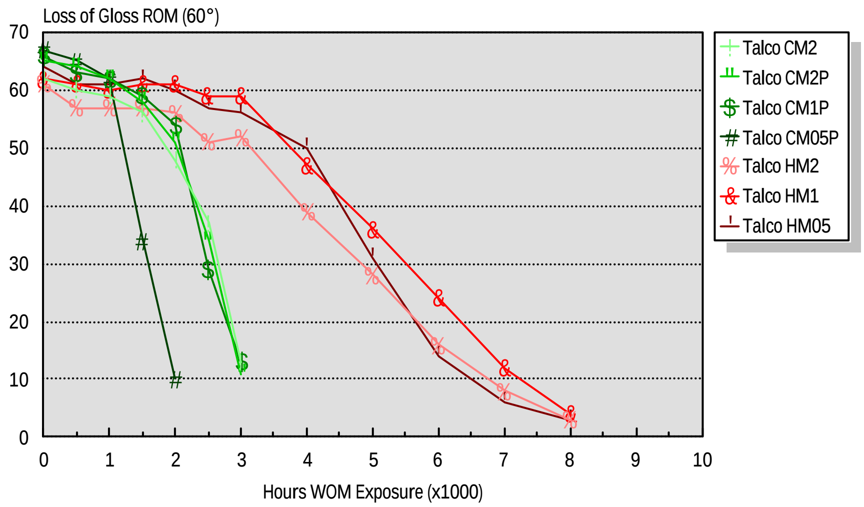
WOM Exposure of PP-Plaques
Filler: 20% Talc of IMI-Fabi
Surface Roughness RA (µm)
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0
2
4
6
8
10
12
Hours WOM Exposure (x1000)
Talco CM2
Talco CM2P
Talco CM1P
Talco CM05P
Talco HM2
Talco HM1
Talco HM05
WOM Ci-65, BPT 63° C, dry, Start Exposure: 4.9.95
2 mm injection molded plaques
0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A + 0.25% Tinuvin 770 + 0.25% Chimassorb 119
Light Stability of Talc Filled PP /
P0558
imi_ciba558EU
Ciba



WOM Exposure of PP-Plaques
Filler: 20% Talc of IMI-Fabi + Pigment: 1% Carbon Black
Surface Roughness RA (µm)
0,5
0,4
0,3
0,2
0,1
0
0
5
10
15
20
Hours WOM Exposure (x1000)
Talco CM2
Talco CM2P
Talco CM1P
Talco CM05P
Talco HM2
Talco HM1
Talco HM05
WOM Ci-65, BPT 63° C, dry, Start Exposure: 4.9.95
2 mm injection molded plaques
0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A + 0.25% Tinuvin 770 + 0.25% Chimassorb 119
Light Stability of Talc Filled PP /
P0558
imi_ciba558EU
Ciba

WOM Exposure of PP-Plaques

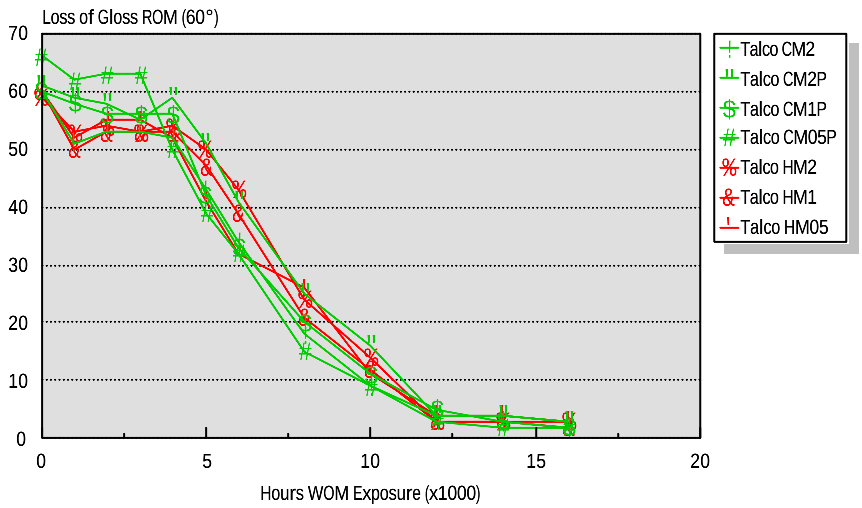
Filler: 20% Talc of IMI-Fabi



WOM Ci-65, BPT 63° C, dry, Start Exposure: 4.9.95
2 mm injection molded plaques
0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A + 0.25% Tinuvin 770 + 0.25% Chimassorb 119

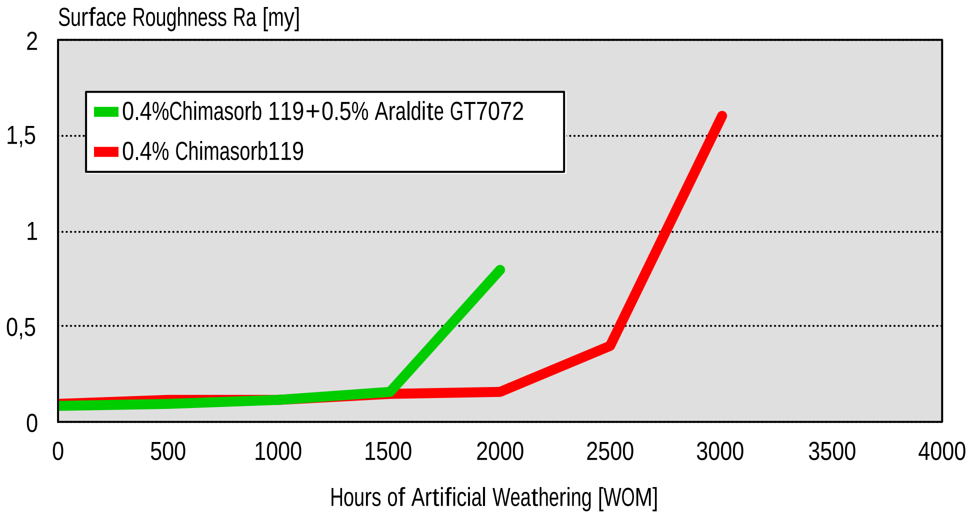
WOM Exposure of PP-Plaques

Filler: 20% Talc of IMI-Fabi + Pigment: 1% Carbon Black



WOM Ci-65, BPT 63° C, dry, Start Exposure: 4.9.95
2 mm injection molded plaques
0.15% Irganox B 215 + 0.05% CaSt + 0.03% DHT-4A + 0.25% Tinuvin 770 + 0.25% Chimassorb 119

Influence of Araldite on Talc filled PP



Base: 0.15% Irganox B215 + 0.05% Ca-stearate +0.03% DHT 4A
Filler : 20 % Talc CM2P of IMI-Fabi, 20 my topsize

Ciba Additives

Light Stability of Talc Filled PP
Conclusions

- **Light stability was evaluated by monitoring**
  - surface roughness
  - loss of gloss
  as function of WOM exposure time

- **Talc performance ranking:**

  HM2 @ HM1 @ HM05 > CM2 @ CM2 P @ CM1 P > CM05 P

- **Carbon black improves the light stability of all samples, however, no differentiation yet between different talc types after 6000 h WOM**

Thermal Stability of Talc Filled PP
Conclusions

- **Long-term thermal stability was evaluated by measuring the time to embrittlement at 135°C and 150°C**

- **Talc performance ranking:**

  HM2 @ HM1 @ HM05 > CM2 @ CM2 P @ CM1 P > CM05 P

This ranking is valid
- **for both stabilization systems (I-1010 / DSTDP or C-119)**
- **with and w/o carbon black**
- **with and w/o filler deactivator**
- **at both temperatures tested**

Ciba Additives

Thermal Stability of Talc Filled PP
Conclusions

- **Effect of stabilizer system (all talc types):**

w/o CB:

w/o Araldite:	**0.4% C-119 > 0.3% I-1010 / 0.6% DSTDP**
with Araldite:	**0.3% I-1010 / 0.6% DSTDP > 0.4% C-119**

with 1% CB:

w/o Araldite:	**0.4% C-119 > 0.3% I-1010 / 0.6% DSTDP**
with Araldite:	**0.3% I-1010 / 0.6% DSTDP @ 0.4% C-119**

Thermal Stability of Talc Filled PP
Conclusions

- **Effect of filler deactivator (Araldite 7072):**

Irganox 1010 / DSTDP

Significant improvement of all talcs, with and w/o CB

Chimassorb 119

w/o CB:	**- improvement of CM talcs** **- no significant effect on HM talcs**
with 1% CB:	**- improvement of all talcs**

Thermal Stability of Talc Filled PP
Conclusions

- **Effect of carbon black:**

  Irganox 1010 / DSTDP

  Reduction of thermal stability of all talcs, with and w/o Araldite

  Chimassorb 119
  w/o Araldite: - no significant effect on CM talcs
  - reduction of thermal stability of HM talcs

  with Araldite: - effect on CM talcs dependent on talc type
  - no significant effect on HM talcs