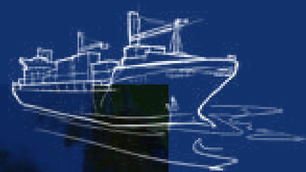
Part of the ROCKWOOL Group

Fire Protective Coatings

Reinforced passive fire protection by Lapinus®



Welcome to ROCKWOOL

Our purpose
Release the natural power of stone to enrich modern living

At the ROCKWOOL Group, we are committed to enriching the lives of everyone who comes into contact with our solutions.

Our expertise is perfectly suited to tackle many of today's biggest sustainability and development challenges, from energy consumption and noise pollution to fire resilience, water scarcity and flooding.

Our range of products reflects the diversity of the world's needs, supporting our stakeholders in reducing their own carbon footprint along the way.

Stone wool is a versatile material and forms the basis of all our businesses. With approx. 10,500 passionate colleagues in 38 countries, we are the world leader in stone wool solutions, from building insulation to acoustic ceilings, external cladding systems to horticultural solutions, engineered fibres for industrial use to insulation for the process industry and marine & offshore.

ROCKWOOL
Firesafe insulation for all types of buildings and installations

Lapinus
Engineered stone wool solutions for global industries

Grodan
Precision growing for the horticultural industry

Rockpanel
Exterior cladding for buildings

Rockfon
Acoustic ceiling and wall solutions

North America

3 stone wool factories,
2 ceiling grid plants

1,000 employees

Europe

16 stone wool factories,
3 ceiling tile plants,
1 ceiling grid plant,
1 facade panel plant,
2 wall systems components plants

7,100 employees

Russia

4 stone wool factories,
1 ceiling tile plant

1,300 employees

Asia

5 stone wool factories,
1 ceiling tile plant

1,100 employees

This is Lapinus

Lapinus is the world leader in precision-engineered stone wool solutions. We develop and supply versatile and innovative products that help global industries to improve quality of life.

Our products are used in a wide range of applications, including friction, water management, tracks, coatings, gaskets and fences.

With more than a quarter-century of expertise and experience, we work closely with customers to adapt to their ever-changing needs, from water management to fire safety, vibration isolation to noise and dust emission reduction.

Made from 100% stone, our sustainable products contribute to shaping a better world for today and tomorrow.

Lapinus is part of the ROCKWOOL Group.

Lapinus
Towards a more sustainable future

Release the natural power of stone to enrich modern living

At Lapinus, we are dedicated to provide solutions that will enable everybody to improve the future. Within the global industry we identify trends and challenges driving the development of tomorrows' products. Using our knowledge of stone wool we design solutions that have a positive impact on safety, emissions, noise, vibration, water management and will improve the quality of life. By developing and sharing our own knowledge and expertise we contribute to solving the challenges of our customers.

Our contribution to a sustainable future.

Ensure safety
All Lapinus products are made from natural stone and are biosoluble. They are safe for humans and the environment.

Reduce fine dust emissions
Friction formulations reducing wear of car brakes contribute to a reduction of fine dust emissions.

Control vibration
Rail tracks with reduced ground-borne vibrations have a positive influence on a comfortable living environment.

Reduce noise
Car brakes that produce less noise and fences that reduce ambient noise result in a healthier society.

Manage water
Water management systems that actively regulate water contribute to a resilient infrastructure and sustainable modern living.

Disseminate knowledge
We generate knowledge and share it with our stakeholders to help solve their challenges.

To address the global challenges, the UN has identified **17** UN **Sustainable** Development **Goals**:

As part of the ROCKWOOL Group, we actively contribute towards achieving **10** of the 17 goals.

Together with our group, we are **committed** to the **sustainable goals** by **2030**:

Health, Safety and Wellbeing:
- Driving a zero accident culture

10% reduction in LTI per year **0** fatalities per year

CO_2 Emissions and Energy:
- Reduce CO_2 from factories ($t\ CO_2$/t Wool)

10% by 2022 **20%** by 2030

- Improve energy efficiency in own (non-renovated) building stock kWh/m^2

35% Savings by 2022 **75%** Savings by 2030

Water Management:
- Reduce water consumption in factories (m^3/t Wool)

10% by 2022 **20%** by 2030

Circular Economy:
- Increase the number of countries where we offer reclaiming of products from the market

15 countries by 2022 **30** countries by 2030

- Reduce landfill waste

40% by 2022 **85%** by 2030

Intumescent coating for fire protection

An intumescent coating is the perfect way to protect both simple and complex constructions. It allows the design of elegant steel structures as they no longer need to be covered by thick fire-proofing materials.

An intumescent coating looks like any ordinary coating under normal conditions but foams in case of a fire. This process is called “intumescence”. The foam forms a thick fire resistant char when exposed to high temperatures. The char forms a protective layer around the structure, which prevents it for a certain period of time from reaching the critical temperature at which the stability of the structure can no longer be guaranteed. In this way, an intumescent coating allows more time for evacuating a building and extinguishing the fire before the structure loses its strength and collapses.

Lapinus products, such as Lapinus CF and Lapinus MS fibres, are used in intumescent coatings to help formulators worldwide meet ever increasing requirements and new regulations. The fibres are registered as Note Q fibres. This implies that they are safe to use without any risks to people and the environment. With its stable product quality, supply chain and R&D activities, Lapinus is a solution provider for the intumescent coating industry.

Modern intumescent products:

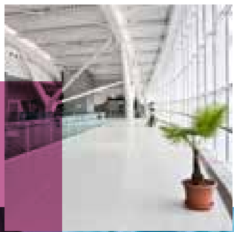
- provide passive fire protection without the need for maintenance;
- provide corrosion protection;
- are aesthetic because the films applied are thin;
- offer long protection times of up to 3 hours;
- protect filigree structures;
- are cost-efficient;
- meet regulations and standards worldwide;
- are durable.

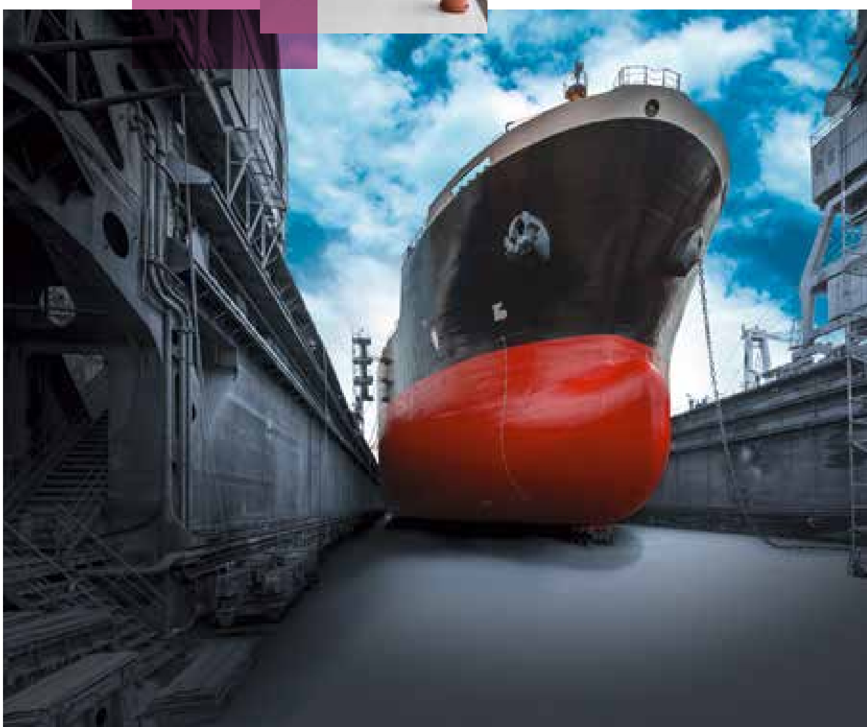
In the building and offshore industry

Intumescent coatings may look just like normal paint and can be applied using standard application methods such as brush, roller or spray. They are used in areas where passive fire protection is an absolute must, such as the on- and offshore and building and construction industries. The use of intumescent coatings allows oil rig operators to meet the strict regulations for protecting employees and equipment in case of a fire. In the building and construction segment, intumescent coatings allow engineers and architects to design complex structures without compromising safety. In both cases, a complex chemical solution is waiting inside the coating for just that single yet undesired moment when it may need to become active.

The intumescent reaction is initiated at a temperature of approximately 200 °C (392 °F). Initially, the reaction absorbs heat and emits inert gases. In combination with the melting of the binder, an effective insulation layer is created which turns into a char. The reactions taking place inside the intumescent coating:

- decomposition of the acid donor (e.g. APP) forms polyphosphoric acid;
- reaction between polyphosphoric acid and the carbon donor (e.g. pentaerythritol) forms an inorganic/organic ester;
- decomposition of the blowing agent (e.g. melamine) releases gases causing the ester to create a foam; at higher temperatures, the foam turns into a char, forming an insulating barrier which adheres to the substrate;
- crosslinking reaction including TiO_2 leads to an inorganic char, allowing the insulating barrier to stay in place even when no organic material is left.





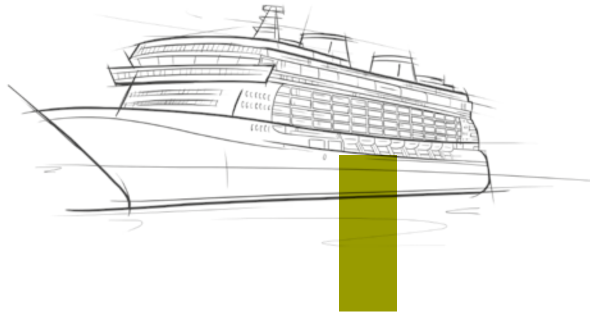
Key properties determining the performance of an intumescent coating

Finding the optimal combination of these parameters is essential in the development of a successful intumescent coating. Lapinus fibres are an additive with a proven track record of supporting intumescent paint producers with their development work.

Lapinus fibres in intumescent paint formulations:

- reinforce the char structure and improve fire resistance;
- increase cost efficiency;
- are safe to use for people and the environment;
- ensure high consistent performance.

Over the years Lapinus has continuously invested in R&D capabilities to increase application knowhow for intumescent coatings. This brochure summarizes the results of the development work.



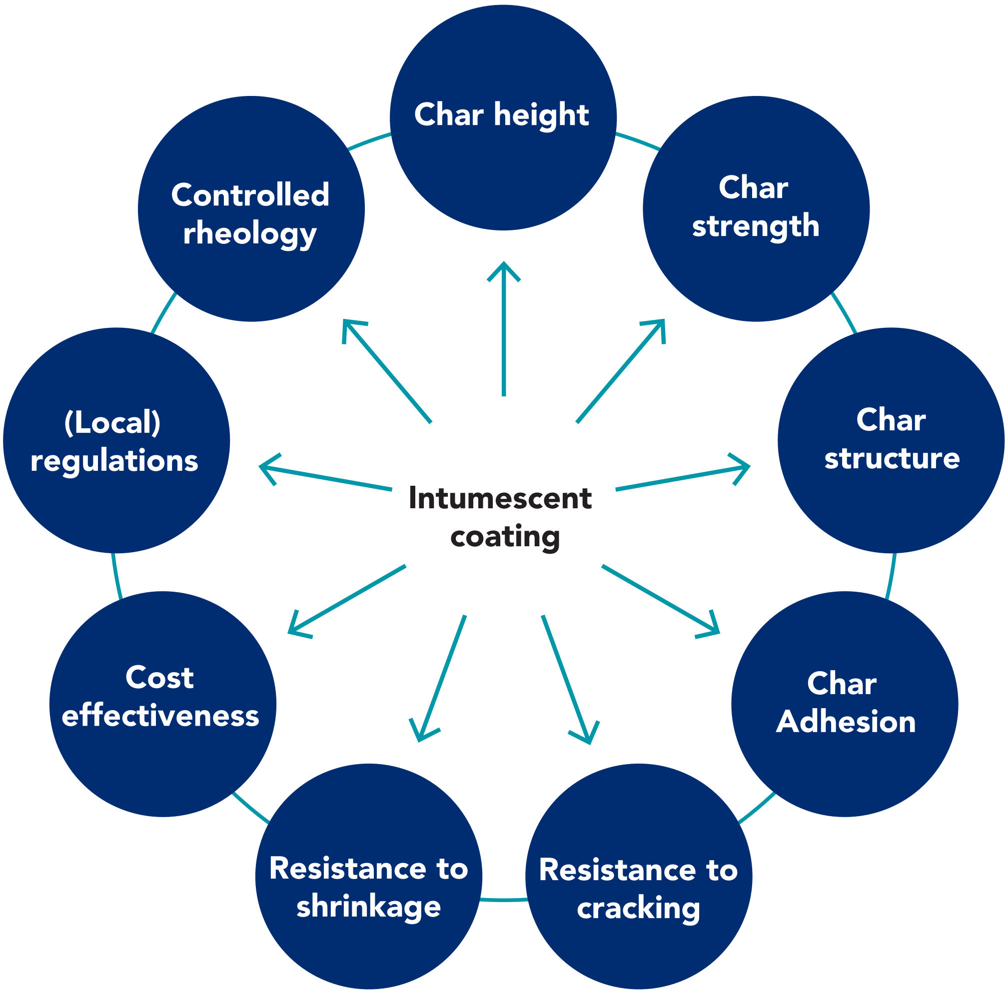
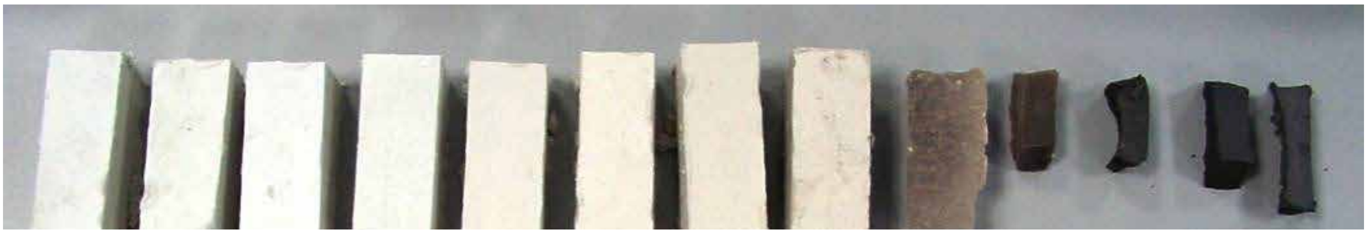


Figure 1 *Important parameters for the development of intumescent coatings*

Lapinus fibres reinforce the char structure

Their high thermal and dimensional stability make Lapinus fibres a very suitable raw material for intumescent coatings. Lapinus CF fibres are dimensionally stable up to a temperature of approx. 750 ˚C (1380 °F).

Lapinus MS fibres maintain their shape even above 1000 ˚C (1830 °F).
This is shown by the dimensional stability of blocks consisting of fibres and starch (as a binder) at increasing temperatures.



nr.	1	2	3	4	5	6	7	8	9	10	11	12	13
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832

Figure 2 *Lapinus CF*

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 3 *Lapinus MS*

Figure 4 *Lapinus CF*
700 °C (1292 °F)

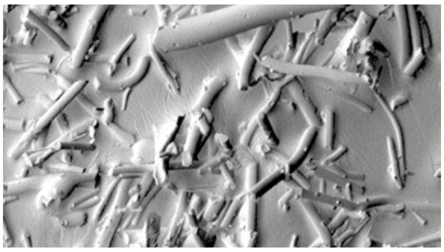


Figure 5 *Lapinus CF*
800 °C (1472 °F)

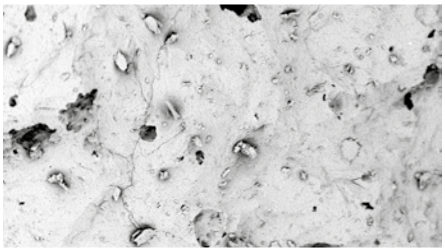


Figure 6 *Lapinus CF*
900 °C (1652 °F)

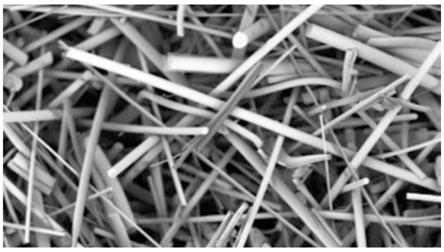


Figure 7 *Lapinus MS*
700 °C (1292 °F)

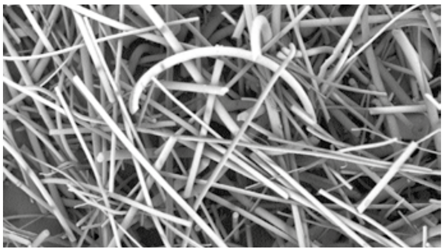
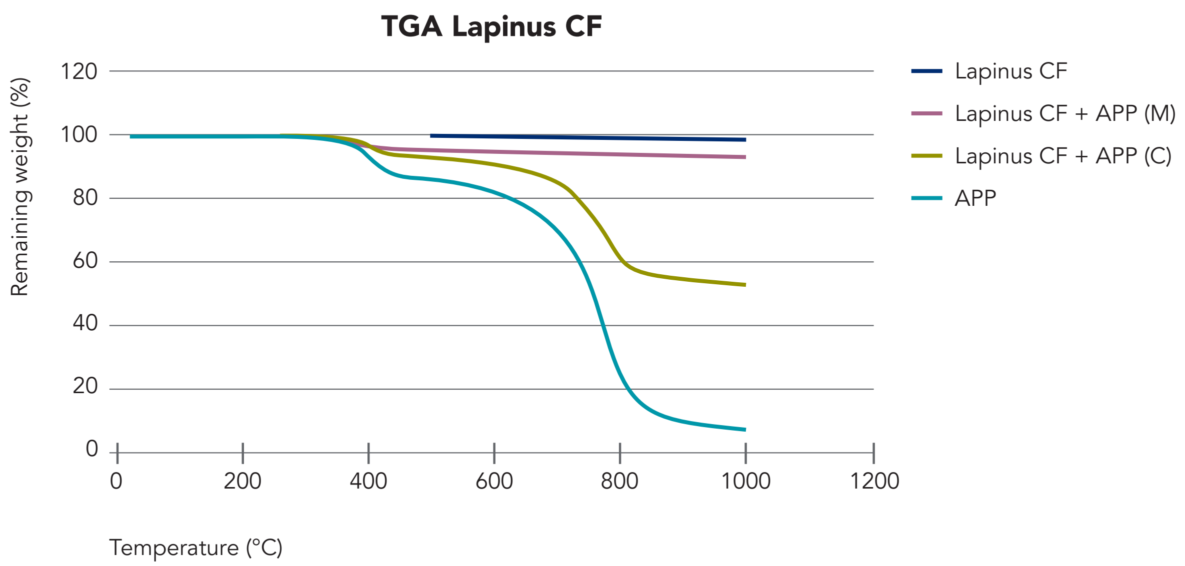


Figure 8 *Lapinus MS*
800 °C (1472 °F)

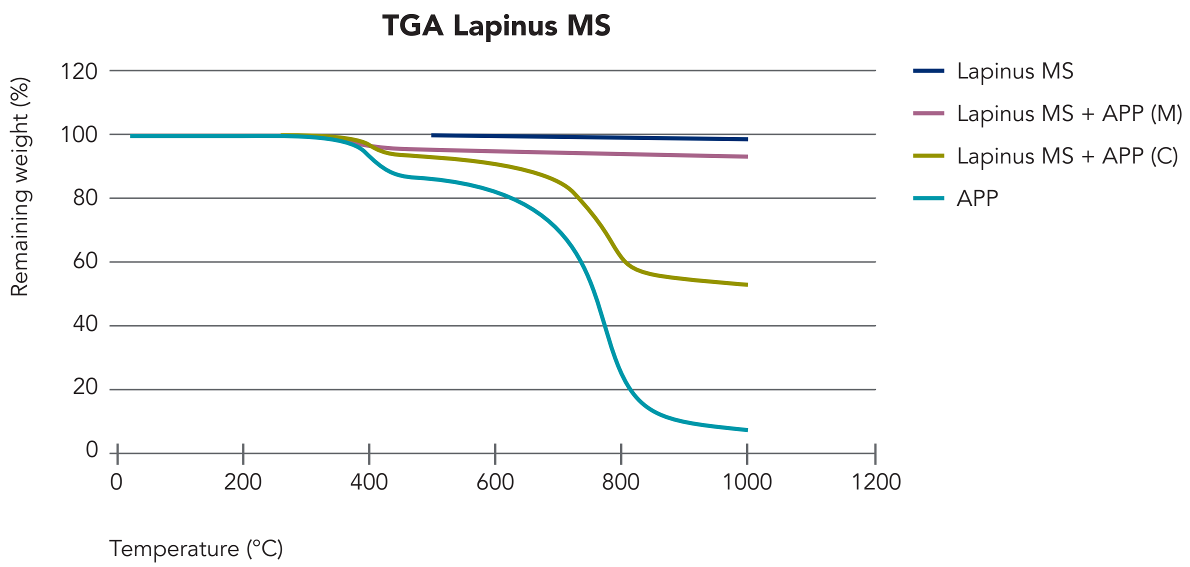
Figure 9: *Lapinus MS*
900 °C (1652 °F)

Lapinus CF fibres have proved their value in cellulosic fire applications although they show lower heat resistance compared to Lapinus MS fibres. Research has shown that their role is different. Lapinus MS fibres maintain their shape and therefore give a physical reinforcement to the char. Lapinus CF fibres reinforce the char structure in a chemical way. The explanation for this behaviour can be found in TGA (thermogravimetric) experiments, in which Lapinus fibres are mixed with APP (one of the main components of intumescent coatings) at a 1:1 weight ratio.

In both cases, the yellow line (C) indicates the Calculated value of weight loss vs. temperature for a 50:50 mixture of fibres and APP; the green line indicates the Measured value (M). The fact that the measured value is significantly higher than the calculated value shows that APP reacts with Lapinus fibres. The resulting product, containing Lapinus CF fibres, has a higher dimensional stability, as is shown in figure 10 and figure 15. APP has hardly any impact on the dimensional stability of Lapinus MS fibres.



Graph 1 *TGA Lapinus CF*



Graph 2 *TGA Lapinus MS*

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 10 *Lapinus CF + APP*

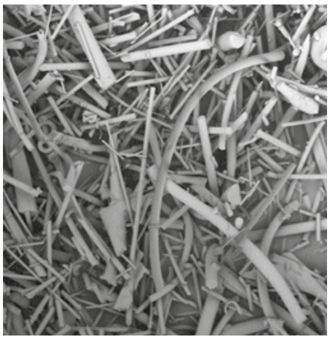


Figure 11
Lapinus CF + APP
700 °C (1292 °F)

Figure 12
Lapinus CF + APP
850 °C (1562 °F)

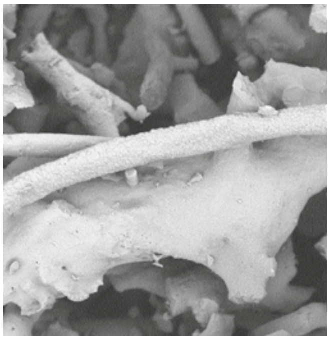


Figure 13
Lapinus CF + APP
1100 °C (2012 °F)

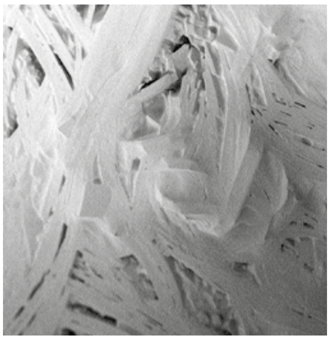


Figure 14
Lapinus CF + APP
1250 °C (2282 °F)

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 15 *Lapinus MS + APP*

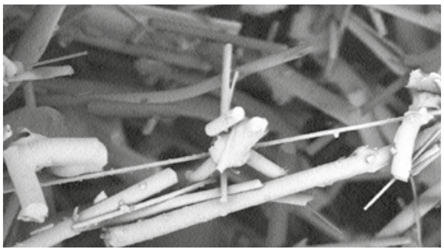


Figure 16
Lapinus MS + APP
700 °C (1292 °F)

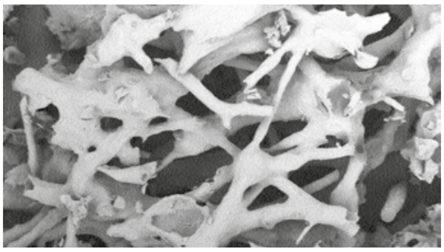


Figure 17
Lapinus MS + APP
1000 °C (1832 °F)

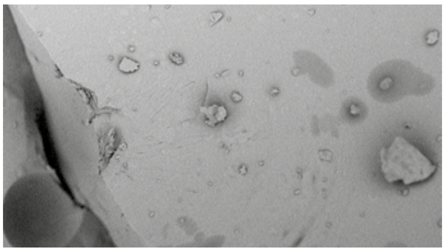


Figure 18
Lapinus MS + APP
1250 °C (2282 °F)

Due to the reaction between APP and the fibres, the Lapinus CF fibres, whose initial dimensional stability is lower than that of Lapinus MS fibres, provide approximately the same level of dimensional stability when combined with APP.

Reactivity with TiO_2

Besides reactivity with APP, there is also reactivity between Lapinus CF fibres and TiO_2. This cannot be visualized with TGA experiments, as there is no weight loss when both products react with each other, but the dimensional stability tests using the blocks make things clear.

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 19 *Lapinus CF + TiO2*

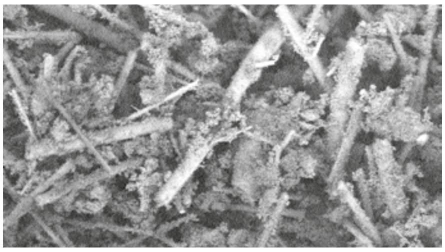


Figure 20
Lapinus CF + TiO2
800 °C (1472 °F)

Figure 21
Lapinus CF + TiO2
850 °C (1562 °F)

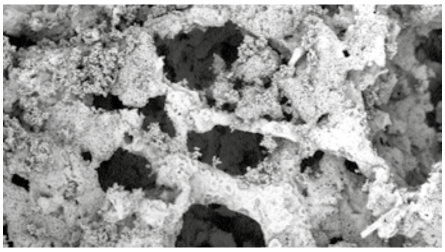


Figure 22
Lapinus CF + TiO2
1000 °C (1832 °F)

Up to a temperature of 1000 °C, the fibrous structure of the Lapinus CF fibres is maintained thanks to the reactivity between both components. With Lapinus MS fibres, there is no reactivity between both components up to 1000 °C. The fibres and TiO_2 simply exist next to each other.

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 23 *Lapinus MS + TiO2*

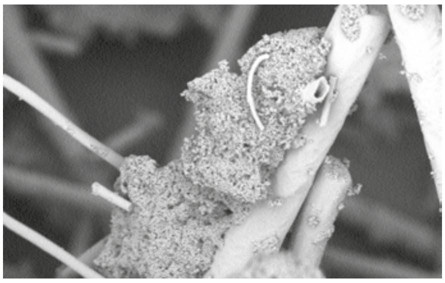


Figure 24 *Lapinus MS + TiO2*
1000 °C (1832 °F)

Reactivity with APP and TiO2

If the fibres are combined with APP and TiO2, similar results are seen regarding dimensional stability for the Lapinus CF and Lapinus MS fibres.

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 25 *Lapinus CF + APP + TiO2*

Figure 26
Lapinus CF + APP + TiO2
600 °C (1112 °F)

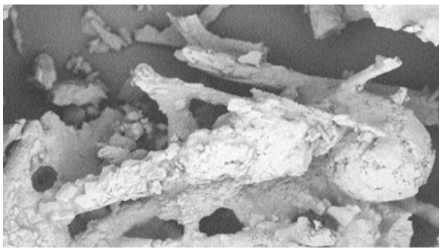


Figure 27
Lapinus CF + APP + TiO2
1100 °C (2012 °F)

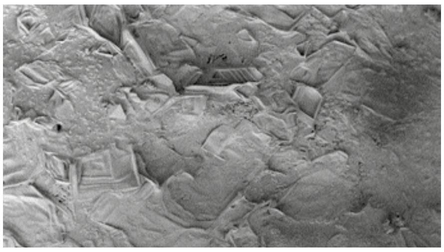


Figure 28
Lapinus CF + APP + TiO2
1250 °C (2282 °F)

nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
°C	200	300	400	500	600	650	700	750	800	850	900	950	1000	1150	1250
°F	392	572	752	932	1112	1202	1292	1382	1472	1562	1652	1742	1832	2102	2282

Figure 29 *Lapinus MS + APP + TiO2*

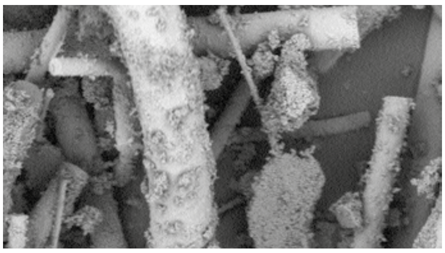


Figure 30
Lapinus MS + APP + TiO2
600 °C (1112 °F)

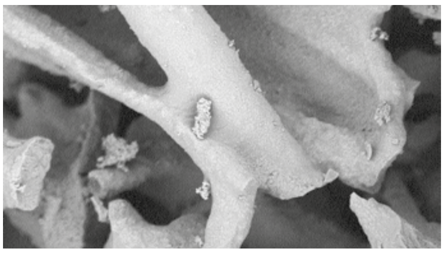


Figure 31
Lapinus MS + APP + TiO2
1100 °C (2012 °F)

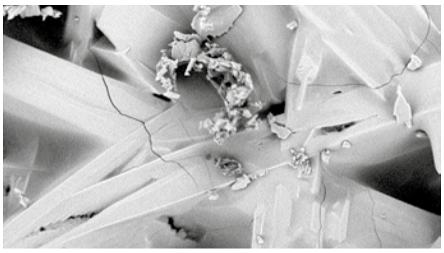


Figure 32
Lapinus MS + APP + TiO2
1250 °C (2282 °F)

The above information shows that the fibres interact with at least two of the key components present in an intumescent formulation. It also shows that the differences in initial dimensional stability between Lapinus CF and Lapinus MS should not automatically be considered a drawback.

Lapinus fibres increase cost efficiency

All results are based on the following reference formulation:

Waterborne WB formulation (PVC ~ 80%)

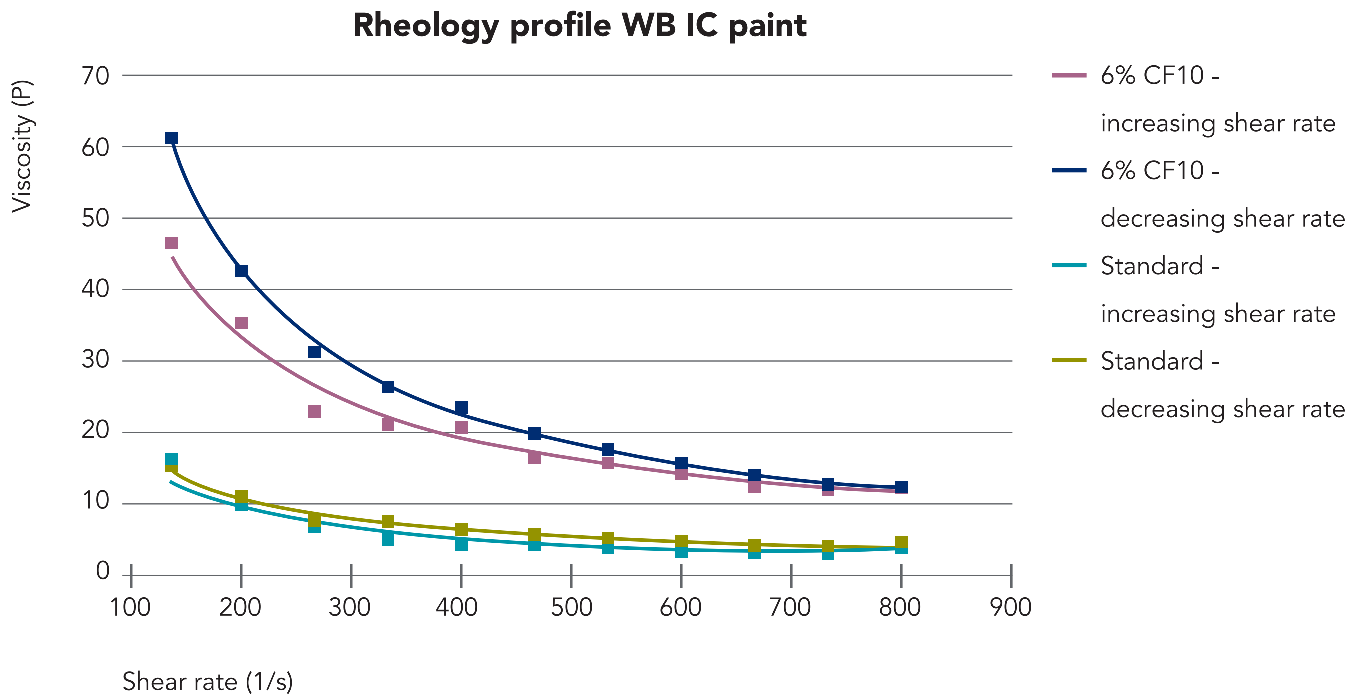
	Chemical	Mass [g]	Mass[g]
1	Ammonium polyphosphate	28.49	28.49
2	Melamine	12.17	12.17
3	Pentaerythritol	11.36	11.36
4	Titanium dioxide	13.97	13.97
5	Vinylacetate/VeoVa 10	18.75	18.75
6	Water	14.28	14.28
7	5% Xanthan gum	0.98	0.98
	Sub total	100.00	100.00
8	Lapinus fibres	3.00	6.00
	Grand total	**103.00**	**106.00**

Table 1 *Waterborne WB formulation (PVC - 80%)*

Adding Lapinus fibres to the intumescent paint is cost-effective because it enables the application of thicker paint layers.

1. The fibres prevent the paint from sagging easily

The addition of fibres increases viscosity (see Graph 3). At high shear rates the impact is limited. At low shear rates, however, the difference becomes more significant. These rheological characteristics allow the applicator to apply thicker layers because the tendency of the paint to sag is reduced.



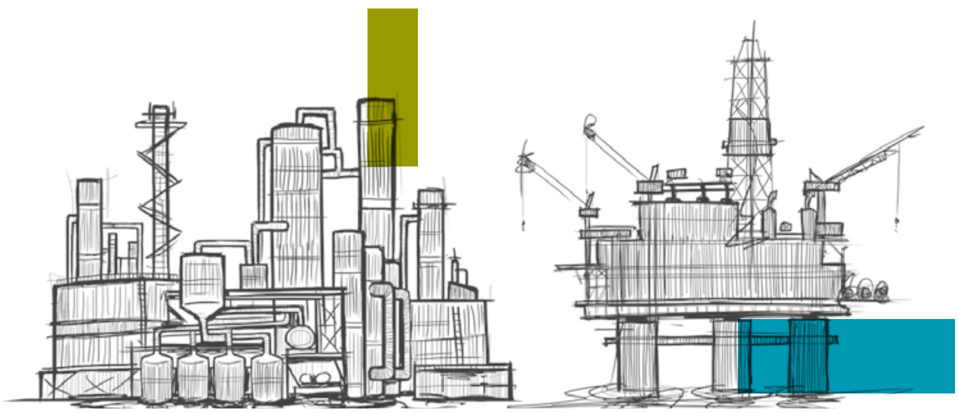
Graph 3 *Rheology profile WB IC paint*

2. The fibres reduce crack formation

Applying thick film waterborne paints can result in mud-cracking of the paint film. The reinforcing properties of Lapinus fibres prevent the formation of such cracks during drying, resulting in a closed and stronger coating. Applying thicker film layers which have a reduced tendency to sag, in combination with the elimination of cracking, greatly reduces labour costs due to the decrease in coating sequences required to reach the desired dry film thickness. Thicker films help in achieving improved fire rating, although this is also depending on the exact composition of the intumescent paint formulation.

Elimination of mud-cracking

Figure 33 *Elimination of mud-cracking*



Controlling char parameters

The use of Lapinus CF10 in the waterborne formulation results in a reduced tendency to slump, as shown in figure 34 and 35.

The formulation used in figure 34 contains no fibres, resulting in sagging of material to the bottom half of the test panel. With 6% Lapinus CF10 (figure 35), the slumping is significantly reduced, which is shown by a more evenly distributed char layer.
The following table shows the effect of fibre chemistry, amount and length on the properties of an intumescent char.

Figure 34 *Reference*

Effect of fibre properties on char parameters

Parameter	Chemistry		Amount			Length		
	Lapinus MS	Lapinus CF	0%	3%	6%	125 µm	300 µm	500 µm
Char height	+	-	0	-	--	+/-	+	+/-
Char strength	-	+	0	+	+	+	-	+/-
Char adhesion	+/-	+/-	0	+	++	+/-	+	+/-

Table 2 *Effect of fibre properties on char parameters*

Table 2 shows that Lapinus MS fibres have the least impact on char height. The more fibres present in the formulation, the larger their impact on this property. When we look at fibre length, the medium length fibres have the least impact on char height; the difference between the influence of short and long fibres is limited.

Figure 35
+ 6% Lapinus CF10

In relation to char strength, it is clear that using 3% or 6% of short Lapinus CF fibres in the formulation leads to the strongest char.

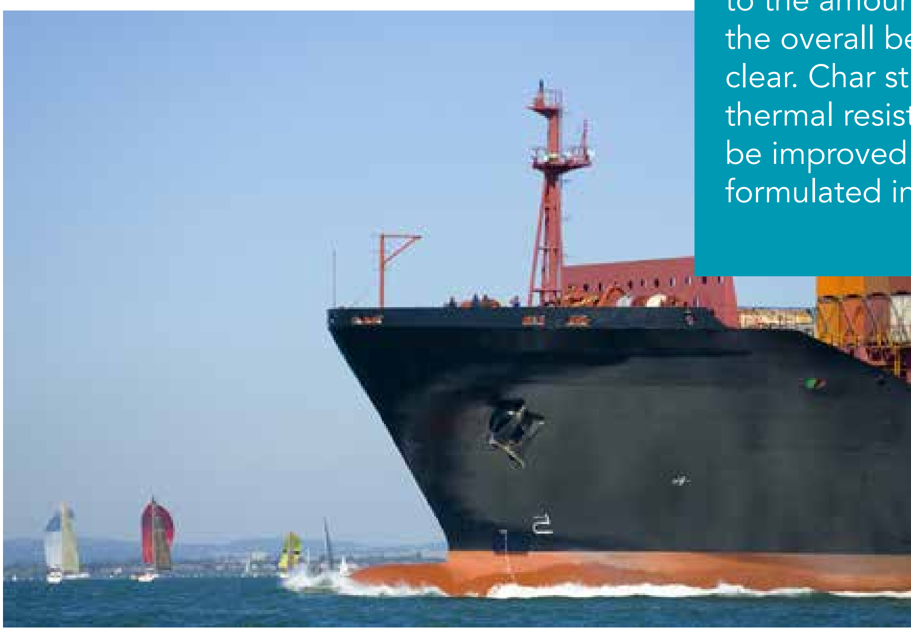
Finally, the chemistry of the fibres doesn't seem to have any effect on the adhesion of the char to the substrate. Their presence, however, does have a positive effect, most pronounced when fibres of medium length are used.

Using Lapinus fibres
in an intumescent formulation

- allows the application of thick paint layers because the fibres support shear thinning behaviour of the paint;
- allows the application of thick paint layers because the fibres prevent the formation of cracks during drying;
- leads to a more controlled foam formation by preventing slumping behaviour in the early stages of the intumescent process;
- leads to a more controlled char formation by regulating char height;
- leads to the formation of a stronger, longer lasting char which helps in reaching longer fire protection times;
- leads to an improved adhesion of the char to the substrate, thereby also leading to a longer-lasting char.

Additional remarks

The addition of Lapinus fibres to an existing formulation worked well for the formulations tested. However, we recommend optimizing the formulation in order to fully benefit from the use of fibres in intumescent systems. The same applies to the amount of fibres to be used. But the overall benefits of using fibres are clear. Char strength, char yield and char thermal resistance characteristics can all be improved if Lapinus fibres are properly formulated into an intumescent system.



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