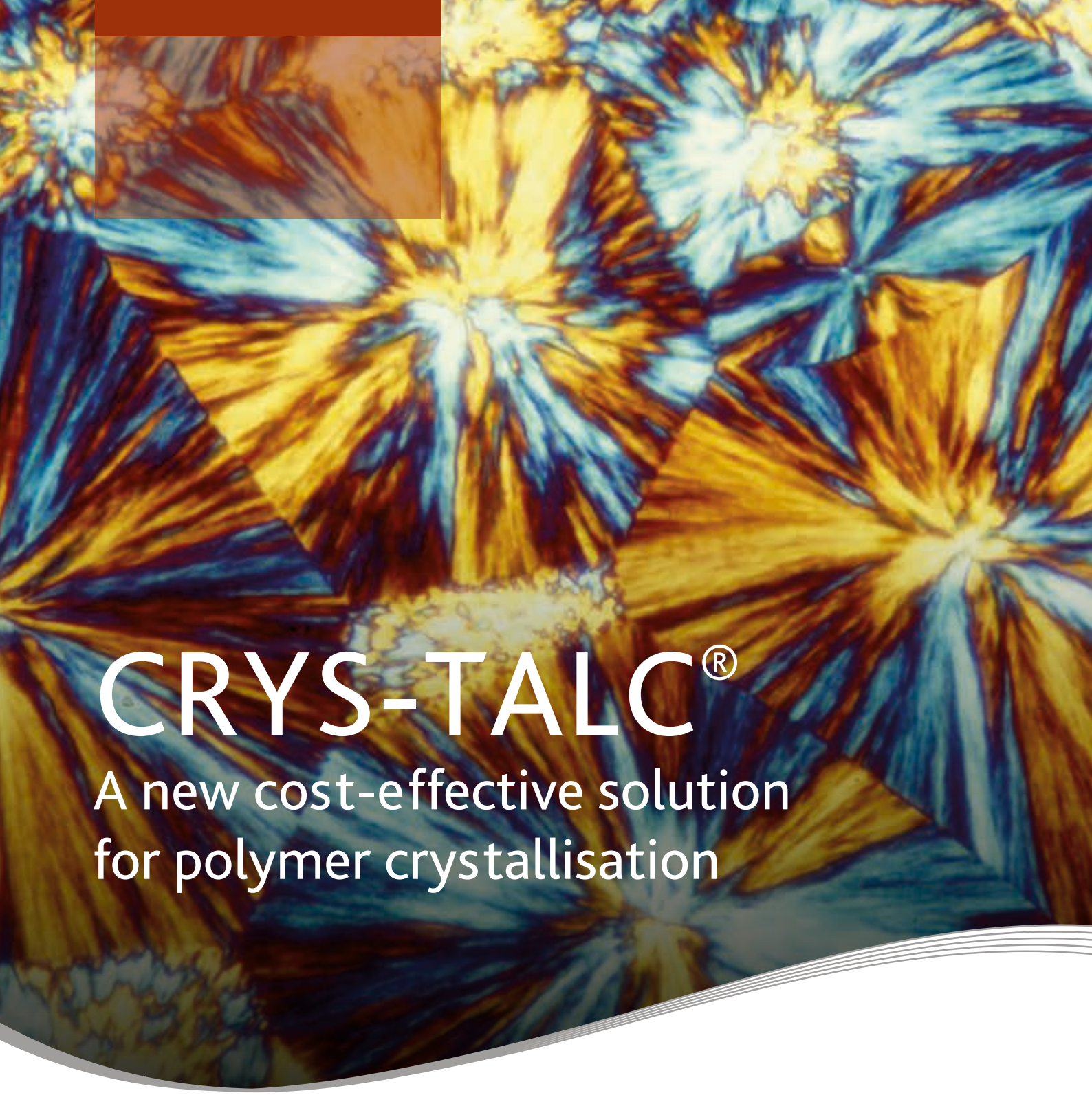

CRYS-TALC®

A new cost-effective solution for polymer crystallisation

- Optimum performance in homopolymer and copolymer polypropylene
- Improves rigidity and impact resistance
- Increases injection-moulding and extrusion output by 10 to 15%
- Excellent mixing behaviour and dispersion

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IMERYS

Performance Additives

INTRODUCTION

Polypropylene (PP) has become the material of choice for injected and extruded plastic parts.

One reason for this is its superior cost/performance ratio. Recent progress in polymerisation technology has resulted in a very broad spectrum of PP grades, ranging from rigid, highly isotactic products to soft and highly ductile thermoplastic olefin (TPO) grades.

The apparent rigidity of PP is influenced by its molecular weight and weight distribution as well as its polymer chain structure which has an impact on the level of crystallinity.

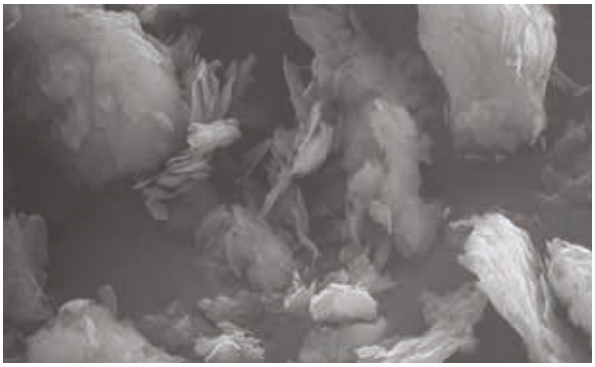
As a semi-crystalline resin, PP will only crystallise up to a certain level. Used as a nucleating agent, talc influences the way and the speed at which the resin crystallises, significantly improving mechanical performance in terms of rigidity, impact resistance and heat deflection temperature.

For maximum efficiency, we recommend Imerys' new nucleation product range, Crys-Talc®, at addition rates of 0.5 to up to 5%.

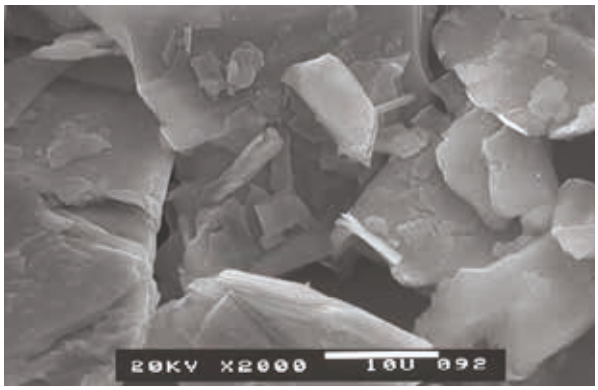
CRYS-TALC®

Crys-Talc® is a new, high brightness, micro-lamellar talc development which is suited to all kinds of nucleation applications.

Figure 1. Micro-lamellar talc compared to conventional lamellar talc

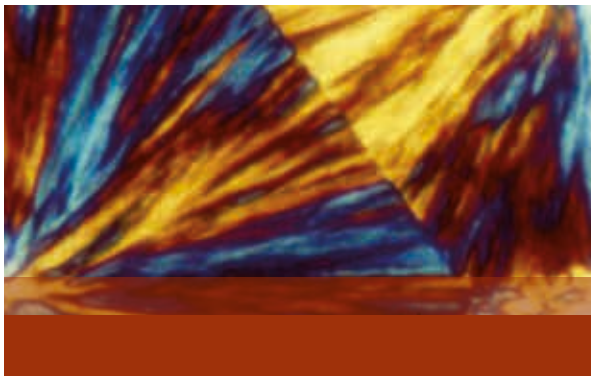


Crys-Talc® micro-lamellar talc with a high specific surface area showing higher number of nuclei centers



Conventional lamellar talc

Micro-lamellar Crys-Talc® contains many more ultrafine particles than conventional lamellar talc of similar fineness of grind. This difference can be seen clearly when we convert a Sedigraph® particle size distribution curve (Q3) into the corresponding particle number distribution curve (Q0) as shown in Figure 2. (see relevant section in Experimental data, page 7). 95% of the total number of Crys-Talc® particles are smaller than 1µm. Around 55% of all Crys-Talc® particles are under 0.5µm whereas conventional, lamellar talc with the same fineness does not contain these fine particles at all.



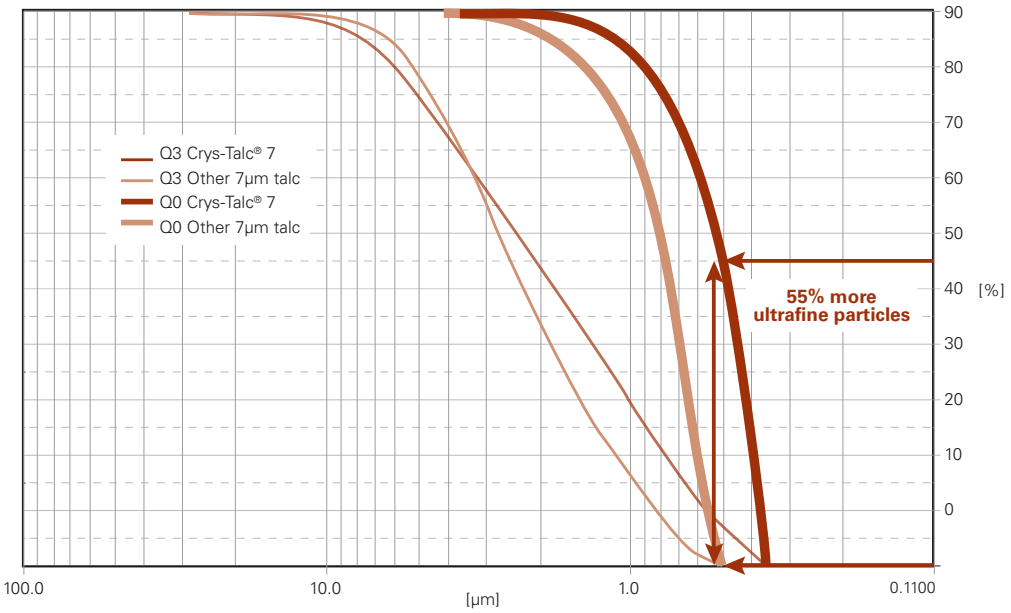
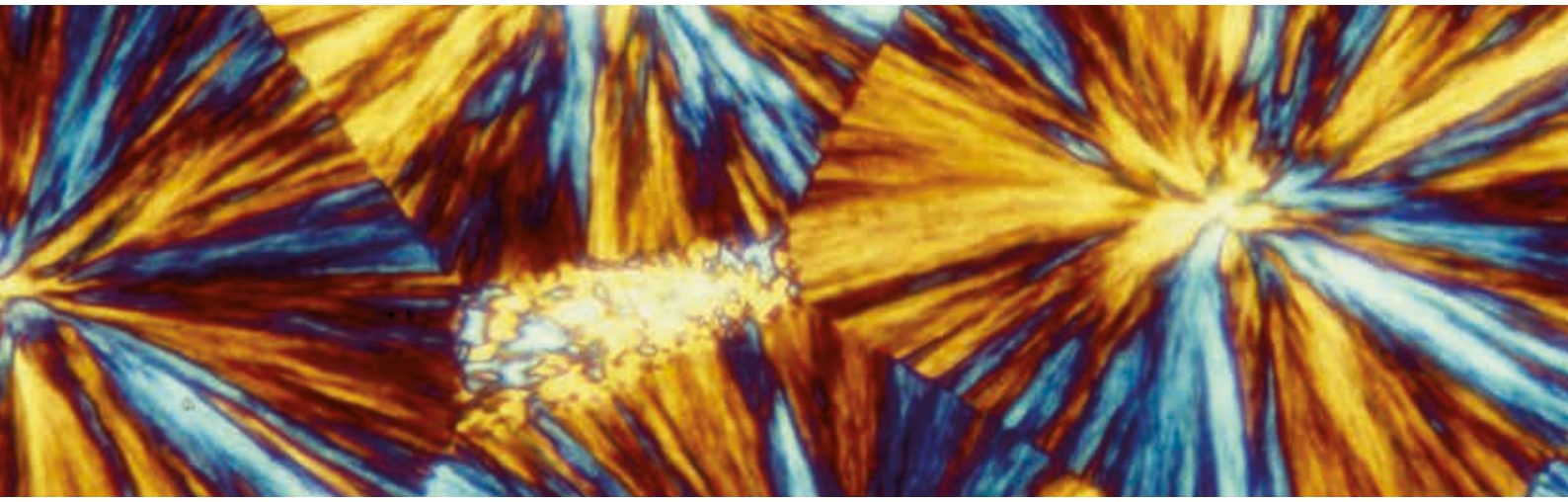


Figure 2.
Sedigraph® particle size distribution (Q3) and particle number (Q0) distribution of Crys-Talc® compared to conventional 7µm top-size talc



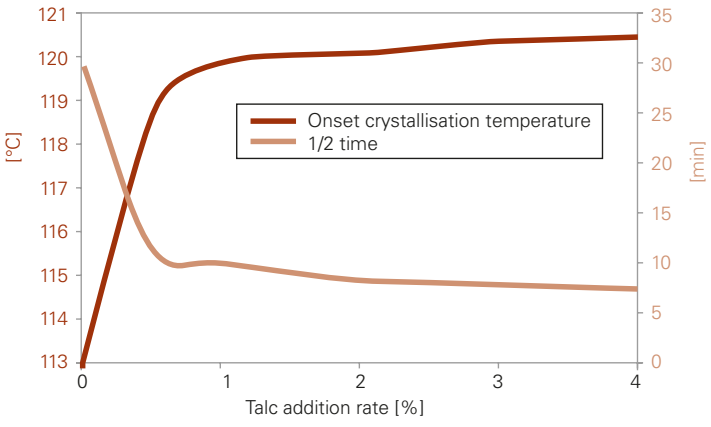
CRYS-TALC® IMPROVES CRYSTALLISATION

Crys-Talc® significantly influences the crystallisation behaviour of PP at addition rates as low as 0.5%. Nucleating copolymer PP with Crys-Talc® demonstrated that maximum onset crystallisation temperature was more than 7°C higher than that of the pure unnucleated resin.

Corresponding crystallisation half-time can be reduced by two thirds, from 30 minutes for pure resin to under 10 minutes. Consequently, PP nucleated with Crys-Talc® cools faster during processing, reducing injection moulding cycle times.

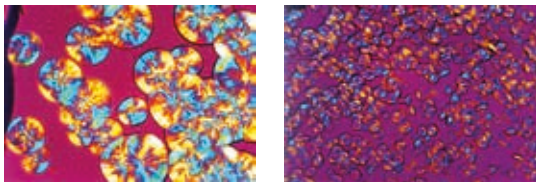
Furthermore, PP grades nucleated with Crys-Talc® increase the output of pipe and profile extrusion machines. The resulting productivity gains translate into significant cost savings for plastics manufacturers.

Figure 3. Onset crystallisation temperature and crystallisation half time of copolymer PP nucleated with Crys-Talc®



Talc modifies PP morphology during crystallisation by increasing the number and type of nuclei formed from the polymer melt. The resulting increase in flexural modulus and heat deflection temperature are explained by a very strong talc/PP affinity.

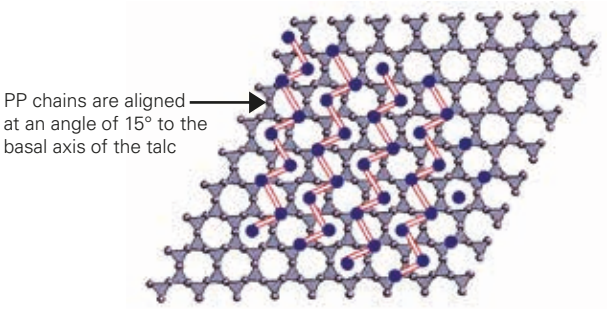
Figure 4. Crystallisation progress of PP with and without talc



Neat PP crystallisation after 15 minutes in isothermal conditions

Crystallisation with Crys-Talc® after 15 minutes in isothermal conditions

Figure 5. Epitaxial growth of PP chains on a talc surface



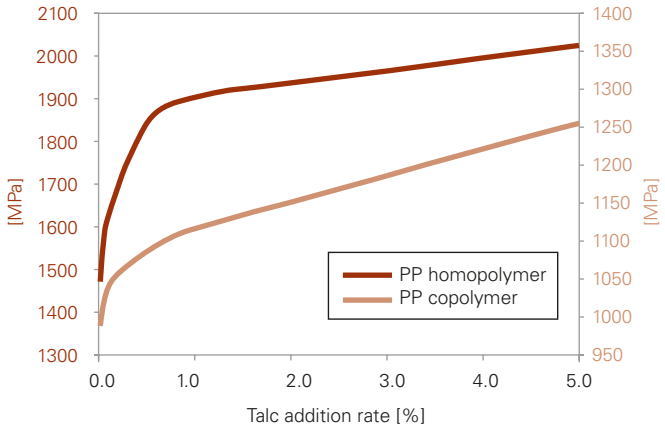
The PP chains position themselves parallel to the talc surface at an angle of 15° to one of the main basal axes of the talc (epitaxial growth). Other minerals do not have this affinity with PP.

Like most nucleating agents, talc is an **α**-nucleator which catalyses the formation of the helical modification of PP. Crys-Talc® gives excellent crystallisation properties at addition rates as low as 0.5%. At higher addition rates, Crys-Talc® acts as a reinforcing agent, increasing rigidity linearly with increasing talc content.

CRYS-TALC® GIVES OPTIMUM PERFORMANCE IN HOMOPOLYMER AND COPOLYMER PP

The nucleation effect is observed in homopolymer as well as in copolymer PP, but at different base resin property levels and with different specific effects. Nucleating a typical homopolymer PP with 0.5% Crys-Talc® results in an increase in flexural modulus of up to 350 MPa, whereas an average increase of 100 MPa is observed for typical impact block copolymers.

Figure 6. Modulus of elasticity of homopolymer and copolymer PP nucleated with Crys-Talc®



The excellent nucleation effect of Crys-Talc®, also contributes to increasing heat deflection temperature (HDT).

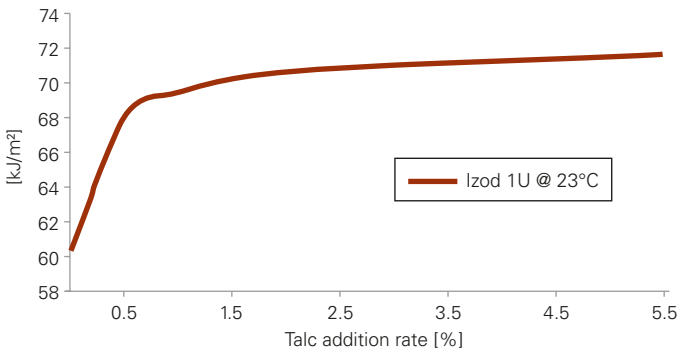
Table 1. Heat deflection temperature of copolymer PP nucleated with Crys-Talc®

Crys-Talc® addition rate [%]	0	0.5	0.9	1.8	3.4
HDT A [°C]	48.7	50.3	51.1	52.0	53.2

At 0.5%, Crys-Talc® increases the tensile strength of homopolymer PP by around 10%. This rise is linked to the nucleation effect itself—we did not observe any further increase at higher addition rates (up to 5%).

As Crys-Talc® modifies homogeneous PP crystallisation, the impact resistance of the resin increases as well. This effect is observed at talc addition rates as low as 0.5%. In high-impact copolymer PP, impact resistance can be maintained at higher talc addition rates of up to 5.5%, while resin rigidity increases linearly with talc content.

Figure 7. Unnotched Izod impact resistance of copolymer PP nucleated with Crys-Talc® at 23°C



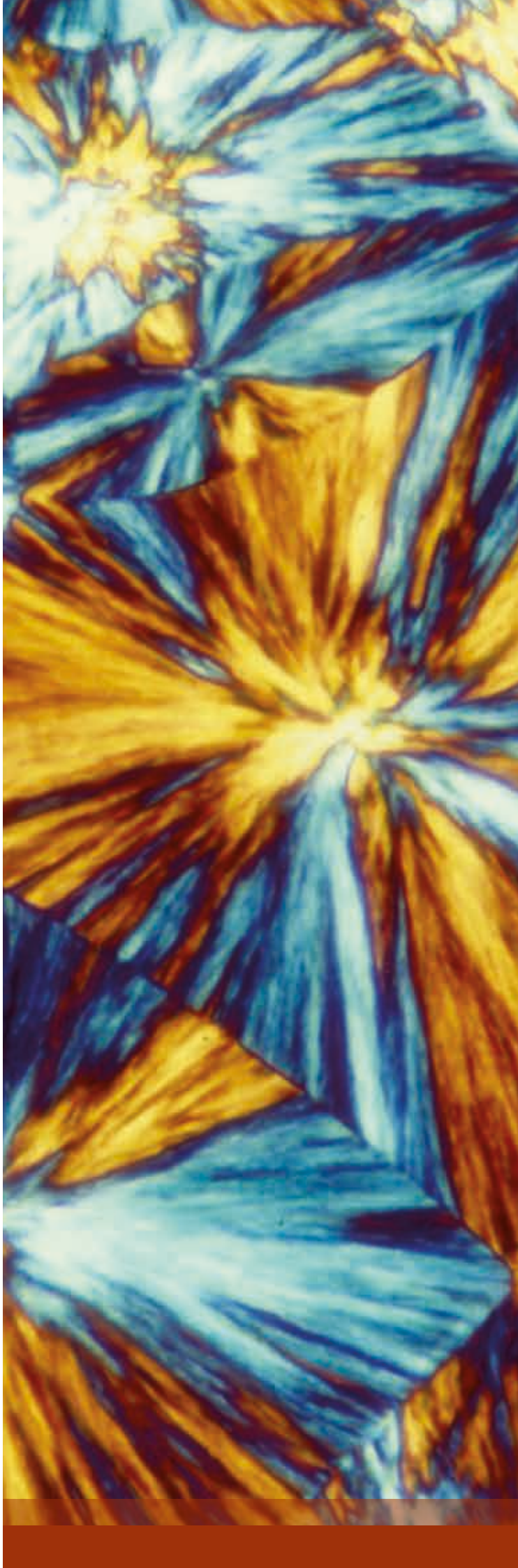


Figure 8. Overall property comparison

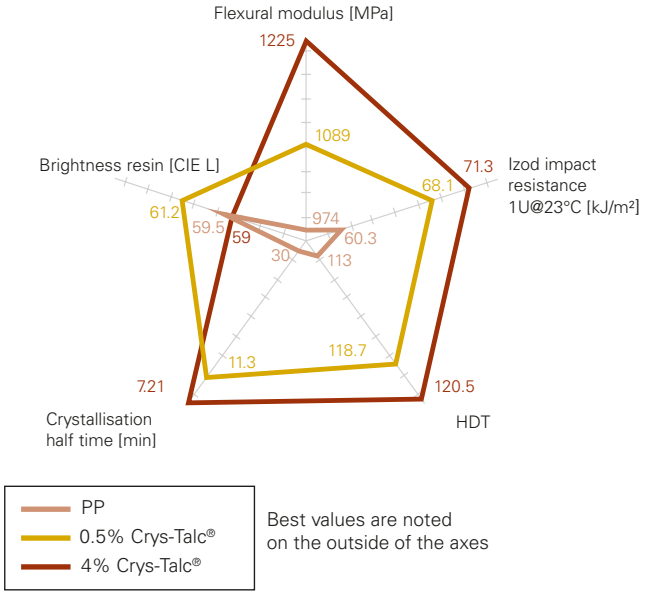
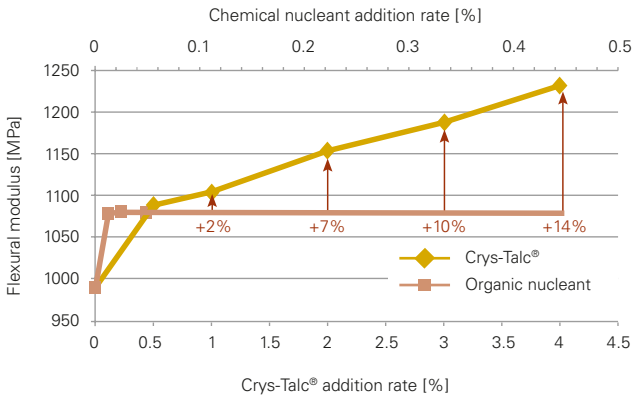


Figure 9. Reinforcement effect of Crys-Talc® compared to chemical nucleants



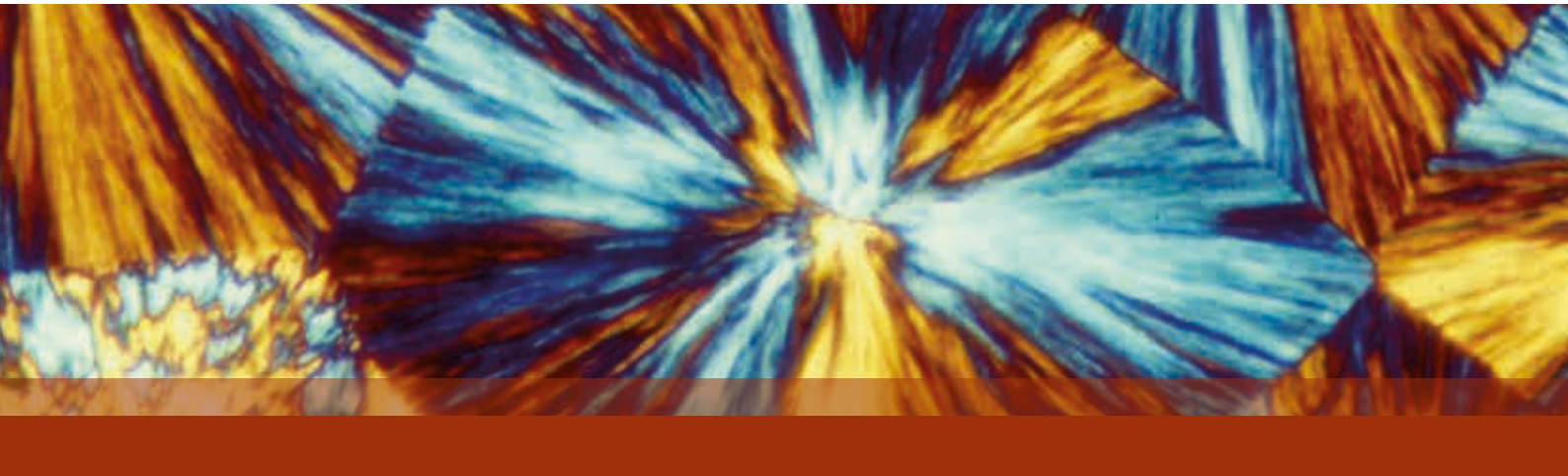
CRYS-TALC® PERFORMANCE COMPARED TO CHEMICAL NUCLEATING AGENTS

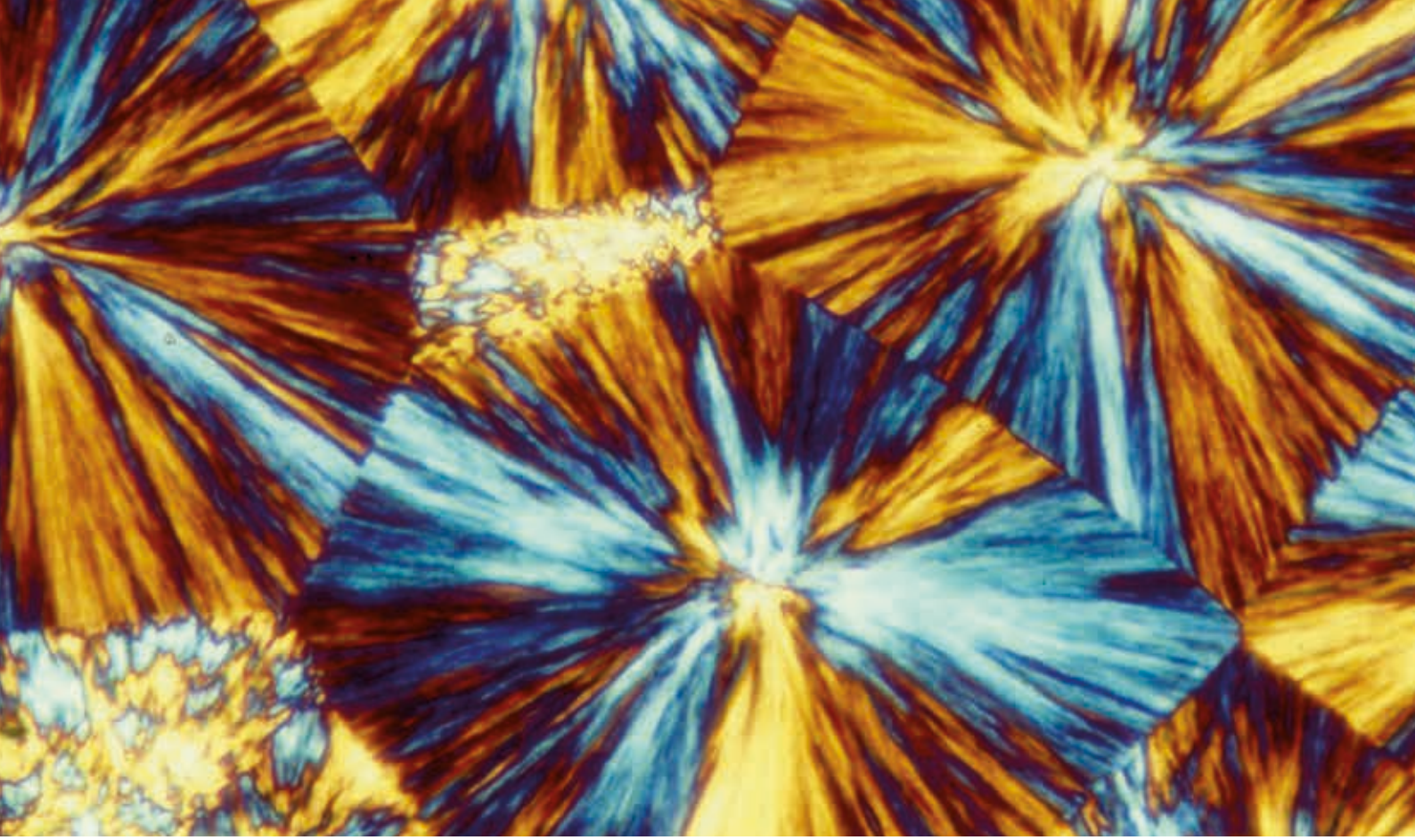
Certain chemical substances such as organic acid metal salts are also commonly used as nucleating additives. Typically, such substances require low incorporation rates in order to fully nucleate a resin matrix but, beyond that, they do not provide additional reinforcement. Although only small amounts of these additives are used, they are expensive, pushing up formulation costs.

Crys-Talc® can both nucleate and reinforce the semi-crystalline resin matrix. Comparative trials in low MFR PP copolymer showed that the same nucleation performance of 125ppm *o*-cyclohexyldicarboxylic acid calcium salt can be achieved with 0.5% Crys-Talc®. Increasing the Crys-Talc® content up to 4% resulted in 14% higher flexural modulus without reduction in impact resistance. Chemical nucleating additives do not show the same beneficial effect.
Crys-Talc® also improves dimensional stability and mechanical properties such as tensile and impact strength.

CONCLUSION

Crys-Talc® is a new micro-lamellar, very bright, cost effective and highly efficient nucleation talc grade. It can be used at addition rates as low as 0.5% for the complete nucleation of PP homo-polymers and copolymers. At concentrations of up to 5.5%,Crys-Talc® has a reinforcement effect which increases linearly with the addition rate without compromising impact resistance. Crys-Talc® demonstrates excellent mixing behaviour in resin and additive powder blending and disperses well in industrial granulation equipment. Used as a nucleation additive in injection moulding and extrusion applications, Crys-Talc® can increase production machine output by 10-15% resulting in significant cost savings.
Crys-Talc® is available in compacted form for easy handling, less dust and improved productivity.





PRODUCT AVAILABILITY

The Crys-Talc® product range is available worldwide:

- Crys-Talc® 7
- Crys-Talc® 7 C

EXPERIMENTAL DATA

Materials
- Neat reactor flake grades of homopolymer (MI 14) and impact modified heterophasic copolymer (MI 0.3) PP.
- Crys-Talc®
- Hyperform HPN 20E from Milliken Chemical
- Additives: 0.1% calcium stearate, 0.2% Irganox® B225

Compounding
- Twin-screw extruder Leistritz ZSC Maxx, D = 18mm, L/D = 48

Injection moulding of samples
- Billon Proxima 50T
- Pellets dried 2h at 80°C before injection

Mechanical properties
- Moulded samples conditioned at 23°C, 50% RH for 14 days

Specimens have been tested in compliance with:
- Flexural modulus: ISO 178
- Tensile test: ISO 527
- Izod impact: ISO 180
- HDT: ISO 75 A
- Crystallisation measurements by DSC performed in an external laboratory on granular PP samples at a constant cooling rate of -20°C/minute (220 – 50°C)
- Annealing procedure: heating/holding/cooling sequence (50 – 220°C/2 min/220 – 50°C)
- Brightness: internal method

Conversion of the volume weighted particle size distribution function (Q3 distribution) to the particle number distribution function (Q0)
The Sedigraph® PSD curve is a cumulated volume distribution curve, describing what percentage of the sample volume has a size (diameter of a "sphere") of less than a certain value.

Dividing the population of each fractile q3 of the distribution curve by **the average diameter** of the particles of that fractile x_i **to the third** results in the average number of particles in a certain fractile q0.

$$q_{0,i} = \frac{q_{3,i}}{{x_i}^3}$$

The particle number distribution curve Q0 is then defined by:

$$Q0 = \frac{\int_0^{x_i} q_{0,i}\, dx}{\int_0^{x_{max}} q_0\, dx}$$

ABOUT IMERYS

Imerys is the world leader in mineral-based specialty solutions for industry. We transform a unique range of minerals to deliver functional specialty solutions that are essential to customers' products and manufacturing processes. With 300 scientists, eight research and technology centres, 21 market-focused regional laboratories and close ties with renowned research institutes, we lead the way in engineering minerals for industry.

ABOUT PERFORMANCE ADDITIVES

Performance Additives is a division of Imerys. With over a hundred years' experience in the minerals business, we offer customers engineered solutions derived from our portfolio of diatomite, mica, perlite, talc and wollastonite. We refine and engineer these minerals through various—often proprietary—processes that influence their concentration, size, shape, structure and surface chemistry to obtain the exact properties our customers require. Each year, we process thousands of tons of materials to the highest standards of quality, consistency and reliability.

Our polymers team has in-depth knowledge of polymer processing and of how minerals interact in polymers and a proven track record for developing new, value-added solutions for customers. Our product and applications laboratories are equipped with a full range of analytical and polymer-specific equipment enabling us to spearhead applications innovation as well as to provide customers with bespoke formulation services and technical support.

DELIVERING THE GOODS

With production sites in Australia, Belgium, Canada, France, Italy, Japan, Mexico, Spain and USA we are able to provide customers with optimised logistics and costs. Our sales administrators organise the optimum transport, warehousing and product delivery form to meet our customers' specific needs.

MEETING TODAY'S NEEDS, SECURING TOMORROW'S

We believe that running a successful business and sustaining quality of life and the environment go hand in hand. From implementing behaviour-based safety training to rehabilitating the land, we think it's important that future generations' needs are not compromised by our actions today.

OUR FUNDAMENTAL SUSTAINABILITY PRINCIPLES

- SAFETY - We promote the health and safety of employees, contractors, customers, neighbours and consumers through active caring.
- PARTNERSHIP - We seek to understand the issues that are important to our neighbours, and to make a lasting contribution to the communities in which we operate.
- ENVIRONMENTAL PROTECTION - We work to minimise our environmental footprint by using natural resources efficiently, preventing pollution, complying with applicable laws and regulations and continually improving our performance.
- ACCOUNTABILITY - We conduct business in an accountable and transparent manner, relying on external auditing and reporting to understand and reflect our stakeholders' interests.
- PRODUCT STEWARDSHIP - We are committed to ensuring that our products are safe for people and the environment, employing best available technology and following best-in-class procedures to ensure that our standards and practices meet or exceed safety requirements everywhere we do business.

We conduct life cycle assessments (LCA) at all our operations to quantify the environmental effects associated with producing our products from the mine to factory gate, and to identify areas for improvement. Likewise, we compile life cycle inventories (LCI) of the energy consumption, materials used and emissions generated by each of our product ranges. These LCI can be made available to customers and research institutions on request.

FOR MORE INFORMATION,
please visit **www.imerys-performance-additives.com**

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