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CRYS: high performance for polymer composites

Light-weight microcrystals with tunable properties – very high mechanical, chemical and thermal stability >650°C – polyimides from "green production"

The requirements for high-performance materials are increasing rapidly. These materials often have to withstand extreme stresses, e.g. high temperatures and chemically aggressive substances. Low weight is additionally required for many applications.

Although polymers are among the lightest existing materials, they cannot compete with inorganic substances – such as metals and ceramics – with respect to thermal and chemical stability as well as some mechanical properties (e.g. hardness or shape retention at elevated temperatures).

Composite materials offer the possibility of combining the low weight and processability of polymers with the stability of (inorganic) fillers. Composite fabrication comprises embedding fillers in a polymer matrix. It must be ensured here that the total weight does not increase excessively due to the nature and quantity of the fillers, and that matrix and filler are compatible.

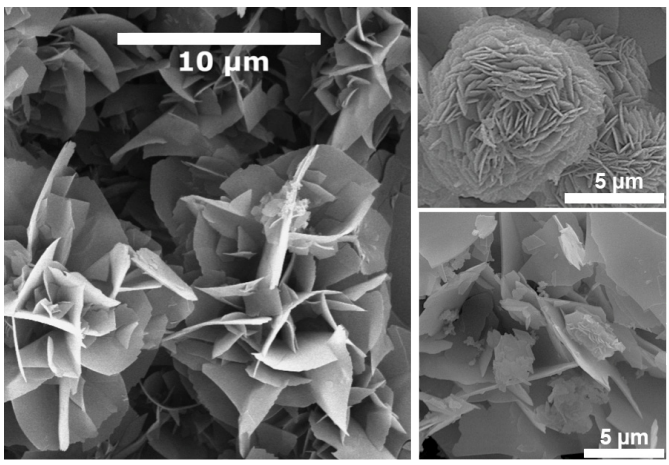
Objective

The Advanced Organic Materials research group led by Prof. Dr. Miriam M. Unterlass at TU Wien's Faculty of Technical Chemistry aimed at developing high-quality organic fillers particles that are light, yet stable and wear resistant, that can be compatibilized with virtually any polymer matrix, and fine-tuned for each composite's intended use.

Solution

The Unterlass Lab developed a "green", i.e. environmentally friendly method for highperformance polymers: hydrothermal polymerization (HTP). With HTP, outstanding polymer microparticles are generated in solely water, without the need for organic solvents, mineral acids or toxic catalysts.

Fully crystalline microparticles with high chemical and thermal stability and tunable morphology can be produced using HTP. The research group demonstrated that the properties desired for different types of use, such as shape, strength, stiffness, wear behavior and gliding resistence, can be achieved quickly and easily.



Different shapes of CRYS particles

Results

The microparticles produced by HTP are composed of a fully crystalline polyimide – hence their name, CRYS. The morphology of CRYS particles is tunable without any decline in crystallinity or particle stability. Possible shapes range from microflowers of varying packing density of petals to microplatelets. The market for products made from high-performance composites, which are based on high-quality polyimides, is estimated to be approx. USD 13-15 billion, with a growth potential to about USD 30 billion by 2025 according to market analysts.

CRYS particles have the following characteristics:

- Fully crystalline and therefore very high thermal and chemical stability
- Temperature-resistance up to 650 °C
- Particle sizes in the lower micrometer range
- Tunable particle shapes (e.g. flower-like, platelets)
- Low weight – particularly compared to inorganic fillers, such as ceramics
- Highly compatible with various polymer matrices
- Environmentally-friendly production using HTP

Manufacture and supply

CRYS is manufactured and distributed by a spin-off of TU Wien, UGP Materials GmbH. It can currently (mid 2019) be supplied in kilograms, up to 50 kg. UGP Materials GmbH also offers contract manufacturing of small batches for smaller specialist manufacturers for the product development and sale of their particular high-performance composites.

The expertise of TU Wien and UGP materials GmbH can provide the best possible support for the rapid development and increasing use of novel high-performance composites in industry.

A composite film reinforced with CRYS particles showing high thermal and chemical stability combined with flexibility.

Applications

CRYS is primarily designed as filler to reinforce polymers. Prototype composites were tested thermally and mechanically. The results show that CRYS-reinforced composites exceed currently available composites. Entirely new products are now becoming possible in terms of radiation, temperature and chemical resistance, at exceptionally low weight.

The avoidance of toxic and questionable additives in production (such as N-Methyl-2-pyrrolidone or dimethyl formamide as solvents, and isoquinoline as a catalyst) reduces costs and risks considerably. This is of enormous significance with respect to the EU's REACH environmental regulations.

Macroscopic aspect of CRYS:
orange powder of the microparticles

Aerospace industry: turbines, jet engines, seals; electrically insulating parts; thermally insulating, fireproof and radiation-sable parts

Automotive, mechanical engineering: piston rings, valve seats, rollers, bearing elements, sliding elements, guiding elements, brake pads, compressor parts, moulded parts and housing parts, turbines

Electronics industry: connecting elements, cable and wire sheaths, printed circuit boards, coil bodies and electric insulation

High-end sports equipment: Boats, skis, racing bikes

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