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CRYS: high performance for polymer composites

Light microcrystals with adjustable properties – very high mechanical, chemical and thermal stability >500°C – polyimides produced using „green methods“

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

Although plastics are some of the lightest materials that exist, they cannot compete with inorganic substances – such as metals and metal oxides – when it comes to thermal and chemical stability as well as some mechanical aspects (e.g. hardness or shape retention at elevated temperatures).

Composite materials offer the possibility of combining low weight with the desired stability. To produce them, inorganic fillers – typically in particle or fibre form – are embedded in a plastic matrix. It must be ensured here that the total weight does not increase too much due to the nature and quantity of the fillers, and that the matrix and filler are highly compatible and produce a sufficiently stable product.

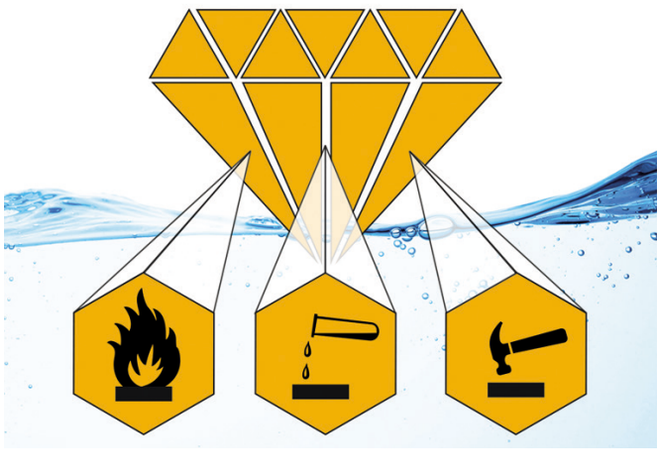
Objective

The Organic High-Performance Materials research group led by Dr Miriam M. Unterlass at TU Wien's Faculty of Technical Chemistry aimed to find a way to discover high-quality polymer particles that were light, yet stable and wear resistant, and that could be adapted to the surrounding matrix and the intended use.

Solution

The working group developed an environmentally-friendly method for the "green synthesis" of high-performance polymers: hydrothermal polymerisation (HTP). HTP does not require any organic solvents, mineral acids or toxic catalysts, and only needs water, pressure and heat as auxiliaries.

Fine, fully crystalline particles with strong chemical and thermal stability can be produced using HTP. The working group demonstrated that the properties desired for different types of use, such as shape, strength, stiffness, wear behaviour and gliding behaviour, can be achieved quickly and easily.



Results

The fine particles that are produced in this way are composed of polyimide and are crystalline throughout – hence their name, CRYS. The market for products made from high-performance composites, which are based on high-quality polyimide, is estimated to be roughly USD 13 to 15 billion with a growth potential to about USD 30 billion by 2025 according to market analysts.

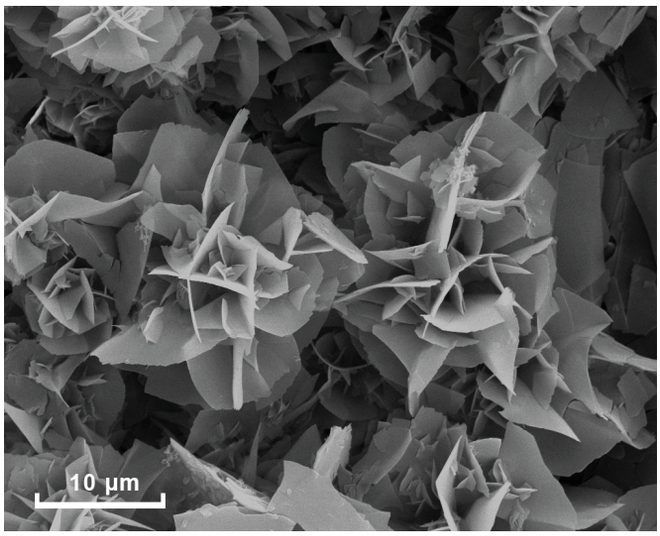
CRYS particles have the following characteristics:

- Fully crystalline and therefore very high thermal and chemical stability
- Temperature resistance up to 650°C
- Particle sizes of a few micrometres
- Flower-like particle shape with large surface
- Low weight – particularly compared with inorganic fillers, such as metal oxides
- Highly compatible with conventional polymer matrices
- Properties can be influenced during production
- Environmentally-friendly manufacture using HTP

Wasser: © adobe.stock.com/siro46

CRYS is clearly destined to be used as a filler in polymer composites. The results of experiments, measurements and tests and the product concepts based on them show that the industrial products will exceed current quality standards. Entirely new products are now becoming possible in terms of radiation, thermal and chemical resistance.

The avoidance of toxic and questionable additives in production (such as N-Methyl-2-pyrrolidone or dimethylformamide as solvents and isoquinoline as a catalyst) reduces costs and risks considerably. This is hugely significant with regard to the REACH environmental regulations.



Microflowers, the world's most mechanically stable organic polymer.

Manufacture and supply

CRYS is manufactured and distributed by a spin-off of TU Wien, UGP materials GmbH. It can currently (as at mid-2018) 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 new high-performance composites in industry.

Applications

- Electronics industry: connecting elements, cable and wire sheaths, printed circuit boards, coil bodies and insulation
- Car, machinery and plant construction: piston rings, valve seats, rollers, bearing elements, sliding elements, guiding elements, brake pads, compressor parts, turbines, jet engines, moulded parts and housing parts
- Aerospace: Seals, insulating films, fireproof, thermally insulated (against heat and cold), radiation-proof clothing
- High-end sports equipment: boats, skis, racing bikes

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