

Lignin: Natural filler brings functionality

- KraussMaffei and Synergie Horizon develop biologically reinforced bioplastic with convincing characteristic values
- From waste product to filler
- Successful process optimization: KraussMaffei integrates up to 30% lignin into PLA matrix

(Laatzen, January 22, 2024) Together with the Polish member of the Cypriot Synergie Horizon Group, KraussMaffei Extrusion GmbH, Laatzen, Germany, has now developed a process for producing a 100% bio-based reinforced thermoplastic: lignin-reinforced PLA.

"With our compounding expertise and our project partner's unique knowledge of lignin preparation, we have succeeded in incorporating up to 30% lignin into the PLA matrix and producing a compound with natural antioxidant capacity/activity, enhanced mechanical properties, and controlled biodegradability," presents Lars Darnedde from process engineering development and project manager at KraussMaffei Extrusion.

With a focus on hydrolysis lignin valorization, the Synergie Horizon group of companies transforms lignin, a biopolymer that is often discarded as a by-product of the bioethanol industry, into valuable products for various applications. Their strong competencies involve lignin purification, its chemical modification and functionalization. They offer lignin-derived products for various applications, such as oil and gas extraction, battery production, water treatment, animal feed and more.

From waste product to filler

The group member, Synergie Horizon Poland Sp. z o.o., has also been recently developing a process at its Polish site in Poznan for the production of free-flowing lignin powder that can be metered into the extruder as a filler. Lignin is a 100% natural substance that is second to cellulose as the most abundant organic material on Earth. Lignin can be extracted from lignocellulosic biomass by various methods. One of these methods is the

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hydrolysis of biomass for bioethanol production, which generates hydrolysis lignin as a byproduct. Hydrolysis lignins have unique properties that make them stand out from other types of lignin. Around 50 million tons of lignin, including hydrolysis lignin, are produced annually worldwide as a waste product from wood processing in the paper and bioethanol industries, 98% of which is incinerated. Various research projects have already dealt with the valuable renewable bioresource, but its use as a filler in a biopolymer matrix is so far unique. "However, processing hydrolysis lignin is not an easy task," knows Alexander Gonchar, the head of research and development at Synergy Horizon, and is proud of the fact that, thanks to intensive development work, his company now operates a commercial production line for manufacturing lignin powder.

Successful process optimization: KraussMaffei integrates up to 30% lignin into PLA matrix

KraussMaffei has demonstrated the incorporation of the natural raw material into the PLA matrix in its newly established technical center at the Laatzen site. Both the laboratory extruder, a ZE Blue Power 28, and the small ZE Blue Power 42 production compounder succeeded in incorporating up to 30% lignin. "We have specially adapted the screw configuration to the lignin with heavy-sensitive mixing elements, operate at a low temperature of 160°C maximum, and use both a 6 D-long filling zone and side degassing," Lars Darnedde gives an insight into the process configuration. The ZE BluePower generation with its optimum Da/di of 1.55 offers all these possibilities "out of the box" and is thus perfectly suited for processing these shear- and temperature-sensitive polymers.

The fact that both the process arrangement of the compounding extruder and the preparation of the lignin at Synergy Horizon are perfect has also been confirmed by extensive mechanical tests. Compared to pure PLA, the lignin reinforcement enables flexural and tensile modulus to be increased by around 30%. It could be useful in packaging applications where the material needs to be stiff enough to hold its shape under load. Another advantage is that lignin adds sufficient antioxidant capacity that can help particularly in food packaging application to prevent oxidation of the food and maintain its quality and safety by inhibiting the radical oxidation and preventing the

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formation of off-flavors, odors, or toxic compounds. Moreover, the biocompound with lignin has no odor unlike other type of lignin, which makes it more suitable for food packaging. A novel biocompound that exhibits antioxidant properties could be applied to biodegradable plastics for agricultural purposes, such as mulch films, to protect them from oxidative degradation.

Unlike pure PLA, which has limited biodegradability due to its dependence on specific enzymes and industrial conditions, PLA biocompounds containing lignin exhibit enhanced biodegradation properties with biodegradation rate more than 90% in 99 days.

Captions:

Photo1_KM_EXT_20240122_Lignin: Up to 30% lignin incorporated into PLA matrix with the ZE Blue Power 28 laboratory extruder. Special screw configuration and innovative technologies enable precise processing at a low temperature of max. 160°C.

Photo2_KM_EXT_20231108_Lignin: Lignin-reinforced PLA: 30 % lignin for improved properties. Natural antioxidants, higher strength, controlled degradability.

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KraussMaffei – Pioneering Plastics

KraussMaffei is among the world's leading manufacturers of machinery and systems for the production and processing of plastics and rubber. Our brand has been synonymous with cutting-edge technology for over 185 years. Our range of services covers all areas of injection molding machinery, extrusion technology and reaction process machinery. In 2022, we integrated additive manufacturing into our portfolio. This broad range of technologies gives KraussMaffei a unique selling point in the industry. With the high innovative power of our standardized and individual product, process, digital and service solutions, we can guarantee customers sustained added value over the entire value-adding chain. Our range of products and services allows us to serve customers in many sectors including the automotive, packaging, medical and construction industries, as well as manufacturers of electrical and electronic products and household appliances. KraussMaffei employs around 4700 people all over the world. With more than 30 subsidiaries, over 10 production plants as well as about 570 commercial and service partners, we are represented internationally close to our customers. The company was founded in 1838 in Munich.

In April 2016, China National Chemical Corp. Ltd. ("ChemChina") became majority shareholder of KraussMaffei Group. In December 2018, ChemChina listed the KraussMaffei Group as KraussMaffei Company Ltd. in Shanghai. This listing opened up access to the Chinese capital market and local investors. Today, ChemChina belongs to Sinochem Holdings Corporation Ltd., one of the world's leading chemical conglomerates with over 220,000 employees.

For further information, please visit: www.kraussmaffei.com

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