Oryzite: A renewable material from rice husks for vehicle interior parts

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AUTHORS

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Almost all plastics used in the automotive industry are derived from petroleum. By analysing the life cycle of the products used, Seat is already gaining important information on how to contribute to a more sustainable future through the use of biomaterials.

Seat has a strong commitment to the 2015 Paris Agreement regarding the general Climate Change goals, which settle the global warming below +2 °C. Therefore, the clear vision of the car manufacturer is to be CO_2-neutral by 2050.

To achieve such an ambitious goal from an engineering point of view, it is important to take into account the entire value chain of the products, dividing this chain into three basic categories: Production, Use-phase and Recycling. Based on internal analysis, the main pillar for reduction comes out of the Use-phase. Switching powertrains to highly efficient e-mobility, with the intensive use of renewable energy, has the potential to reduce the CO_2 emissions of the products by up to 75 %. Nevertheless, around 25 % of the CO_2 generated over the whole lifecycle of our products can be prevented in the production phase and in the re-use-phase. For SEAT R&D this generates a huge engineering playground, which tackles CO_2 emissions from an early Design-phase including the whole Supply-chain of the vehicle parts and the raw materials.

Approximately 15 % of the weight of a complete passenger vehicle today amounts to plastics. The basic plastics, representing round about 2/3 of all plastic parts, are polypropylene (PP), polyurethane (PU) and polyvinyl chloride (PVC). Nevertheless, acrylonitrile butadiene styrene (ABS), polyamide (PA), polystyrene (PS), polyethylene (PE), polyoxymethylene (POM), polycarbonate (PC) and acrylic (PMMA) are also used very frequently. As it is well known, all these materials are often mixed with additives, fillers and strengtheners such as fibreglass, talc, etc., which modify the part's characteristics to fulfill the required use cases. Nearly all these mentioned raw materials are derived from petroleum, from complex chemical processes, which from this early phase a relevant amount of CO_2 is generated.

Seat is searching for alternative materials which can reduce the CO_2 impact at that early point, but without restrictions on the high-quality requirements of the products.

Oryzite is one such product which contributes to the ambitions to a sustainable, CO_2-neutral product. Furthermore, it is a rare measure, which demonstrates that sustainable innovation can also be achieved, generating economic efficiencies at the same time. Seat hopes that the experimental work confirms this potential and that the vehicles in the future will be partly made of rice husks.

WHAT IS ORYZITE?

Oryzite is a material made from rice husk. Rice is one of the most widely harvested cereals in the world and the basic food for many people in the most populated countries around the world. But before rice goes into the food chain system, its exterior shell must be removed as it is indigestible for humans. Annual global rice production is estimated at approximately 800 mio t [1] and rice husk is about 20 % of the weight. This amounts to almost 160 mio t of rice husk every year. Tonnes and tonnes of waste material that is mostly burned to produce silica rich ash used in cement production as a reinforcement.

Rice husks consist of approximately 20 % silica, which is present in many plants with the purpose of increasing their its resistance, and about 80 % organic material (40 % cellulose, 30 % lignin, 10 % fatty acids). Nearly 40 % of this organic material is CO_2 captured from the atmosphere during the plant life cycle. This composition is preserved once it is turned into Oryzite and even once it is applied in the final vehicle part.

The transformation process to obtain Oryzite takes place in a tank under normal atmospheric conditions. Some enzymes, also coming from rice plant, are added. These enzymes convert the fatty acids into a natural polymer, and finally with the application of pressure and temperature until 125 °C, Oryzite is created in powder form. This process requires 0.0625 kwh of energy per kg of generated Oryzite. In comparison, between 0.25 and 0.36 kwh per every kg of PP plastic is required. The main contribution of the transformation process of rice husk is that Oryzite remains structurally stable over time.

This transformation gives a second life to this agro-product waste, since this material can be added to all kinds of thermoplastic compounds in different percentages (in some cases up to 85 %). The final composition of Oryzite is adjusted depending on the polymer with which it is going to be mixed. This bio-filler provides many physical advantages to plastic parts, such as better mechanical properties, dimensional stability or flame retarding. In addition, Oryzite also enables weight and raw material cost efficiencies, hand in hand with a reduction of the vehicle part production cycle.

Oryzite is already present in different branches of the industry. It's applied in civil engineering, in tiles and manhole covers; in outdoor equipment structures and enclosures; in the packaging sector, as trays, pallets or cosmetic containers; sewing notions such as buttons or buckles and bathroom accessories. Now it's time to bring Oryzite to the automotive industry, **FIGURE 1**.

CONTENT AND DEVELOPMENT OF THE RESEARCH WORK

Under the umbrella of the Innovation Team, the group of engineers responsible for the development of interior trim have defined a pilot project based on parts of the latest Seat Leon model, to research the application of Oryzite. With a scope of not less than two years, the aim of this pilot project is to identify and study different candidate parts to be manufactured containing Oryzite. The goal of this pilot project is to obtain a complete validation of selected parts which would enable to introduce Oryzite in series production. The commitment is to apply the standard book of requirements, as well as for mechanical and quality testing. This means no concessions in terms of quality.

This research work has been focused on three different materials: PP, PA and PUR. And besides, in most cases, on different applications and processing technologies.

The general plan is divided into three blocks: viability of the raw material, feasibility of the production process and validation of the final product.

The project started at the end of 2019 with a preliminary phase, just exploring the compatibility of Oryzite with the mentioned polymers. The results of this

FIGURE 1 Transformation chain from rice fields to vehicles (© Seat)

stage were some samples of a tail gate inner trim made of PP; some strips designed to hold the rear parcel shelf and a plastic wheel cover, both made of PA; and some prototype blocks made of rigid PUR foam.

Due to the successful results of this phase 0, the following steps where defined: phase 1, to further analyse the PUR foam, in two forms, rigid and semi-rigid finishing; and phase 2, to study the performance of Oryzite with PP, PA and PUR soft foam.

In phase 1, conducted and still ongoing in 2020, the double floor of the boot has been used as an example of rigid foam. And the ceiling headliner as an example of semi-rigid foam.

The double floor is currently in the testing and quality analysis phase. The initial results regarding breaking strength and rigidity are promising since no breaking was observed and the deformation was similar to the original material composition. **FIGURE 2** shows the average deformation (n = 3) in relation to an applied force of up to 150 daN. However, a second loop of processing will have to be done in order to confirm the expected time and cost reduction and ensure repeatability and quality. Issues caused by the size of the Oryzite particles used in the first loop prevented from performing a standard process. **FIGURE 3** shows a granulometric analysis diagram of the material Oryzite used in phase 1, where particle size is up to 400 µm, which is too big for the standard nozzle used. Additionally, the chart shows the necessary composition for phase 2, where it has to be assured that the whole material particles present a size below 250 µm. According to Iban Ganduxer this is a feasible goal.

Regarding the ceiling headliner project, the situation is different. The characteristics of semirigid foam are still being researched in order to reach a perfect PUR block to reproduce a standard production process. This area of analysis is still ongoing.

And the coming phase 2, expected in 2021, is going to go deep into the research of Oryzite in three main working streams: combined with PP in an inner trim aesthetic part, even with some formulas containing recycled material; mixed with PA in the plastic wheel cover, and finally again with PUR, but now in a form of soft foam, playing with some acoustic pads.

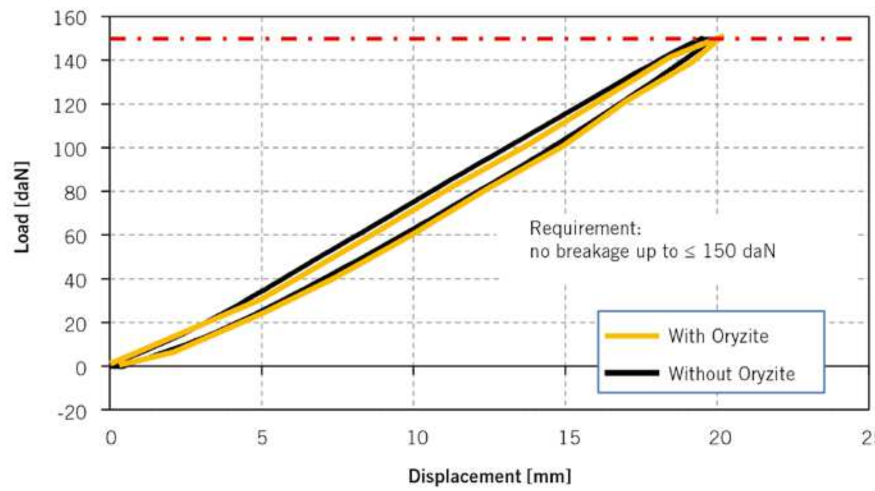

FIGURE 2 Breaking strength and rigidity diagram (© Seat)

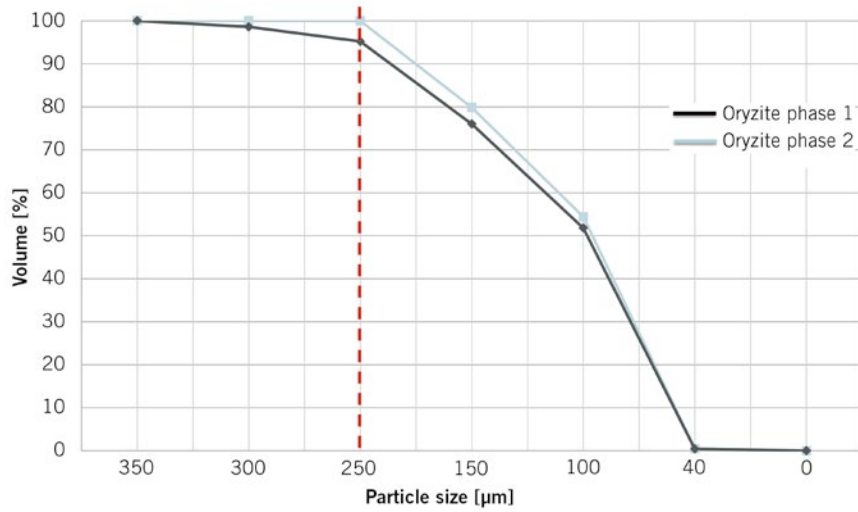

FIGURE 3 Oryzite granulometric analysis (© Oryzite)

POTENTIAL BENEFITS OF ORYZITE

Seat is constantly looking for new materials, new technologies and new industrial processes to reduce the environmental impact of its products. Within this framework, Oryzite offers the possibility to study the application of a naturally originating material with which the environmental impact could be reduced, maintaining the current high-quality standards and without negatively affecting costs. In addition, the company is supporting the circular economy while using a renewable product, one of the main pillars of Seat's sustainable strategy.

CARBON FOOTPRINT REDUCTION

With the use of Oryzite, our carbon footprint can be reduced by influencing different stages of the vehicle‘s life cycle. The current research work on Oryzite will deliver final numbers of the CO_2 reduction capabilities.

Since the goal is to replace an oil-derived material with a plant-derived material, the higher the percentage we are able to mix with the different polymers, the greater the equivalent carbon reduction will be, starting with the raw material in the entire life-cycle of the part. So far, the proportion of Oryzite, considered in the selected vehicle parts, has been 20 % in the case of batches with PP, around 15 % in relation to PA and about 10 % of the whole system in the case of PUR parts.

Oryzite enables a reduction in the injection cycle time. This means the energy consumption during the manufacture of the parts is also lower,

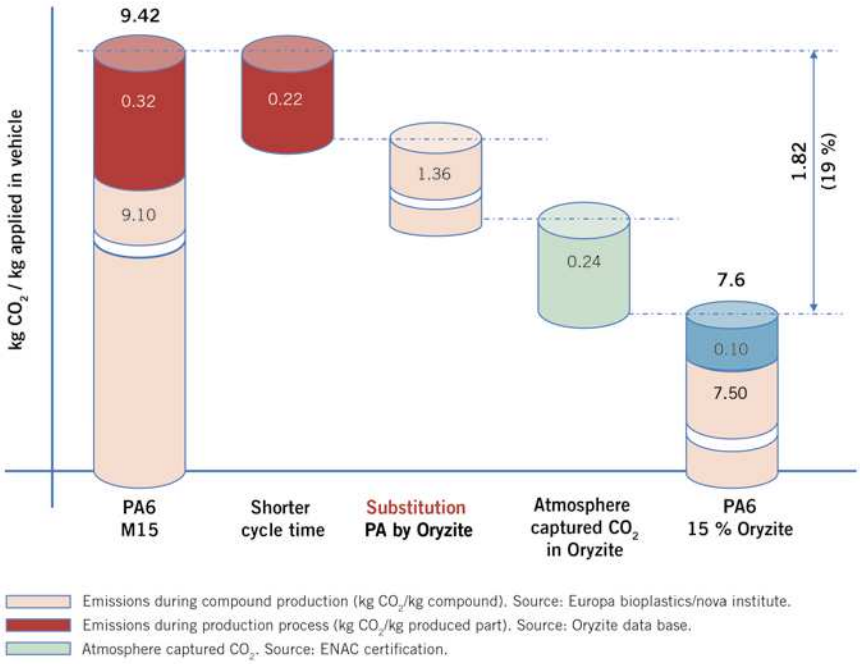

FIGURE 4 Potential CO_2 emissions reduction analysis with base material PA6 (© Seat)

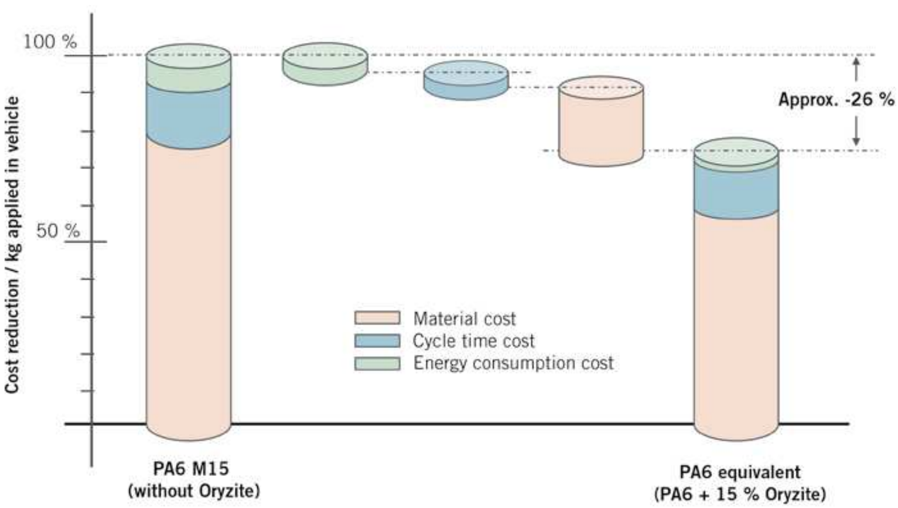

FIGURE 5 Potential cost reduction per kg of part applied in a vehicle (© Seat)

and consequently, the environmental footprint is also reduced in this phase. **FIGURE 4** shows the emissions generated during the production of the base polymer and in the manufacturing process, in this case PA6, with and without Oryzite.

In addition, parts with Oryzite tend to be lighter, so that a reduction of CO_2 during the use phase of the car is expected. Since the weight of the vehicle would be lower, energy consumption would also be lower. According to our findings, the achieved weight reduction with the percentages of Oryzite mentioned before is approximately 12 % in parts made with PA and approximately 15 % in parts made with PP. The weight reduction with PUR is still under research.

Supposing a car lifetime use of 200,000 km, we can deduce that the potential reduction of only 1 kg weight in one car equals a reduction of about 6 kg of CO_2 emitted from its tailpipe [2]. Applied to the whole EU passenger car fleet 2018 [3] it would equal 1.6 mio t of avoided CO_2.

COST EFFICIENCIES

Compared to the polymers we are considering replacing, the cost per kilo of Oryzite is lower.

An additional factor in the final savings is the reduction in cycle time, which also optimises manufacturing costs. During our preliminary tests with tail gate trim parts made of PP, a cycle time reduction of 38.1% (-16s) was obtained. In the case of wheel covers, based on PA, the cycle time could be reduced by up to 29.5% (-5.6 s). These values are preliminary and have to be confirmed at the end of the research project. **FIGURE 5** shows an approach regarding material and production costs based on PA6.

At Seat we are quite convinced that Oryzite soon will find its way into automotive applications. What at the beginning seemed to be a small contribution finally represents a relevant step to fulfill our commitment within Seat's sustainability goals.

REFERENCES

[1] FAO Rice Market Monitor, April 2018, Volume XXI - Issue No. 1)

[2] VW-Group data base

[3] ACEA Report Vehicles in use – Europe 2019