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Benefits of Plastics in Electric Vehicle applications

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Summary

The automotive market has made major moves in developing a need range of electric vehicles for *mass market* (Nissan leaf, Renault Zoe, Tesla Model 3…).

These vehicles require new application parts some of which have never been seen before in the Auto industry. In addition they are facing new challenges such as High Voltage Electrical protection, batteries overheating prevention, batteries thermal chain reactions protection and crash management of the new systems. However, as the OEMs enter into their second and even third series of some of these *cars* and gain greater experience, weight and cost reduction as well as improved functionality, *range*, *reliability* and *safety* are starting to impact greatly on the materials chosen.

Therefore this paper will detail how Polyamide can support the development of Electrical vehicles by providing more safety, more efficiency, more technology and more sustainability (*LCA*).

1 Market projections and the difficulty to forecast

In 2016 the automotive industry has produced around 3 million xEV (EV, PHEV, FHEV). On these 3 Million 2,7 are Hybrids (53% have been produced by Toyota) and 300 000 of them are pure BEV.

Almost all the major OEMs have disclosed their e-mobility roadmap for 2025 or beyond. BMW targets between 15 and 25% of xEV by 2025, VW plan to sell between 25 and 30% of BEV and hybrids. Hyundai recently announced a new Fuel Call car in 2018 in addition to the launch of 26 new xEV by. Daimler is going to invest 7 billion in R&D for e-mobility and target between 15 and 25% of sales in xEV in 2025. Tesla has already 400 000 pre-order for its new Model 3 which will be launched during the second half of 2018.

According to LMC xEV production is expected to grow globally at 14% a year to reach 7.7 Million vehicles by 2023

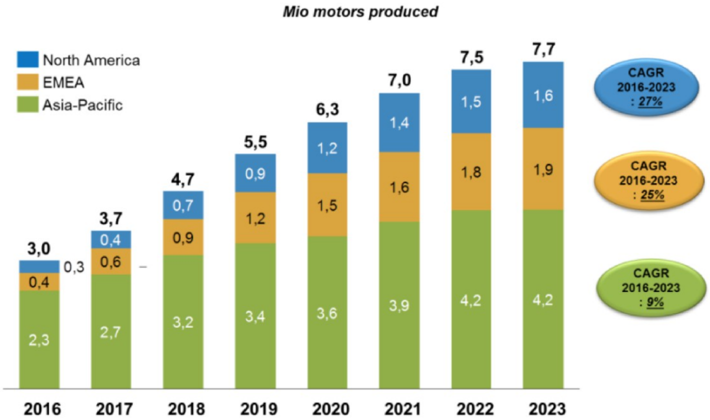

Figure 1: xEV annual production projection

However, if we sum the entire OEMs announcement, the xEV production should reach around 15 Million vehicles per annum.

2 Plastics and E-mobility

These vehicles require new application parts some of which have never been seen before in the Auto industry. In addition they are facing new challenges such as High Voltage Electrical protection, batteries overheating prevention, batteries thermal chain reactions protection and crash management of the new systems. However, as the OEMs enter into their second and even third series of some of these vehicles and gain greater experience, weight and cost reduction as well as improved functionality, reliability and safety are starting to impact greatly on the materials chosen.

2.1 More Safety

2.1.1 Example of the sensors

Sensors durability is key to keep an EV working. Polyamide in use has to be optimized to avoid electronic part failures with dangerous or at least very costly consequences. Halogens and other corrosive additives trigger these defects.

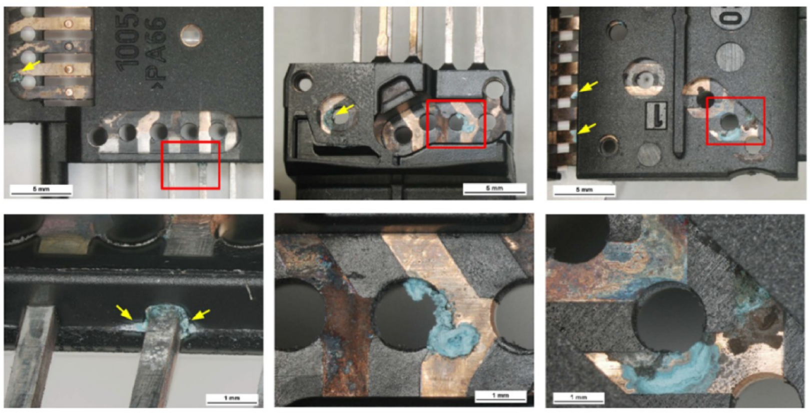

Figure 2: Result of a sensor made with standard PA66 GF 30% Heat Stabilized and aged in a climatic chamber during 6 days at 25/55°C, 93% r.h.

The electrochemical degradation mechanisms are well identified:

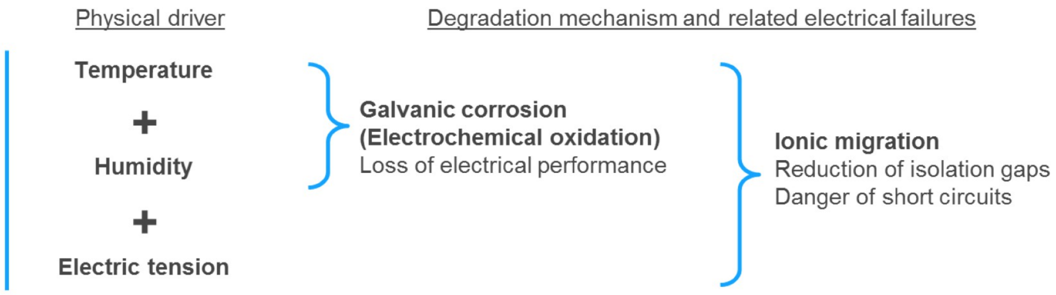

Figure 3: Galvanic corrosion and Ionic migration mechanism

Galvanic corrosion

Corrosion is generally an electrochemical oxidation of metals, which is similar to the ionic-migration, however, it doesn't need the electric field. Galvanic Corrosion can lead to loss of electrical performance.

Ionic migration

An electrochemical process where metal on an insulating material, in a humid environment and under an applied electric field, leaves its initial location in ionic form and re-deposits somewhere else. Such migration may reduce isolation gaps and ultimately lead to an electrical short circuit.

Cu/K+Br/I heat stabilizers and certain additives can sensitize an application to galvanic corrosion and ionic migration which are the basis of the need for electro friendly grades.

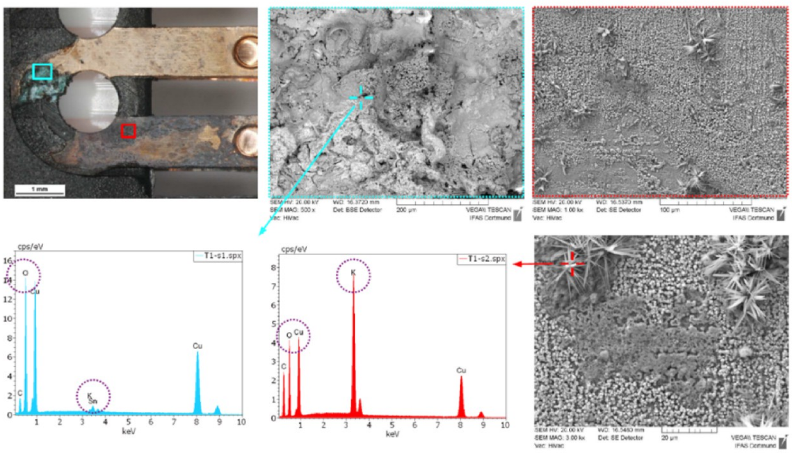

Figure 4: The analysis of this surface deposit show Heat stabilizer traces (Cu, K, I, Br) due to electrochemical corrosion.

2.1.2 How to answer to this technical requirement?

Three levels of needs have been identified:

a) The electro friendly materials where Iodine, Copper, Bromine and Potassium are banned
b) The halogen free materials where every kind of halogen are prohibited
c) The high purity grades where ionic substances are monitored

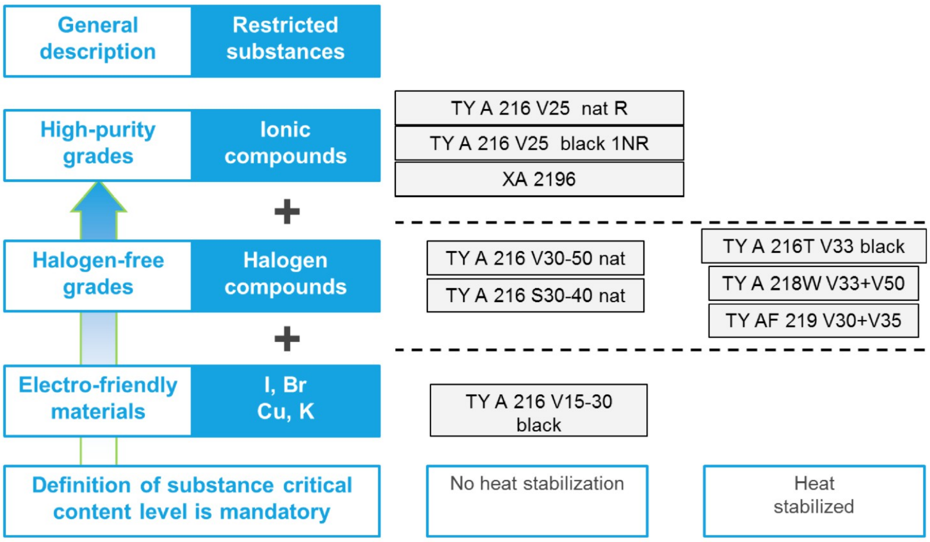

Figure 5: Material offer

2.2 More Technology

2.2.1 The challenge of weight saving

In an EV, every kilogram saved is additional autonomy for the driver.

2.2.2 How to answer to this challenge of weight saving?

MMI is a predictive simulation solution and services package for modelling behaviour of thermoplastics parts.

In order to improve mechanical properties of polyamides, glass fibers are mixed in the matrix. The reinforcement effect is not the same in all directions of space, as fibers have one main direction of reinforcement along their axis. Anisotropy is the term defining material properties different in all space directions.

On a tensile standard specimen like ISO 527, fibers are aligned in the direction of applied force and provide the maximum fiber reinforcement effect in that direction.

To take this variability of mechanical response into account in their simulation, mechanical engineers are applying an empirical coefficient on the stress to modify the material mechanical response. This technic is based on experiment; it depends strongly on the application for which the engineer works.

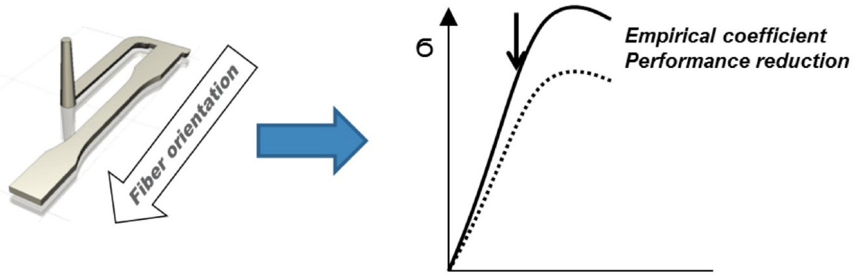

Figure 6: Current understanding with classical approach

MMI brings a complete real and physical representation of anisotropic material behavior, while classical isotropic approach brings a lot of approximation.

MMI takes into account the effect on processing on final performance of a part, it is an integrative simulation tool, while empirical coefficient usage may lead to significant discrepancies, as we will see next.

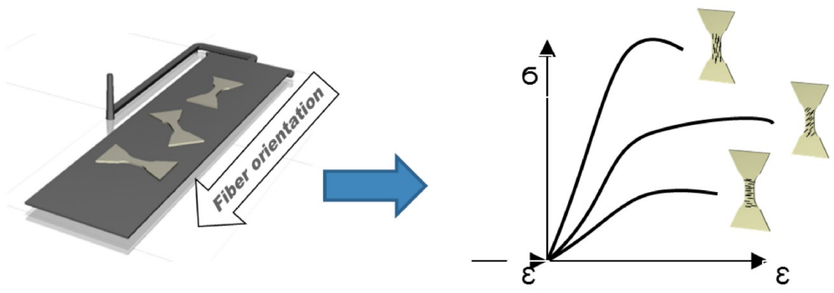

Figure 7: MMI understanding with fiber orientation

Example of the Powertrain mount:

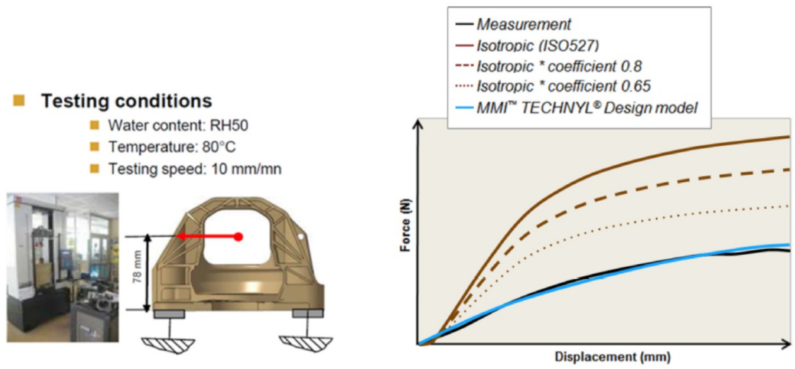

Figure 8: Comparison of the classical approach vs MMI on an Engine Mount [1]

The part in an engine mount, testing conditions are under moisture absorption, a temperature of 80°C and static force. The force displacement curve measured is on the right.

Using raw data from ISO 527 without empirical coefficient the isotropic simulation is much too stiff.

Using a coefficient of 0.8 it's not much better.

With 0.65, which is commonly used in many design offices, result is still overestimated.

Thanks to MMI™ TECHNYL® Design, simulation brings confidence, allowing to go to prototype phase while mastering the innovation costs. Only one prototype is required to validate the part.

2.3 More Efficiency

2.3.1 Example of the battery cooling

The battery of an EV has to remain under 70°C. Thus, failure of the cooling system can be dramatic and lead to the battery over heating with, then, a thermal chain reaction.

To avoid cooling circuit failure designer generally choose materials from the top of thermoplastic pyramid. These materials (PPA, PPS) offer a very good long term chemical and temperature resilience, as well as a high stiffness and strength in temperature.

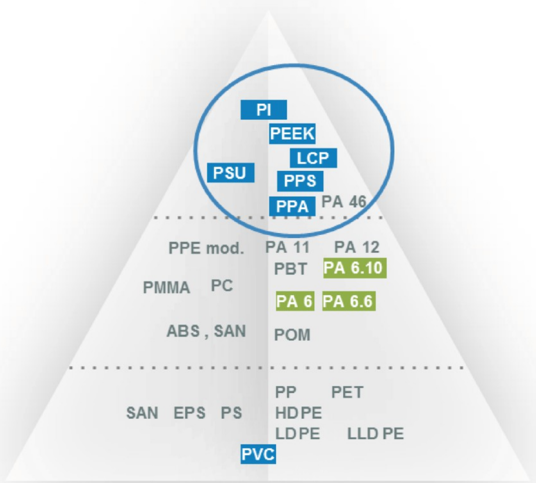

Figure 9: Thermoplastic pyramid

However, these polymers present some important limitations in term of process (long cycle time, difficulty to weld, high cost) and mechanical behaviour (parts are brittle).

2.3.2 How to answer to this technical requirement

Technyl Exten D/CR (D218 CR and D 219 CR) is a new solution to answer failures due to hot glycol, CaCl2 or aggressive chemical contacts.

This material, partially bio-based, combine the benefits of the Polyamide 66 and Polyamide 6.10. It brings a higher chemical resistance, a better heat aging resistance without compromise on the process-ability.

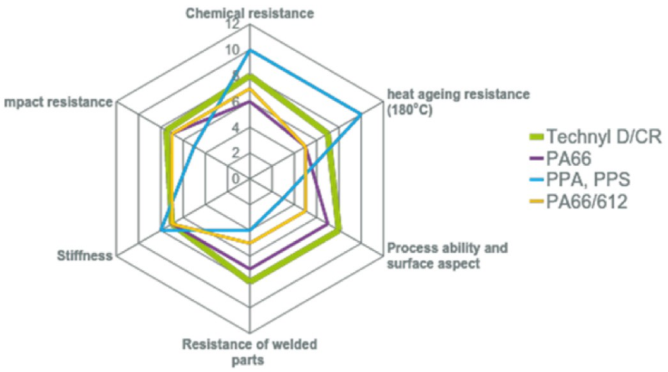

Figure 10: Technyl D/CR assessment vs PA66 and PPA

Glycol resistance:

Tensile strength after aging in G13 coolant at 135°C, measure at 23°C (MPa)

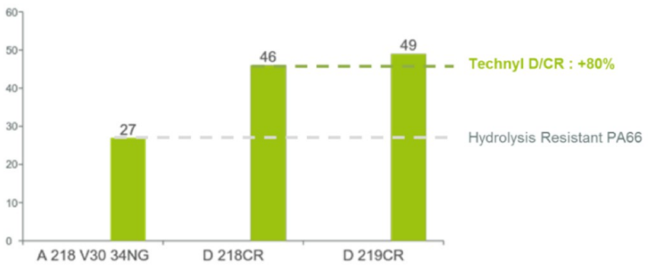

Figure 11: Technyl D/CR aging in glycol

Mechanical resistance:

Burst pressure test made on welded “Clochettes” (small bells):

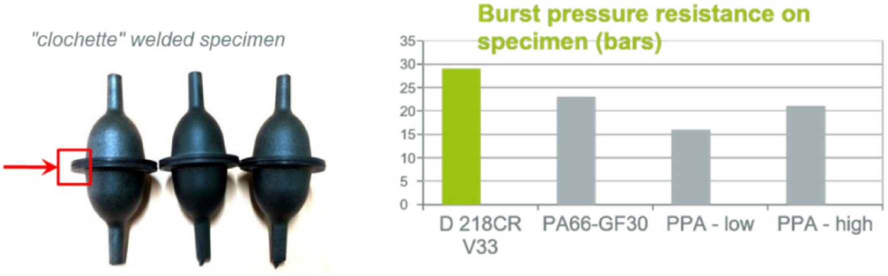

Figure 12: Technyl D/CR Burst pressure

2.4 More Sustainability

2.4.1 The recycling challenge

In Europe every year 25 million tons of plastics end up in the waste upstream every year in Europe. On this 25 million 26% are recycled, 36% are incinerated and 38% goes to the landfill.

In the meantime there is a New Market context for recycle PA materials (Legislations are pushing for new recycled streams in Europe, the EU parliament has already called for reduced VAT for secondary materials, eco-design criteria including recycled content and most of the OEMs are targeting recycled content up to 20% or more). However we are facing limited available raw material. Traditional sources of good quality recycle waste are moving to Asia (textile industry transfer leading to less textile fibres waste in Europe) and the demand grows faster than the sources.

2.4.1 How to answer to this challenge

Technyl 4Earth is exclusively made out of waste coated fabrics from airbags by a breakthrough recycling technology. The main steps of this recycling process are cutting (downsizing pieces of airbags fabrics), fine cutting (increasing the scraps surface before the chemical treatment step), chemical activation (attacking the polyamide-silicon bonds), separation, fibres washing (washing off chemical process liquids from the polyamide fraction), fibres drying, fibres compacting.

The main benefits of using airbag waste instead of other sources are:

- The fabrics are made from high quality PA66 yarns (not TiO2, limited thermal history)

- Raw materials are largely available (industrial size quantity)

- Exclusive process technology to separate silicon from PA

- Significant reduction in environmental impact over all indicators

Environmental Impact:

Reduction over each indicator (percentages)

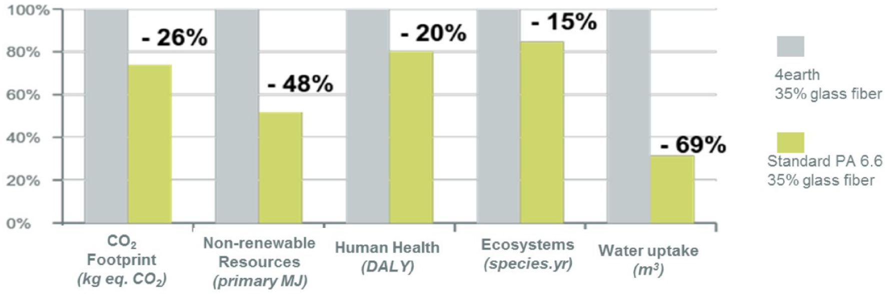

Figure 13: Technyl 4Earth environmental benefits

The cradle-to-gate environmental footprint is significantly reduced as compared to primary PA 66 in all field monitored.

Mechanical properties:

Technyl 4Earth compound offer near prime tensile modulus and tensile strength performances.

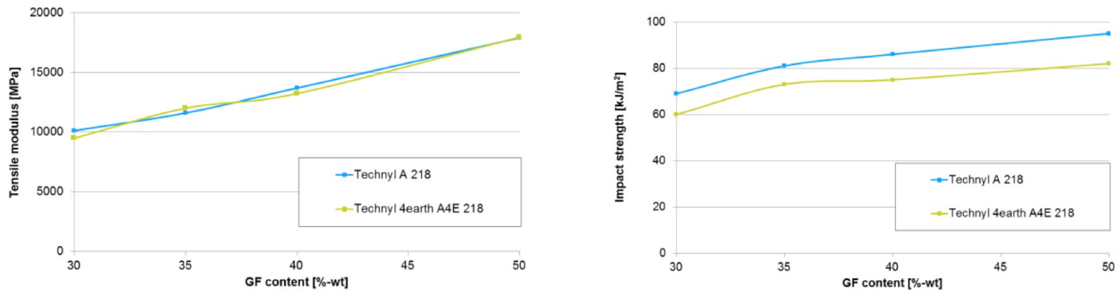

Figure 14: Technyl 4Earth mechanical properties

2 Conclusion

With the increasing electrification of vehicles carmakers are facing new challenges and new needs in term of safety, efficiency, technology and sustainability. Solvay Performance Polyamides has developed new materials and services to support the OEMs and their Tiers to develop more safe, more efficient and more sustainable vehicles.

References

[1] Dr Ludovic Chauvet / TBVC / Digimat User Meeting 2011

Authors

Nicolas has started his career in Automotive Industry 20 years ago, working for major Tiers One and Chemical companies (Electricfil Industrie / Unifil Electronic / Sintertech / Federal Mogul) in France, Turkey and Brazil. He held various increasing positions in Project Management and Sales & Marketing.

Nicolas has been appointed by Solvay Engineering Plastics in 2007 to develop the Thermal Management segment. He became Application Development Manager in 2009 prior to hold the position of Automotive Business Development Manager for EMEA (Europe, Middle East and Africa) in 2011.

In 2016 Nicolas has been appointed Global e-mobility leader and covers now all the new powertrain technologies (Hybrid, EV, Fuel cell…).