

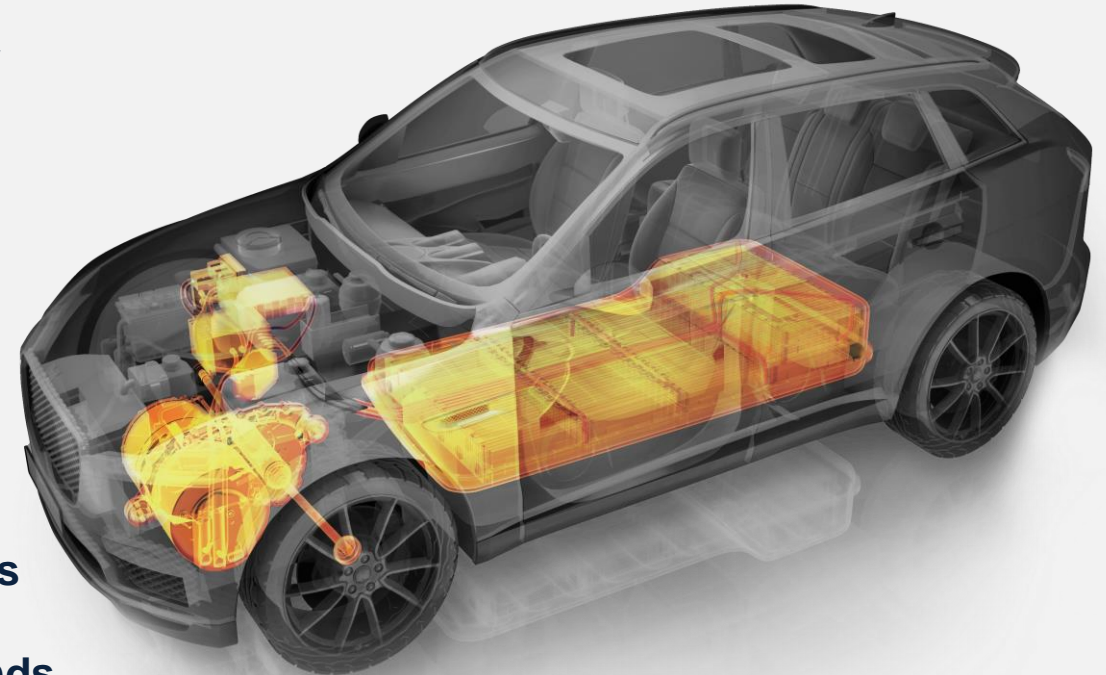
ARALDITE® – Latest Epoxy Resin Innovations for Mass Production of Magnet-free Rotor Designs

The slides following hereafter contain information that is confidential and/or proprietary to Huntsman. Recipients of this presentation and the information contained herein shall not copy or replicate them by any means whatsoever.

While the information contained herein is to the best of our knowledge, information and belief accurate at the date of publication, it is the responsibility of recipients to determine the applicability or the suitability of such information for their own particular purpose. Huntsman Advanced Materials LLC and its affiliates accept no responsibility for any damages of any nature resulting from the use of, reliance upon, or the misuse of such information for any purpose.

Executive Summary

- **PSM motor technology rely on rare-earths magnets which carry ecological, logistical, and geopolitical implications**
- **ARALDITE® epoxy resins enable a sustainable magnet-free technology, making the whole e-motor manufacturing more sustainable**
- **Improved motor efficiency having the capability to adapt the magnetic field on the driving situation**
- **State of the art potting process to achieve 100% resin properties**
- **OEM qualified, very high productivity, cycle time up to 45 seconds possible**



About us

Huntsman Corporation

is a publicly-traded global manufacturer and marketer of differentiated and specialty chemicals. Our products number in the thousands and are sold worldwide to manufacturers serving a broad and diverse range of consumer and industrial end markets.

- We operate more than 60 manufacturing
- R&D and operations facilities in approximately 25 countries
- ~ 6,000 Associates



Polyurethanes



Performance Products



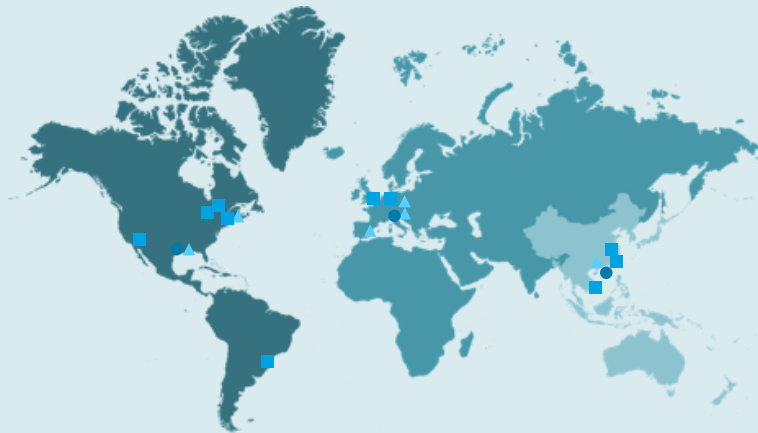
Advanced Materials



More than 60 years' experience and continuous innovation in electrical insulation and thermal management

- A leading global chemical solutions provider
- More than 60 years' experience and continuous innovation in advanced epoxy, acrylic and polyurethane-based polymer solutions
- A leading global innovation partner for the automotive and power and electronics industry

Global development, support, manufacturing and supply



- ▲ = Synthesis site
- = Formulation site
- = Offices

Our markets



Aerospace



Automotive



Adhesives



Power



Electronics



Wind



Coatings



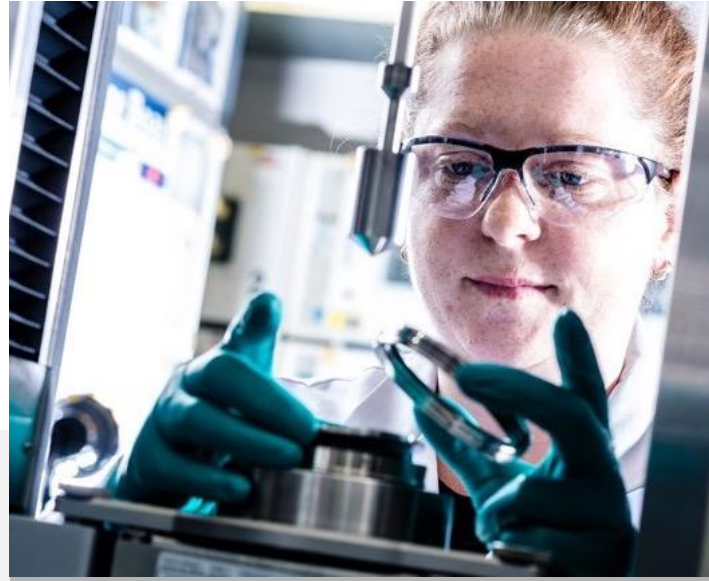
Composites

High-quality products backed by technical support



Simulation

Predict outcomes with a 90% success using detailed property characterization to support your application simulations.



Testing

Speed up your qualification process with reliable testing from an independent and ISO-certified laboratory.



Processing

Optimize cost and efficiency of your processes by ensuring that materials fit your needs.

Huntsman Advanced Materials solutions for tomorrow's mobility

E-Motor



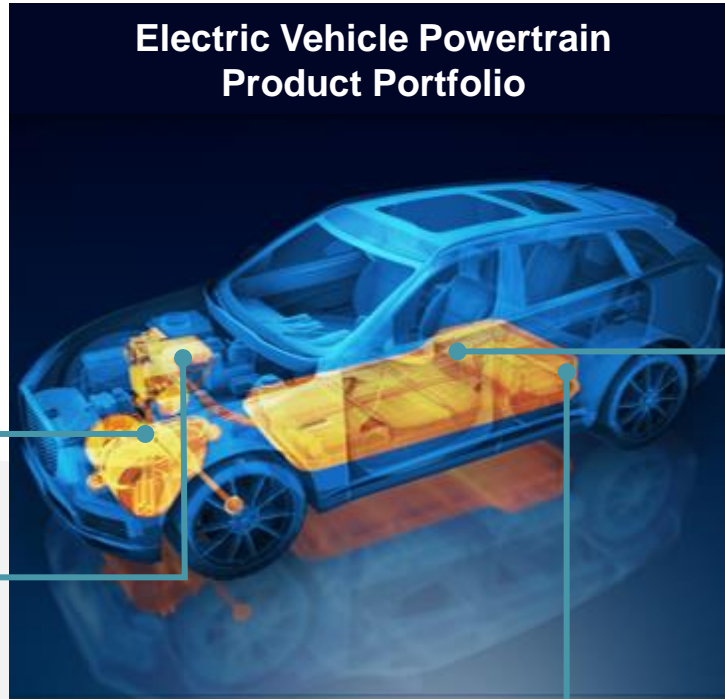
Images: Additive Drives, Huntsman, Hedrich

ARALDITE® encapsulation solutions for electrical insulation and thermal management of high-voltage and magnet-free e-motors

Electronics

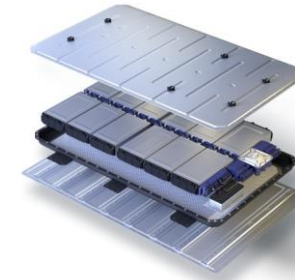


ARALDITE® encapsulation to protect sensitive high-voltage EV power electronics



Electric Vehicle Powertrain Product Portfolio

Battery



ARALDITE® epoxy systems for lightweight and fire-resistant battery composite trays, covers and housings

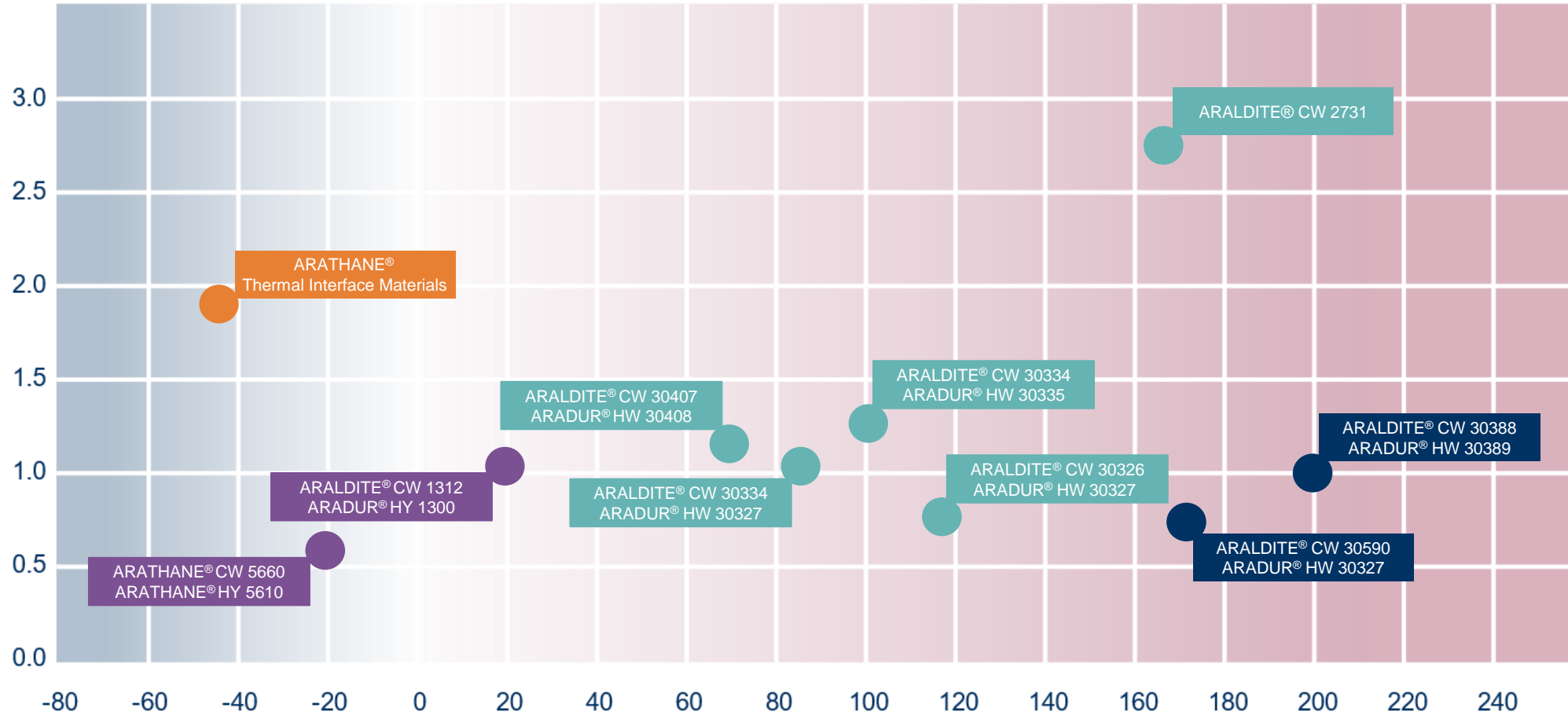
ARATHANE® thermally conductive adhesives and encapsulants for thermal management and protection of battery modules and packs

Hydrogen Storage Tanks



ARALDITE® epoxy systems for mass production of lightweight and safe composite hydrogen pressure vessels

ARALDITE® and ARATHANE® products for electric vehicles



Glass transition temperature Tg [°C] ● Stators ● Batteries ● Rotors ● Electronics



ARATHANE®
Thermal Interface Materials



ARALDITE® CW 1312
ARADUR® HY 1300



ARALDITE® CW 30334
ARADUR® HW 30335



ARALDITE® CW 30388
ARADUR® HW 30389

Sustainability of raw material supplies

- PSM are made with rare-earth metals, increasingly difficult to source in an ethical fashion.
- Rare Earths Elements (REEs) are abundant in the earth's crust, but they come in low concentrations in minerals.
- When found, they are hard to separate from other elements, which is what makes them "rare."



The production of 1,000 electric cars utilizing PSM technology uses on average 1 ton of rare earth metals and generates...



▪ 2,000 tons of mine tailings



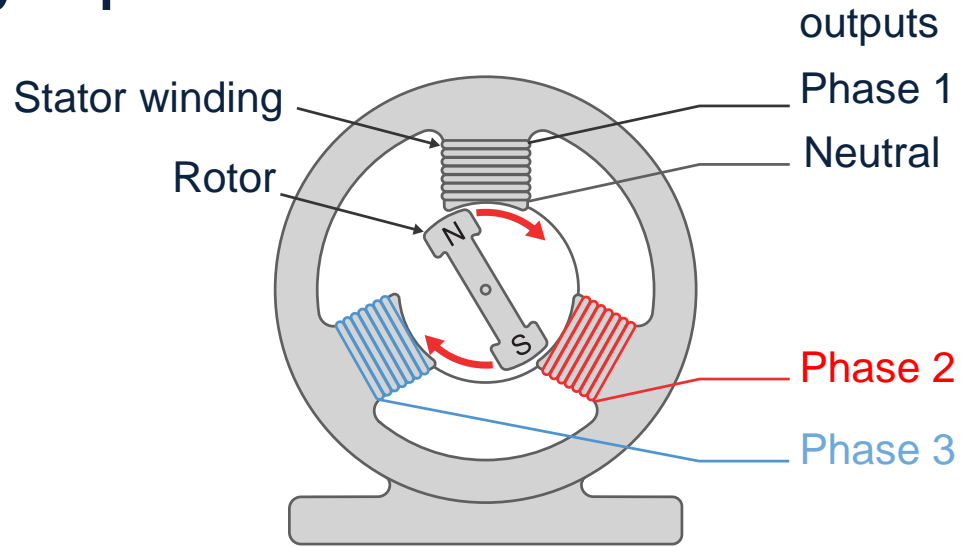
▪ 1 ton of radioactive waste



▪ 70 m3 of acidic wastewater



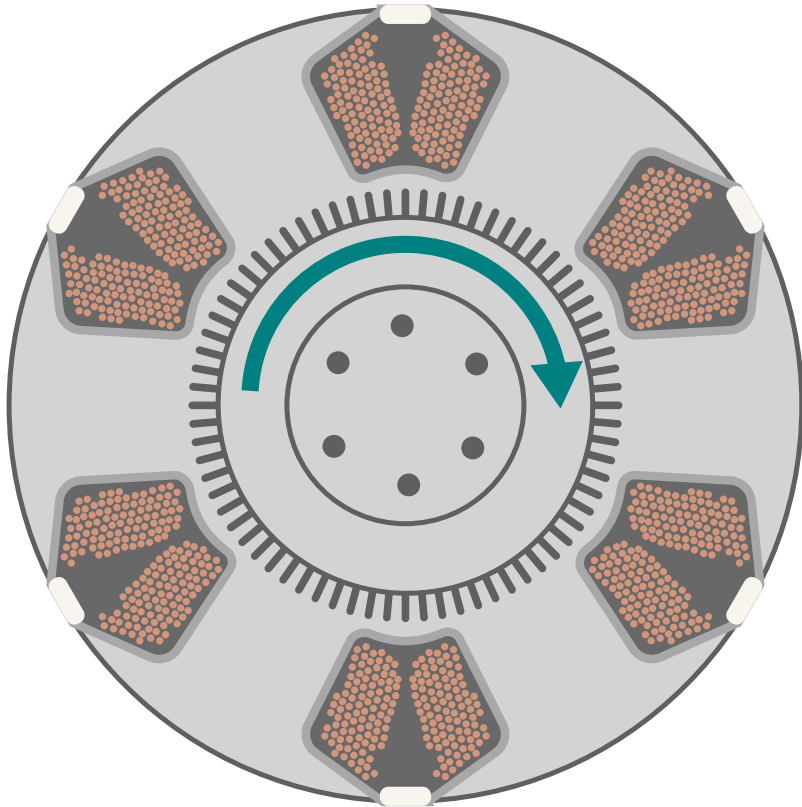
Key Aspects of PSM vs EESM



PSM

- Rotor: permanent magnets inserted to generate a magnetic field
- Stator: conductive wires wound around a ferromagnetic core (electromagnet)
- Opposite poles of the magnets attracted: like poles repelling each other
- Reversing the electric polarity in the stator reverses the magnetic polarity
- Switching pulls the permanent magnets around

ARALDITE® epoxy resins enable magnet-free rotor design



EESM - Externally Excited Synchronous Motor

- Sustainable, no rare-earth materials
- Rotation speed > 15,000 rpm
- High power density
- Reduced weight and improved efficiency
- Excellent driving experience

ARALDITE® CW 30388 / ARADUR® HW 30389 *Key Characteristics and benefits*

- Well balanced filler package design for extending temperature range of the motor
- Exceptionally low CTE matching surrounding metals and so reducing thermally induced stress
- Tg 200°C, all-life fixation of rotor coils within the operating range (-40°C / +180°C)
- High strength and modulus supporting rotor structure in operation
- Low density reducing weight and inertia of the rotor
- High electrical insulation supporting motors architecture – 800+V

A perfect 'three-part' combination...with different key requirements

Resin

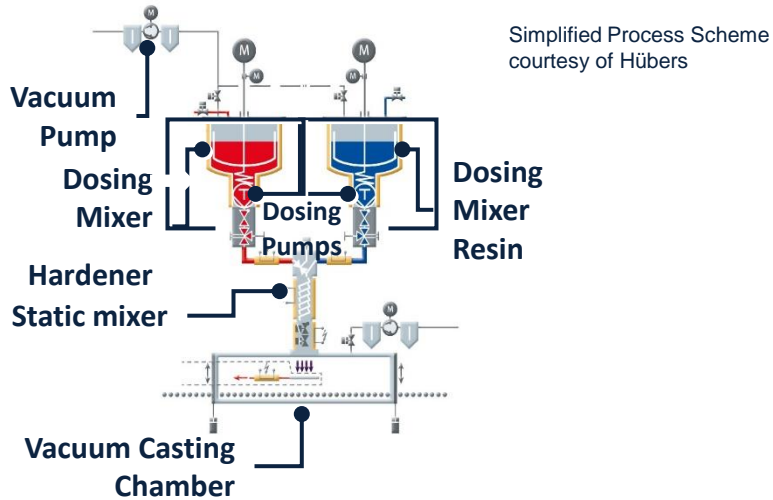
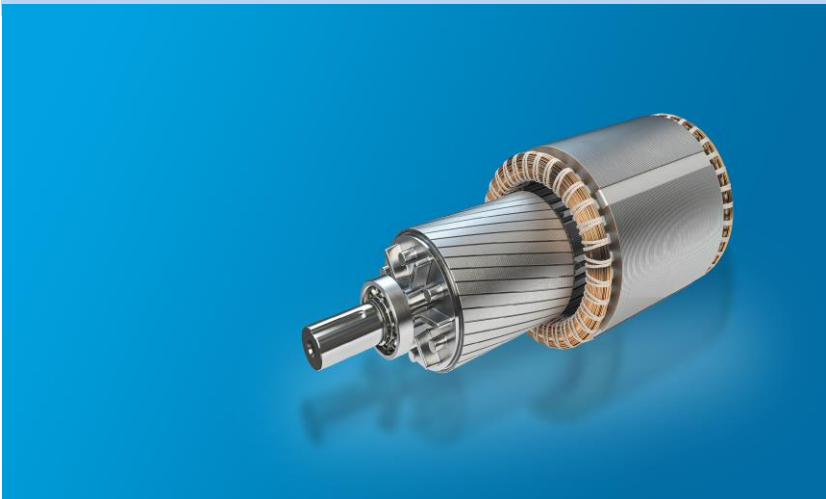
- Low viscosity, flowability and intra-coil impregnation
- Pot-life optimized to avoid viscosity increase during injection
- Curing times and temperatures, supporting productivity

Parts

- Should be 'designed' for potting from initial stage, e.g. introducing flowing channels for the resin
- Molds has to be suitable for holding vacuum
- Funnel to compensate resin penetration and shrinkage is recommended

Equipment

- Homogeneous temperature of materials and parts + pre-drying of both
- Vacuum values during material pretreatment and casting
- Dosing of resin (A) and hardener (B) is volumetric and must be perfectly synchronized to insure the correct mix ratio
- Curing ovens capacity and efficiency



Processing is key for enhancing epoxy resins properties enabling a reliable EESM design

State of the art processing - vacuum casting – APG - to deliver 100% resin properties

Potting optimizes heat transfer within the e-axle, enabling a potential reduction of copper vs. alternative secondary insulation technologies

Very high productivity, cycle time up to 45 seconds possible, OEM qualified

- Strategic casting speed and pressures for a perfect filling rate
- No voids or material losses has a positive impact on electrical performances and overall motor endurance
- Fully automatic, clean and operator-independent processes
- Well established within electronic and industrial drive industries



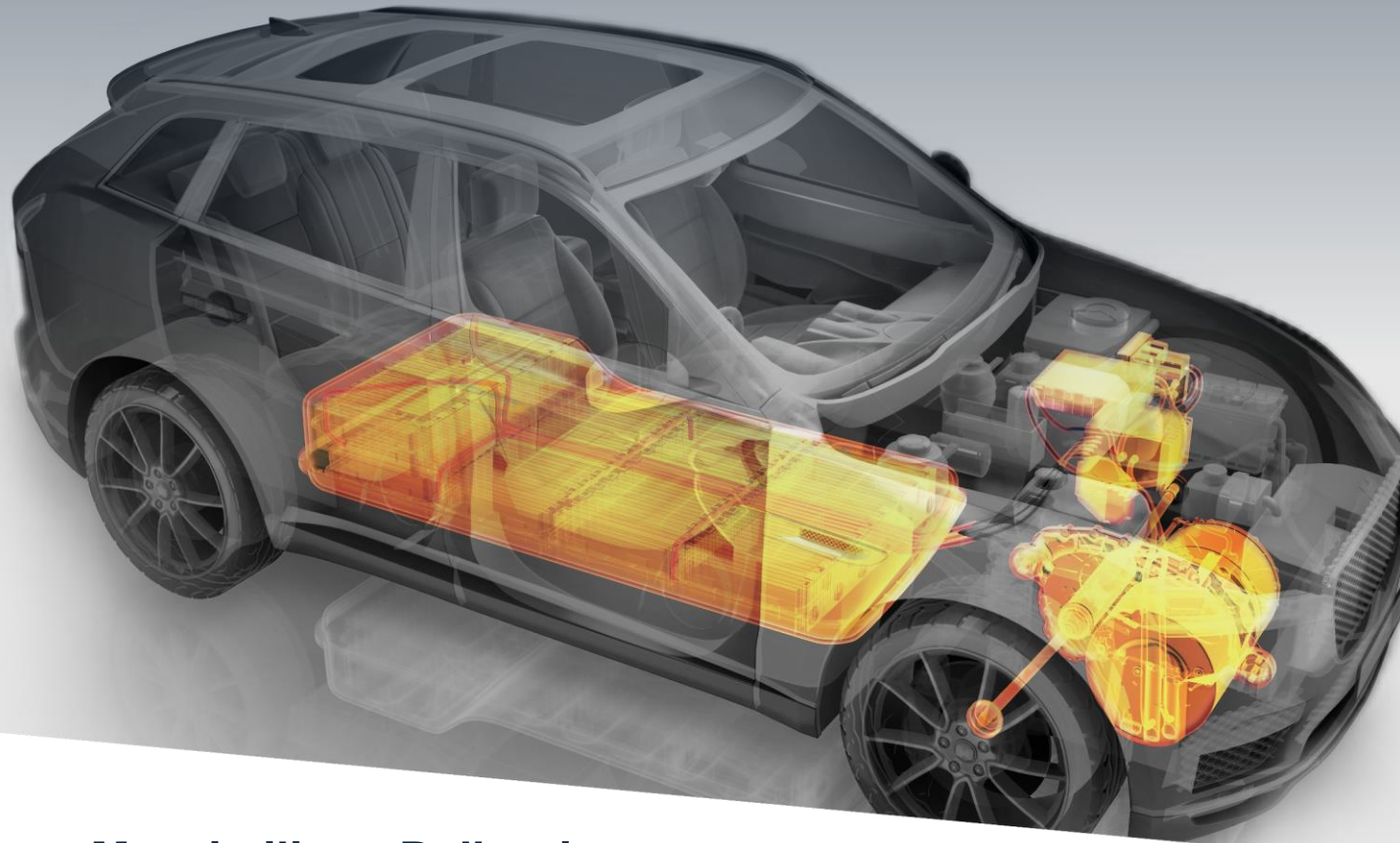
Images courtesy of Hübbers



Images courtesy of Hedrich



MADE POSSIBLE



Get in touch: **Massimiliano Balboni**
Global Marketing Manager (E-mobility)
Massimiliano_balboni@huntsgman.com

Huntsman Advance Materials warrants only that its products meet the specifications agreed with the buyer. Typical properties, where stated, are to be considered as representative of current production and should not be treated as specifications. While all the information and recommendations in this publication are to the best of our knowledge, information and belief accurate at the date of publication, no guarantee, warranty or representation is made, intended or implied as to the correctness or sufficiency of any information or recommendation or as to the merchantability, suitability or fitness of any products for any particular use or purpose. In all cases, it is the responsibility of the user to determine the applicability of such information and recommendations and the suitability of any product for its own particular purpose. Except where explicitly agreed otherwise, the sale of products referred to in this publication is subject to the general terms and conditions of sale of Huntsman International LLC or of its affiliated companies. ARALDITE® is a registered trademark of Huntsman Corporation or an affiliate thereof in one or more, but not all countries. ARADUR® is a registered trademark of Huntsman Corporation or an affiliate thereof in one or more, but not all countries. ARATHANE® is a registered trademark of Huntsman Corporation or an affiliate thereof in one or more, but not all countries. Huntsman Advanced Materials is an international business unit of Huntsman Corporation. Huntsman Advanced Materials operates through Huntsman Advanced Materials LLC, or its appropriate affiliate in different countries including without limitation Huntsman Advanced Materials (Europe) BVBA and Huntsman Advanced Materials Americas LLC. Copyright © 2024 Huntsman Corporation or an affiliate thereof. All rights reserved.