Application note

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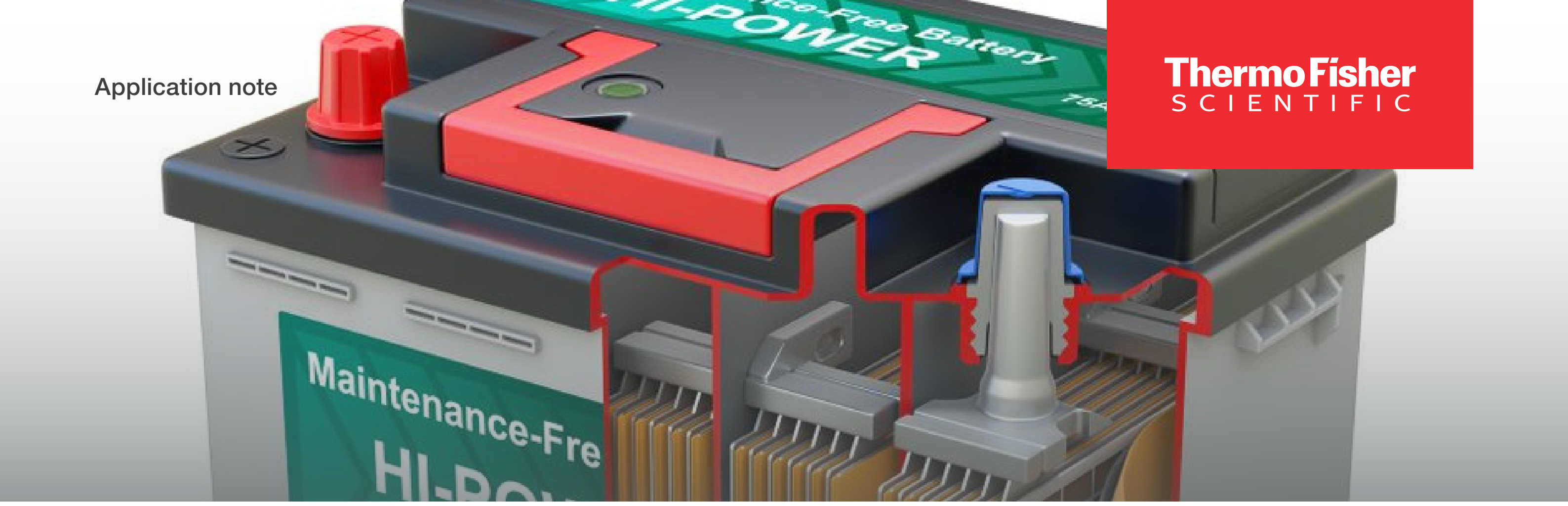

Cost-efficient and ecological twin-screw compounding of dry lithium-ion battery pastes

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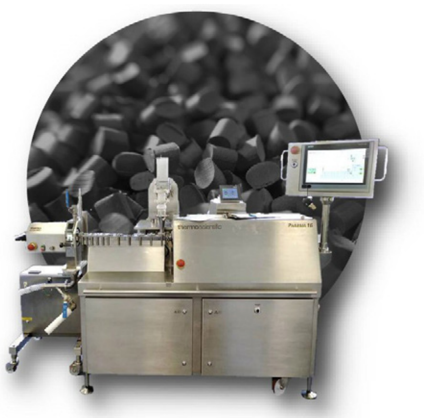

Figure 1. Pharma 16 Twin-Screw Extruder with gravimetric powder and liquid dosing systems and Pharma FaceCut Pelletizer.

Challenges for efficient battery production

The global production of lithium-ion batteries will increase enormously with the rising demand for electromobility. In this respect, ecologically and economically efficient production of electrodes is crucial. Additionally, the process-related structures of the electrodes must be optimized in order to ultimately improve the range, safety, and performance of electric vehicles, while at the same time lowering the price for the consumer.

One approach to achieve such goals, is to develop innovative processes for dry or low-solvent electrode manufacturing. Conventional coating of the electrode collector foil requires low-viscous slurries with a solvent content of 45%.[1] Subsequent solvent evaporation and recycling consumes a majority of energy, using 20% of the total energy required for cathode manufacturing.[2] Solvent reduction in slurries could significantly improve the ecological and economic efficiency of electrode production. But it also requires novel processing solutions for compounding and coating of the anode and cathode pastes.

Low-solvent battery paste extrusion

Twin-screw extruders achieve fine dispersion in high-viscous pastes through strong shear forces acting on the material. This alone reduces the solvent content by 50% in cathode pastes.[3] Polytetrafluoroethylene (PTFE) forms fibrils under shear and has been determined to be a suitable binder, fixing the electrode structure and at the same time creating a pore network that ensures the diffusion of lithium ions. Compounding extrusion of active material with PTFE yields high-viscous electrode pastes with solvent contents below 5%.

Thermo Scientific™ extruders are successfully used in research projects for innovative electrode manufacturing.[4] The twin-screw extruder compounds anode material with minimized solvent added. The highly viscous pastes are processed into pellets with the Thermo Scientific Pharma FaceCut Pelletizer (Figure 2). In this shape, they are easily transported and stored without aging. To form electrodes, the pellets can later be coated on collector foil and calendared in one step.

This electrode manufacturing route is scalable to mass production and prospectively demands 60% less energy than conventional manufacturing.[4] The technology is expected to be applicable to polymer electrolyte electrodes and, after minor adjustments, to solid-state electrodes.

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Extruder design

The split barrel design and the segmented screws allow for fast cleaning and process customization (Figure 3). This makes the twin-screw extruders ideal for the development of novel formulations and evaluation of extrusion in lab and pilot scale as a production compounding solution.

Depending on the availability of material, electrode pastes can be compounded with throughputs between 200 g/ hr and 30 kg/ hr with 11 mm, 16 mm, or 24 mm screw diameters. Identical geometry ratios enable easy scalability of the compounding process between the extruder sizes. All extruders are available in pharma grade stainless steel that is chemically resistant against corrosion, in CPM hardened steel that can withstand abrasion, or in nitriding steel 1.7361 (EN40B) that exhibits a well-balanced mix of both qualities.

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Figure 2. Pharma FaceCut Pelletizer cuts extruded paste into pellets with rotating blades directly at the die exit.

Figure 3. Twin-screw extruder split barrel design.

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