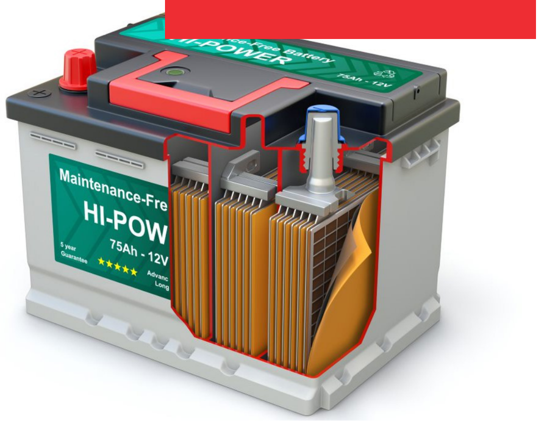

Cost-efficient and ecologically twin-screw compounding of dry lithium-ion battery pastes

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Challenges for efficient battery production

The global production of lithium-ion batteries will increase enormously with the increasing 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 is the major energy consumer with 20% of the total energy required for cathode manufacturing[2]. Solvent reduction in the slurries bears the potential to significantly improve the ecological and economic efficiency of electrode production. But it requires also 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 onto the material. This alone allows to reduce the solvent content by 50% in cathode pastes[3]. PTFE forms fibrils under shear and has been determined as a suitable binder, which fixes the electrode structure and at the same time creates 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%.

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

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

Figure 2: Pharma FaceCut 16 pelletizer cuts extruded paste into pellets with rotating blades directly at the die exit.

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

Thermo Scientific extruder design

The split barrel design and the segmented screws of Thermo Scientific Twin-Screw Extruders allow for fast cleaning and process customization (Figure 3). This renders them ideal for development of novel formulations and evaluation of extrusion in lab and pilot scale as a compounding solution for production.

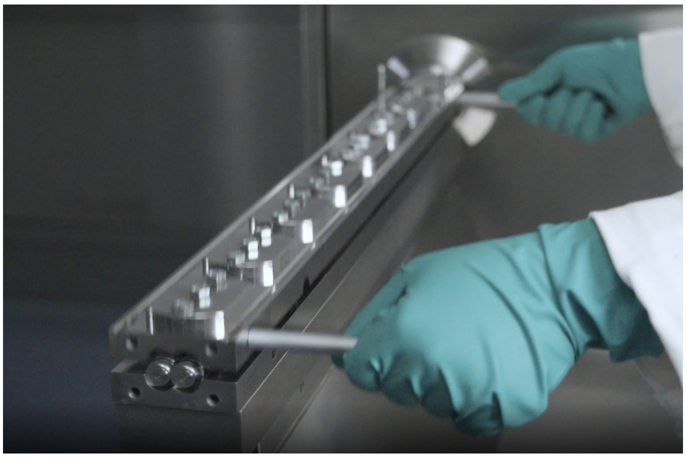

Figure 3: Split barrel design of Thermo Scientific Twin-Screw Extruder.

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

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