
1

FROM POWDER TO THE ROLL: DRY-COATED BATTERY ELECTRODES

THE TASK

The standard industrial process for the production of battery electrodes is currently based on wet chemical coating processes in which the active material in the form of suspensions is applied to a metal foil. To ensure that the electrodes produced are of high quality, the removal of the partially toxic solvents used is of great importance. For this, very long and expensive drying sections are needed, which means an immense use of energy.

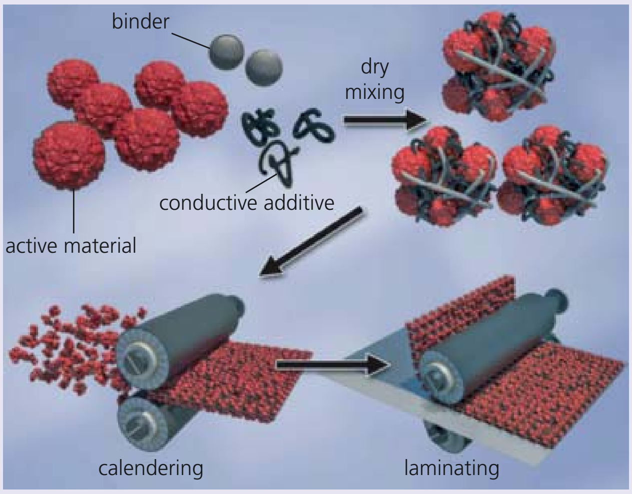
New environmental regulations and increased energy costs demand a rethinking of the concept for new production technologies for battery electrodes. A method of electrode production that does not require the use of solvents therefore has great potential for the saving of production costs.

OUR SOLUTION

Fraunhofer IWS starts here with the dry coating processes, with which the powder is converted in a solvent-free manner to layers and free-standing dry films. Within the collaborative projects DryLIZ (FKZ: 02PJ2302) and BaSta (FKZ: 0325563A) the foundation for the dry materials processing of battery electrodes is laid. Cathode materials for lithium-ion technology (lithium iron phosphate LFP; DryLIZ) and carbon-sulfur composites for room temperature sodium/sulfur batteries (BaSta) were investigated. Within BaSta, an experimental system emerged which was technically expanded for continuous operation. The process of dry coating includes two essential steps. First the powders of the active materials, additives and binders were blended in a dry-mix process. The structure and distribution of the polymer binders are of decisive importance. With optimal distribution of polymer fibrils, with a low binder proportion below 5 % wt., mechanically stable, freestanding films are obtained.

The mixing process yields a powdery material, which is now pressed into thin electrode films of around 50 – 100 µm thickness. These films are either freestanding or bonded to a current collector substrate. The uniform distribution of the powdery material is here of high importance. IWS engineers developed a special applicator system for this step. The IWS has flexible systems so that the powders can be continuously processed into coiled electrode films. In future work, the processes and system components can be adjusted to special customer requirements and further developed.

Process schematic to fabricate dry films



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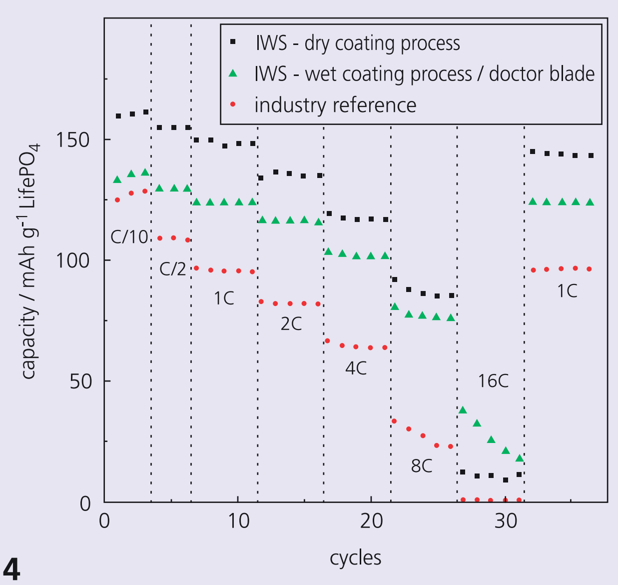
RESULTS

The lithium iron phosphate cathodes manufactured by dry coating were electrochemically investigated and then compared to conventionally processed cathodes. Both for the active material utilization as well as the rate capability (the capacity at increased C-Rate), higher values were obtained with the dry film electrodes than for the reference electrodes.

Likewise, dry-produced carbon/sulfur cathodes are superior to the carbon/sulfur cathodes produced by doctor blade processes. Thus, a specific capacity of over 1,100 mAh g^{-1}-sulfur in the Li-S battery can be achieved with a surface load of over 3 mg cm^{-2}.

Comparison of $LiFePO_4$ cathodes produced by different methods



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By means of an experimental setup used for the conception of demonstration equipment, already 100 µm thick cathode layers could be produced on an aluminum foil with a line speed of 1 m min^{-1}. The enormous potential of the new dry film process, which can be used for different electrode materials in the future, could be revealed.

From the results the following advantages of the dry coating process can be deduced:

- cost savings through the elimination of solvents and drying process,
- environmentally-friendly through the elimination of toxic solvents,
- defect-free application of thick coatings,
- capability to process additives and active materials that are difficult to disperse,
- prevention of negative interference from solvents / drying process.

1 Roll-to-roll process for dry coating

3 Fabrication of a freestanding $LiFePO_4$ cathode

5 Dry coating machine

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