Study of the cathode coating-drying manufacturing process by design of experiments

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The understanding of traditional battery manufacturing operating conditions on electrode structure and final electrochemical performance is currently limited. In this study, the design of experiments methodology (DoE) is applied for the identification of the main operating variables (factors) of the coating-drying process in the manufacturing of cathodes at the pilot-scale. The experimental design is a saturated design that considers only two settings (levels) for each of the factors. The factors studied are: comma bar gap (80 and 140 µm), coating ratio (110 and 150%), web speed (0.5 and 1.5 m/min), drying temperature of the first oven zone (85 and 110 °C) and drying air speed (5 and 15 m/s). The output variables (responses) include pre-calendered and calendered physical electrode properties (mass loading, thickness and porosity) as well as gravimetric and volumetric energy capacities. Analysis of variance and multiple linear regression determines the relationship between factors and responses and their statistical significance with a confidence level of 90% (p-value =0.1). Empirical models for the responses are obtained in terms of the statistically significant factors. Results show that comma bar gap and coating ratio are critical parameters since have a direct impact on battery electrochemical performance. The drying temperature is not statistically significant at the conditions studied and therefore is a non-critical parameter. The correlations show a good agreement between the experimental data and the models, resulting in correlation coefficients (R^2) as high as 0.99 in some cases. The work demonstrates the applicability of DoE to the manufacturing process of Li-ion batteries at a pilot-scale for the identification of important operating variables and their effect on battery performance. The obtained models are useful in the determination of operating parameters settings to achieve a robust manufacturing process, therefore reducing time and cost.