

# Use of Pulsed Electric Field (PEF) Technology to Reduce the Bacterial Contamination in E-coating Lines

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With the increasing application of environmentally friendly E-coating systems, water-based paints are being widely used. However, lower process temperatures and water recirculation promote microbial growth, leading to contamination in processing tanks and rinse water systems. Traditional disinfectants, such as biocides, face regulatory restrictions and risk bacterial resistance, necessitating alternative solutions. Pulsed Electric Field (PEF) treatment, which permeabilizes bacterial cell membranes through high electric field strengths, represents a sustainable method for microbial control in E-coating systems. However, paint deposition on electrodes and paint coagulation must be prevented during PEF treatment to maintain coating quality and system functionality. Calculations showed that this can be achieved using pulses in the range of few ns, while longer pulses promote paint deposition on electrodes. Electrodeposition on metallic substrates occurs through water electrolysis, where a pH increase at the cathode causes coating particles to become water-insoluble, leading to their attachment. Reducing the pulse duration below the induction time for OH<sup>-</sup> formation was ineffective, as even short pulses (< 1 μs) could not completely prevent deposition. High pulse repetition rates further promoted coating formation by continuously increasing pH levels. A more effective approach involved using bipolar pulses, where alternating anodic and cathodic interfaces neutralized OH<sup>-</sup> and H<sup>+</sup> ions. Short bipolar pulses (0.75 + 0.75 μs and 1 + 1 μs) completely prevented deposition, whereas longer pulses (5 μs) resulted in paint deposition. A solution was found by using a semiconductor-based pulse generator that ensured charge symmetry, preventing ion accumulation and coating formation. Experiments with 1.5 + 1.5 μs bipolar pulses demonstrated long-term prevention, with no deposition after extended operation. This patented process was integrated into a pilot e-coating system. PEF treatment, using short bipolar pulses, offers an effective solution to bacterial contamination while maintaining coating quality, reducing freshwater consumption, and minimizing effluent generation in E-coating process.

## Acknowledgment

This study was carried out in the joint project DiWaL, funded by the German Federal Ministry of Education and Research (BMBF) under the WavE programme, FKZ 02WAV1405C. The consortium of this project was built with following partners: BMW Group Leipzig; Eisenmann GmbH; Emil Frei GmbH & Co. KG; PPG Deutschland Business Support GmbH; Pforzheim University, Institute for Industrial Ecology (INEC); KIT, Institute for Pulsed Power and Microwave Technology (IHM-IHM) and the Institute of Functional Interfaces (IFG-IHM).