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Characterization of Heterogeneous Reaction Systems by Thermal Analysis and Mathematical Modeling

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Abstract

In recent years, aluminum alloys have become a primary option as an alternative to low-carbon steels for uses in the automobile and aerospace industries. Metals are typically coated in a pre-treatment process for the purposes of resistance to corrosion and high-temperature degradation; however, this has been achieved for decades via chromate-based processes, which are now known to have severe environmental consequences. Such processes have been targeted for elimination by the United States Environmental Protection Agency. There is a marked movement to phase these processes out in the near future in favor of alternative, environmentally friendly options. This research focuses on calorimetric analysis and mathematical modeling to develop an alternative process using an aryl phosphate capable of forming films on iron-containing surfaces. This research shows that these ester phosphates can promote organic coatings on aluminum substrates when supplemented by iron additives. The film-forming reaction is monitored using a differential scanning calorimeter, and the kinetic parameters (namely, the pre-exponential factor, order of reaction, and activation energy) are extracted through differential kinetic analysis. It is anticipated that this research will lead to scale-up parameters that can be used to model a laboratory-scale deposition furnace, and guide further experimentation to advance technologies for protective and conversion coatings.