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Investigation of Characteristic Values in TDR Waveform Using SHapley Additive exPlanations (SHAP) for Dielectric Constant Estimation During Curing Time

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ABSTRACT

As materials cure, the internal electrical flow changes, leading to variations in the dielectric constant over time. This study aims to assess the impact of voltage values extracted from time domain reflectometry (TDR) waveforms, measured during the curing of materials, on predicting the dielectric constant. The experiments are conducted over a curing period ranging from 60 to 8640 minutes, with 30 TDR trials. From the measured waveforms, values of V_0, V_1, V_2, V_f, and Δt are deduced. Additionally, curing time is included as an input variable. Groups A and B are distinguished based on the presence or absence of Δt, indicating a physical relationship between Δt and the dielectric constant. The dielectric constant is set as the output variable. The SHapley Additive exPlanations (SHAP) algorithm is applied to the compiled data. The results indicate that Δt and V_1 are the most influential input variables in both Group-A and Group-B. The study also presents the distribution of SHAP values and interacts SHAP values to infer the interrelationships among the input variables. To validate the reliability of these findings, the partial dependence (PD) algorithm is applied to estimate the marginal effects of each input variable, with outcomes closely aligning with those of the SHAP algorithm. This research suggests that understanding the contributions and proportional relationships of each input variable can aid in interpreting the relationships among various material properties.

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