

A Machine Learning approach for enhancing permittivity mixing rules of binary liquids with a Gaussian modification and a new interaction factor estimation

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Abstract-

The microstructure and solvation mechanics of binary liquids are key for predicting mixture permittivity. However, since traditional mixing rules do not consider this complexity, they must be modified to address the mixture characteristics through an interaction factor ϵ_{int} . This paper evaluates this parameter for several mixing rules, applying Support Vector Regressor models trained with glycerin-water reflective signals acquired with a Dielectric Resonator sensor. The regression error of these models indicates both the optimal interaction factor and the mixing rule that fits the most with experimental permittivity values. Kraszewski and Hashin-Shtrikman mixing rules achieved the best performance with an RMSE of around 1. In addition, this paper suggests that the interaction factor can be estimated through the molar volume and the dielectric contrast between liquids $(K_{int}=2.67)$ without acquiring experimental data. Moreover, after analyzing the physical limitations of a linear modification formula, this paper proposes an alternative based on a Gaussian function that avoids unrealistic volume fractions. Both contributions enhance mixing rule accuracy and improve the flexibility to model mixture dielectric behavior.

Index Terms- Binary mixture; Dielectric characterization; Machine Learning; Mixing rules; Permittivity

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