

A Hyperbolic Approach from the Hashin and Shtrikman's Equation: Survey of Permittivity Prediction

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Using a variational approach, Hashin and Shtrikman¹ established the upper and lower bounds for the effective permittivity of a macroscopically homogeneous and isotropic two-phase material. These bounds can be derived from the knowledge of phase volume fractions and permittivities of the pure components. In this work from the demonstration of Hashin and Shtrikman's equation, a hyperbolic approach is introduced that let describe and compare mixture formulae mostly developed for predicting the effective permittivity of mixtures. Then we analyze about 20 mixing formulae that were developed for predicting the permittivity of isotropic two-phase mixtures or the relative permittivity of binary liquid mixtures. The results of this examination are grouped into two main classes according to the behavior of the predicted asymptote values upon changing composition of binary mixtures. For completeness, we give customary representations of these mixture formulae, frequently in the form preferred by Sihvola.² We show that all of these formulae can be described in terms of rectangular hyperbolae and that, for a given mixture at specified composition, temperature and pressure, a single parameter fixes both asymptote values. Some formulae are in fact segments of a certain hyperbola, whereas others can only be represented by a succession of hyperbolae with sliding asymptotes with changing composition of the mixture. On the basis of this hyperbolic approach, we propose to examine experimental data on relative permittivities by analyzing the dependence on composition of asymptote values, which are also related to the excess relative permittivity. We report new experimental relative permittivities of binary mixtures of tetraglyme with the hydrocarbons hexane, cyclohexane and benzene at various temperatures. By bringing together the methods of chemical thermodynamics and our hyperbolic approach to dielectrics mixture formulae, we propose a novel method for the analysis of excess relative permittivities of binary liquid mixtures.

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