Viscosity of multimodal suspensions predicted from solid fraction model for mixtures
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The model is able to predict the viscosity of a suspension of non colloidal rigid spherical particles in a Newtonian fluid. The theory is developed to highlight a new relation between relative viscosity and the solid volume fraction. A new version of the Compressible Packing Model (CPM), the 4-parameter CPM, is introduced to predict the solid fraction of maximally dense disordered packings of spherical particles. It is apt to account for the geometrical interactions between particles.

4-parameter Compressible Packing Model (CPM):

\[
\gamma_i = 1 - \sum_{j=1}^{n_i} \left[ \beta_i \left( 1 - \frac{a_j}{\bar{a}_j} \right)^{1 - \beta_i} \right] \left( 1 - \beta_i \right) \gamma_j + \frac{\sum_{j=1}^{n_i} (1-\beta_i) \gamma_j}{\bar{a}_i},
\]

where:
- \( \gamma_i \): suspension viscosity
- \( \beta_i \): viscosity of the Newtonian suspending fluid
- \( \phi \): volume fraction of the suspended spheres in a total volume unity
- \( \gamma_j \): volume fraction of the class \( j \) considering the presence of finer class
- \( \bar{a}_i \): maximal volume fraction of the class \( i \) considering the presence of finer class

In agreement with a previous work of [BOURDOS], the iterative approach advocated by Farris and a power-law relation (Krieger-Dougherty type) are used for the relative viscosity. The theory is developed to highlight a new relation between relative viscosity and the solid volume fraction, compatible with the Einstein relation. When the solid volume fraction reaches its critical value, the suspension is jammed and the mixture reaches the packing density of the solid skeleton.

Viscosity of a suspension:

\[
\eta = \eta_0 \prod_{i=1}^{n_i} \left( 1 - \frac{\gamma_i}{\gamma_{i_{MAX}}} \right)^{C_{PM}} \quad C_{PM} = 2.5
\]

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References: