Modeling of an electrically driven droplet generator

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ABSTRACT

The application of strong electric fields on liquids is used in many engineering applications to induce liquid atomization in a controlled manner. In electrosprays, the droplet size and the opening angle of the spray cone can be affected by charging the liquid prior to its atomization. Controlled detachment of single liquid droplets for experiments under different atmospheric conditions can be achieved using strong electric fields in on-demand droplet generators [1].

Deformations of the phase boundary induced by electric fields result in changes in the electric field and force distribution. The mechanical and electric problems are thus strongly coupled. Additionally, due to the presence of intrinsic ionic species and dissolved impurities, liquids exhibit some electrical conductivity associated with charge migration. Dynamic charging effects in liquid droplets and convection of free charge can strongly alter liquid motion. Moreover, the accumulation of free charge in droplets can result in the generation of charged droplets from initially uncharged liquid. This behaviour requires an electroquasistatic field representation, taking into account both conduction and displacement electric currents in the liquid.

We discuss a conduction-convection model for the simulation of droplet dynamics under the influence of electric fields. The liquid interface is captured using the Volume of Fluid method , allowing for an efficient representation of topology changes in the phase boundaries. The electric problem is solved using the resulting diffuse interface, and the resulting electric force is introduced as a source term for the hydrodynamic problem. Wetting is taken into account by using a dynamic contact angle model.

The numerical study of liquid droplets generation in an on-demand droplet generator [1] is considered in this work. Detachment dynamics of acetone and pentane droplets, exhibiting respectively high and low conductivity, are reproduced numerically, and illustrate the effect of conductivity on electrically induced droplet motion.

REFERENCES

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