Mechanical Engineering Doctoral Defense

A study on the evaporation and dynamic wicking on a passive air freshener

School for Engineering of Matter, Transport and Energy

Jing Yuan

Advisor: Kangping Chen

Abstract

In this dissertation, two types of passive air freshener products from Henkel, the wick-based air freshener and gel-based air freshener, are studied for their wicking mechanisms and evaporation performances.

The fibrous pad of the wick-based air freshener is a porous medium that absorbs fragrance by capillary force and releases the fragrance into the ambient air. To investigate the wicking process, a two-dimensional multiphase flow numerical model using COMSOL Multiphysics is built. Saturation and liquid pressure inside the pad are solved. Comparison between the simulation results and experiments shows that evaporation occurs simultaneously with the wicking process. The evaporation performance on the surface of the wicking pad is analyzed based on the kinetic theory, from which the mass flow rate of molecules passing the interface of each pore of the porous medium is obtained. A 3D model coupling the evaporation model and dynamic wicking on the evaporation pad is built to simulate the entire performance of the air freshener to the environment for a long period of time. Diffusion and natural convection effects are included in our simulation. The simulation results match well with the experiments for both the air fresheners placed in a chamber and in the absent of a chamber, the latter of which is subject to indoor airflow.

The gel-based air freshener can be constructed as a porous medium in which the solid network of particles spans the volume of the fragrance liquid. To predict the evaporation performance of the gel, two approaches are tested for gel samples in hemispheric shape. The first approach is the sessile drop model commonly used for the drying process of a pure liquid droplet. It can be used to estimate the weight loss rate and time duration of the evaporation. Another approach is to simulate the concentration profile outside the gel and estimate the evaporation rate from the surface of the gel using the kinetic theory. The evaporation area is updated based on the change of pore size. A 3D simulation using the same analysis is further applied to the cylindrical gel sample. The simulation results match the experimental data well.

October 6, 2021; 9:30 AM;

Zoom Link: https://asu.zoom.us/j/6947454708