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Deposition modeling of hygroscopic saline aerosols in the human respiratory tract: Comparison between air and helium-oxygen as carrier gases

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Abstract

When hygroscopic aerosols are inspired, the size and temperature of the dispersed droplets, as well as the temperature and moisture content of the carrier gas may change due to heat and mass transfer between the dispersed phase and the gas, and also between the gas and the airway walls. This two-way coupled problem is numerically analyzed, with the focus on the effect of using helium-oxygen instead of air as the carrier gas on hygroscopic size changes and deposition of aqueous solution aerosols. Coefficients of heat and mass transfer in each generation of an idealized respiratory tract are specified based on realistic assumptions. Aerosols of initially isotonic droplets are considered. Differential equations of heat and mass transfer for both the continuous and dispersed phases are numerically solved to simulate the evaporation and condensation. Once the droplet sizes are determined in each respiratory tract generation, deposition is estimated based on existing correlations for stable particles. The results include regional deposition, in percentage of inhaled NaCl, for both helium-oxygen and air for a variety of size distributions: MMD between 2.5 and 8.5 micrometers and GSD of 1.7. Moreover, the size and temperature variations of the droplets as well as the temperature and humidity variations of the carrier gas are reported. To investigate the impact on deposition caused by hygroscopic size changes, the hygroscopic effectiveness is defined, which specifies the differences in He-O_2 and air deposition caused by hygroscopic size changes. The results, in general, suggest that the lowest deposition fraction in the