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RESPIRATORY AEROSOL PARTICLE EMISSIONS AND CONTROL IN THE CLEAN ROOM ENVIRONMENT

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1 INTRODUCTION

The current COVID-19 pandemic has highlighted the importance of understanding better the rapid aerosol transmission of pathogens, especially in respiratory aerosol particles (Greenhalg et al., 2021; Pai et al., 2016). Respiratory aerosol particle and droplet emissions vary widely between individuals and various activities such as breathing, speaking, singing, and coughing (Alsved et al., 2020; Asadi et al., 2019; Morawska et al., 2009). Important parameters in assessing the risk of infection with pathogens are respiratory particle emission rates and size distributions, as well as dispersion and dilution (Peng et al., 2022).

In this study, the emission mechanisms, and dynamics of aerosol particle emissions from respiratory tract are presented based on our pilot studies and the recently published articles. A new developed portable measurement system for respiratory particle emission experiments and some preliminary results are presented.

2 METHODS

The portable measurement system (Figure 1) enables the investigations of absolute and time-resolved exhaled aerosol emission rates with controlled drying and dilution processes of generated droplets. The system has an aerosol chamber having background aerosol concentration ca 0 after feeding clean pressurized air through HEPA filter. Temperature in the chamber was about 20°C and relative humidity was less than 1%, allowing the respiratory droplets to dry quickly. The relative humidity of the environment affects the final size and dynamics of the respiratory droplets, so it is an important parameter in the measurement system. Aerosol emissions were collected with aerosol sampling tubes at about 20 cm from the subject. The aerosol sample was fed to the real-time aerosol instruments (TSI 3776 CPC, Airmodus A20 CPC, TSI APS, Palas Fidas Frog) that are installed under the aerosol chamber. Parallel CO_2 concentration was measured (LI-840A, LI-COR Inc) to obtain information on aerosol dilution.

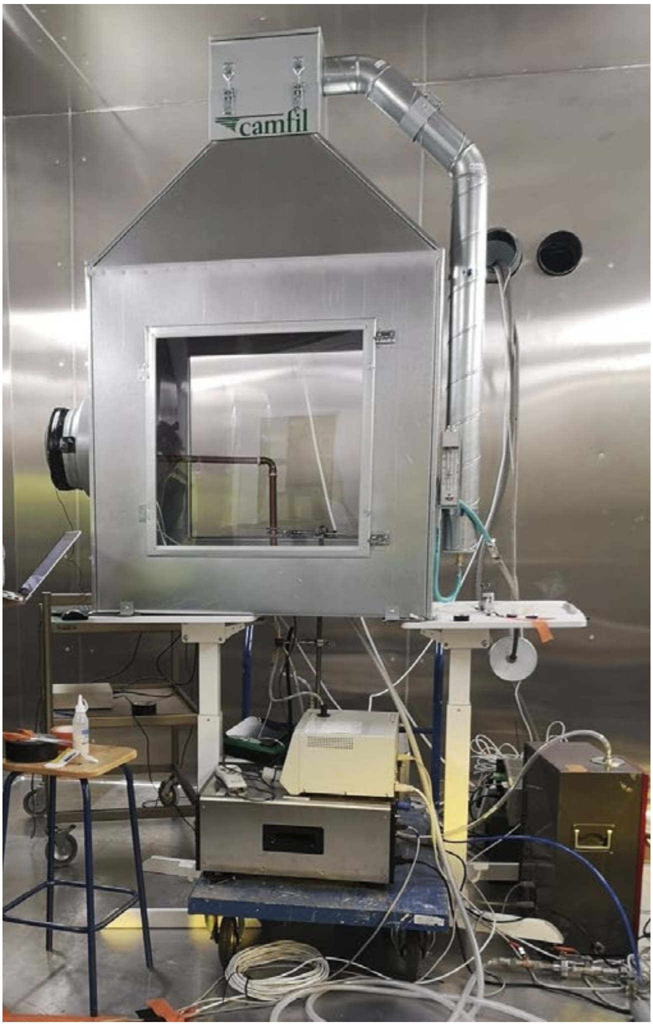

Figure 1: Portable measurement system for respiratory aerosol emission studies.

3 RESULTS AND DISCUSSION

Using the current measurement system, we can study respiratory aerosol particles generation rate in real time over a wide particle size range (0.01–10 µm). CO_2 measurement allows us to estimate dilution ratio of the aerosol emissions, so we can estimate the absolute aerosol emission concentrations. The results showed that most of the aerosol particles were smaller than 0.5 µm in size. The results are in line with the previous observations in which the highest number concentration of respiratory particles was estimated to be around 0.1 µm in size (Pöhlker et al., 2021). The results indicate that the number of respiratory viruses may also be significant in this particle size range. However, the smallest particles are not necessarily relevant carrier of the virus, as individual viruses are typically larger than about 0.08 µm. Particle emissions varied between the speaking, singing, and coughing. Interestingly the particle emissions correlated with CO_2 concentration, which can be a useful indicator for assessing airborne aerosol particle emissions and dilution in indoor environments. An interesting question is whether emissions by particle volume concentration are more critical than particle number concentration because larger particles may have more infectious pathogens than smaller ones. That is one of the most important questions in future studies.

4 IN CONCLUSION

The results will help us gain new insights on aerosol transmission events, especially on the differences between common spreaders and potential super-spreaders. The study also indicates the efficiency of some potential aerosol control measures in the clean room environment such as face masks, air purifier and filtration. Because most respiratory particles are small, it is recommended that the performance and leakage of face masks, air purifiers and filtration equipment be tested over a size range of 0.1 to 10 µm.

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