Aerosol chamber studies to characterize the SARS-CoV-2 transmission through aerosol particles (AEROVIR)

Hartmut Herrmann[1], Hans-Hermann Richnow[2], Uwe G. Liebert[3]

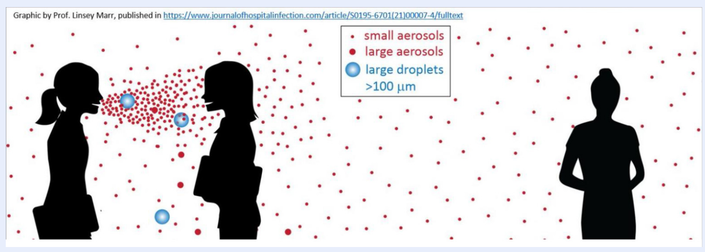
1 Leibniz Institute for Tropospheric Research, Leipzig, Germany
2 Helmholtz Centre for Environmental Research (UFZ), Leipzig, Germany
3 Institute of Virology, Universitätsklinikum Leipzig, Germany

contact: hartmut.herrmann@tropos.de

Objectives

One of the most important challenges of the current COVID-19 pandemic is to understand the transmission process of the SARS-CoV-2 through aerosol particles which appears to govern spread from infected persons [1-4]. Recent laboratory studies demonstrated that SARS-CoV-2 remained viable in aerosol particles throughout several hours of laboratory experiments [5]. Field experiments could proof that Covid-19 patients produce aerosol particles containing viable SARS-CoV-2 serving as a source of transmission of the virus [6-8].

COVID-19 Focus Funding: Aerosol Particles and their Distribution



AEROVIR project aims for a better understanding of the transmission of SARS-CoV-2 through aerosol particles by investigating the temporal physico-chemical and virological behaviour of virus-loaden aerosol particles in aerosol chamber experiments under variation of the experimental conditions, like temperature, humidity, irradiation, carrier aerosol particle chemical composition, resulting in the identification of the most important impact factors on virus transmission through aerosol particles with the health effects caused.

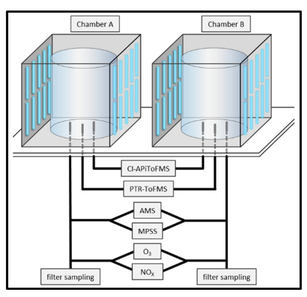
➡ **Health related chamber studies for comprehensive overview about the SARS-CoV-2 transmission through aerosols**

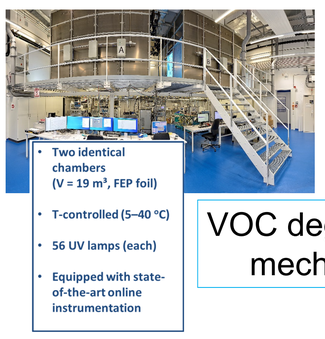
Aerosol Chamber Experiments

Atmospheric Chemistry Department – Chamber (ACD-C)

ACD-C with its twin chamber setup is a new research infrastructure with broad online and offline instrumentation to study:

- SOA formation processes
- Multiphase chemistry
- VOC degradation mechanism
- Toxicological effects of formed SOA





PI: Prof. Hartmut Herrmann (herrmann@tropos.de)
Contact person: Dr. Falk Mothes (mothes@tropos.de)
General contact: acdc@tropos.de

Work Programme and Research Methods @ ACD-C

1) Target virus will be the Feline coronavirus as proxy for SARS-CoV-2, alternatives are the bovine or canine respiratory coronavirus (BCoV, CRCoV)
2) Matrices of the aerosol particles to be loaded with viruses will consist of an artificial mucus like seed solution [9] and one of the classical environmental seed solutions based on ammonium sulfate $(NH_4)_2SO_4$
3) Generation of aerosol particles with a size of 150 nm upwards by dispersion of aqueous seed solutions containing the virus, for experiments with aerosol particles in the size range around 3 µm, a PARI BOY® nebulizer will be applied [10, 11]
4) Development and optimization of a suitable sampling strategy for virus-loaden aerosol particles allowing further cultivation of sampled viruses without the destruction or severe damage of the sampled viruses

Course of planned chamber experiments (about 70 in total)

a) Variation of the relative humidity (RH)
RH1=~0, RH2=20%, RH3=40%, RH4=60% and RH5=80%

b) Variation of the temperature
T1=278K, T2=298K and T3=318K

c) Variation of the irradiation
dark, L1= standard UV-A light at 2J(NO_2), L2=UVC with light at 253.7nm

Injection of quantitated (RT-PCR & titer) virus and sampling after different time points T1=0min, T2=30min, T3=60min and T4=120 min → Analysis of the chemical composition → Virus analysis → Gene copy quantification (proxy for total virus) → Titer determination (infectious particles) → Visualization (location of viral particles in aerosol particles)

High Resolution Visualization Techniques

Characterization of architecture and chemical composition of individual virus-loaden aerosol particles by UFZ

1) Chemical microscopy to analyze the organic and inorganic composition
2) Gene FISH probes to identify viruses, direct-geneFISH is a Fluorescence In Situ Hybridization method that directly links gene presence for identification of microbial cells or virus targeting mRNA [12-14] → method need to be adopted to the planned feline coronavirus
3) High resolution MS for determination of the aerosol matrix chemical composition, e.g., lipids, carbohydrates and amino acids and their chemical altering to investigate the function of the matrix regarding the protection of the virus load
4) NanoSIMS and ToF SIMS to analyze elementary composition and organic matter of aerosol particles

Corona Viruses Cultivation and Virological Analysis

- The model corona virus FCoV [15, 16] for the chamber experiments will be provided by the University of Leipzig, UKL virology
- Virus will be cultured, isolated and mixed with artificial model exudates (secretion) to simulate infection of throat, pharynx or lung leading exhalation by sneezing, coughing or speaking
- Fluids and secretions are supposed to reproduce the natural structure of saliva or sputum, this includes culturing the viruses on cell lines and preparation of the artificial matrices
- Viral genome copies from fractions of aerosol particles collected on impactors will be quantified by RT-PCR
- Further analysis planned regarding their infectivity by using cell culture isolation techniques to determine the virus titer in order to obtain information on half–lifetimes under tested environmental conditions

References

[1] M.A. Kohanski, et al., Int. Forum Allergy Rh. (2020), 10, 1173. [2] S. Tang, et al., Environ. Int. (2020), 144, 106039. [3] Robert Koch Institut, Epidemiologischer Steckbrief zu SARS-CoV-2 und COVID-19, https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Steckbrief.html (14.07.2021). [4] L. Morawska, et al., Clin. Infect. Dis. (2020), 71, 2311. [5] N. van Doremalen, et al., N. Engl. J. Med. (2020), 382, 1564. [6] J.A. Lednicky, et al., Int. J. Infect. Dis. (2020), 100, 476. [7] P.Y. Chia, et al., Nat. Commun. (2020), 11, 2800. [8] K. Nissen, et al., Sci. Rep. (2020), 10, 19589. [9] S. Kirchner, et al., J. Vis. Exp. (2012), [10] K.H. Chang, et al., Pharmaceutics (2020), 12, [11] E. Fröhlich, et al., Toxicol. in Vitro (2013), 27, 409. [12] E. Allers, et al., Environ. Microbiol. (2013), 15, 2306. [13] Y.M. Castillo, et al., Front. Microbiol. (2020), 11, [14] J. Liu, et al., bioRxiv (2020), 2020.04.21.042911. [15] M.J. Hosie, et al., Viruses (2021), 13, [16] A. Alazawy, et al., J. Electron Microsc. (2011), 60, 275.