

Maxairea CO₂ removal

ExpertsessionXL

Jacobs, P. (Piet) |

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Background:

Maxairea has developed an air filtration unit that extracts CO₂ from ventilation supply air. To explore whether this technology could reduce the risk of exposure to COVID (SARS-Cov-2) TNO has desk reviewed a number of scientific publications on this topic. The results are listed in this powerpoint.

This study has been carried out in the framework of the TNO Fast Track programme.

Summary

Carbon dioxide is usually treated as a signal of how well an occupied room is ventilated. New laboratory research as reviewed by TNO for this study suggests it may have a second role also: the carbon dioxide level around a respiratory particle may influence how quickly severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) loses infectivity after exhalation. In controlled laboratory experiments, higher surrounding carbon dioxide microclimates has helped the virus remain infectious for longer by decreasing the pH of the respiratory droplet. Simulation studies indicates that this might have a significant effect. However, real buildings are more complex: particle size, relative humidity and other gases in indoor air can change the same chemistry and may weaken, strengthen or reverse the effect.

Validation of the laboratory results in real world situations is complex as currently infectivity measurements can only be carried out under controlled laboratory settings. Validation of the effectivity of CO₂ filtration in real practice would involve a large amount of occupied buildings with and without CO₂ filtration, careful logging of all Indoor Air Quality parameters and sick leave due to airborne virus infections.



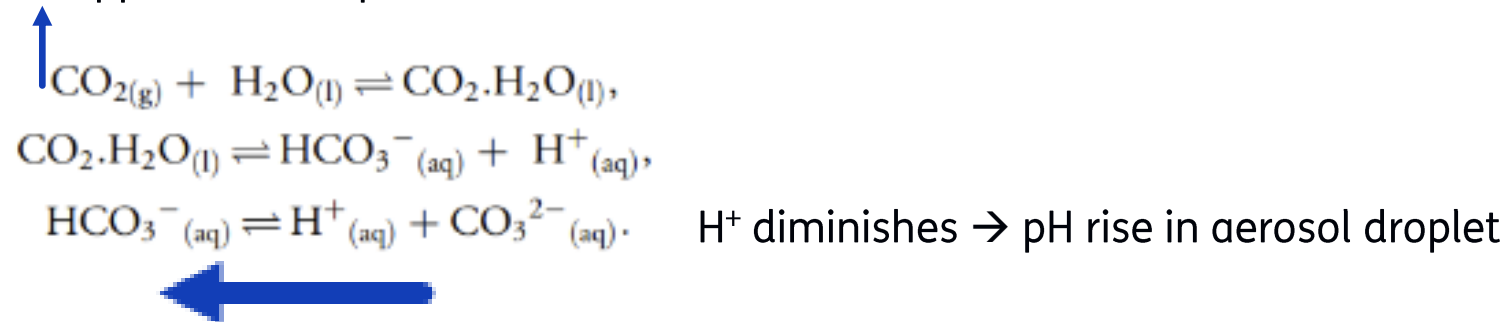
The dynamics of SARS-CoV-2 infectivity with changes in aerosol microenvironment

Henry P. Oswin^a, Allen E. Haddrell^{a,1}, Mara Otero-Fernandez^a, Jamie F. S. Mann^b, Tristan A. Cogan^b, Thomas G. Hilditch^a, Jianghan Tian^a, Daniel A. Hardy^a, Darryl J. Hill^c, Adam Finn^c, Andrew D. Davidson^{c,1}, and Jonathan P. Reid^{a,1}

Edited by Michael Oldstone, The Scripps Research Institute, La Jolla, CA; received January 6, 2022; accepted April 28, 2022

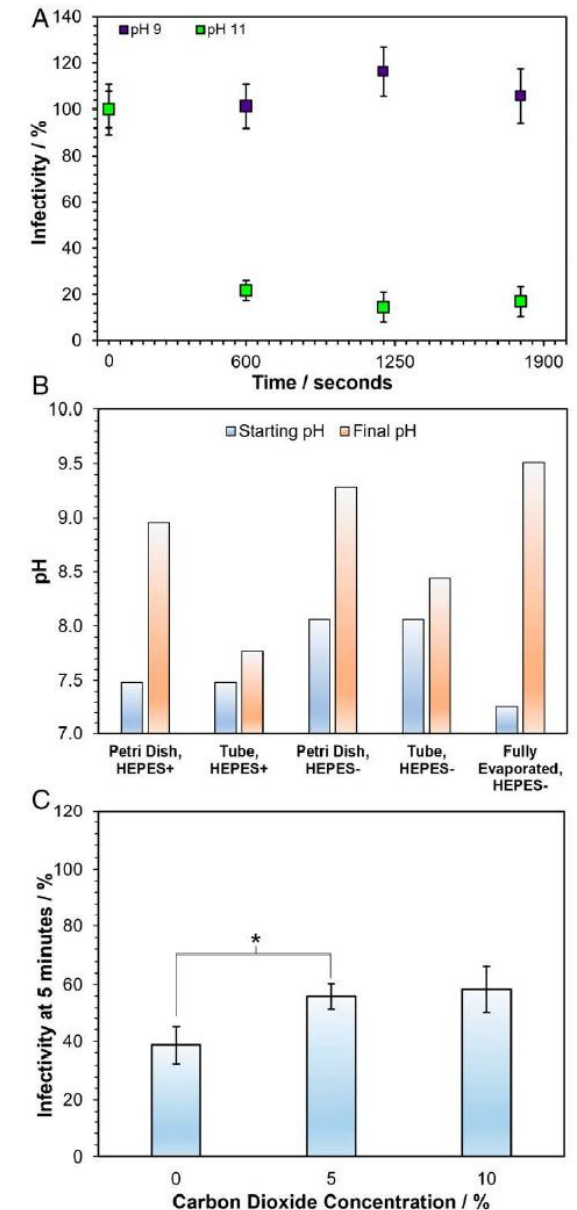
A) Faster virus deactivation at high pH

B) Culture medium solution with HEPES buffer: pH rise from 7 to 9,5 in open air (400 ppm) and evaporation



C) Virus is less stable at low CO₂ concentration due to pH rise in aerosol droplets

Note: CO₂ exhalation air 40.000 - 50.000 ppm.

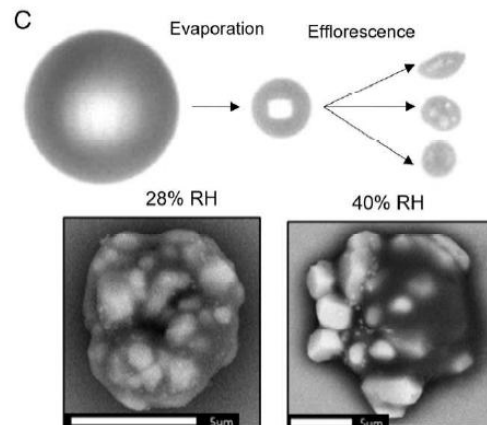
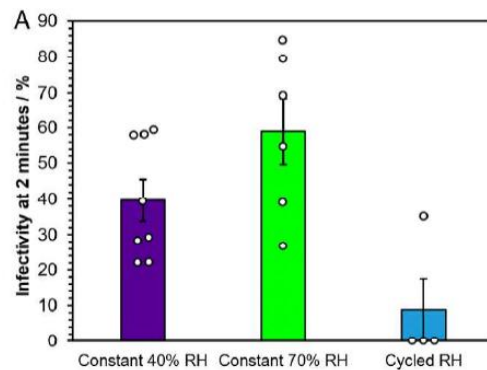




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Virus infectivity loss correlates with rapid evaporation, aerosol diameter reduction and crystallisation

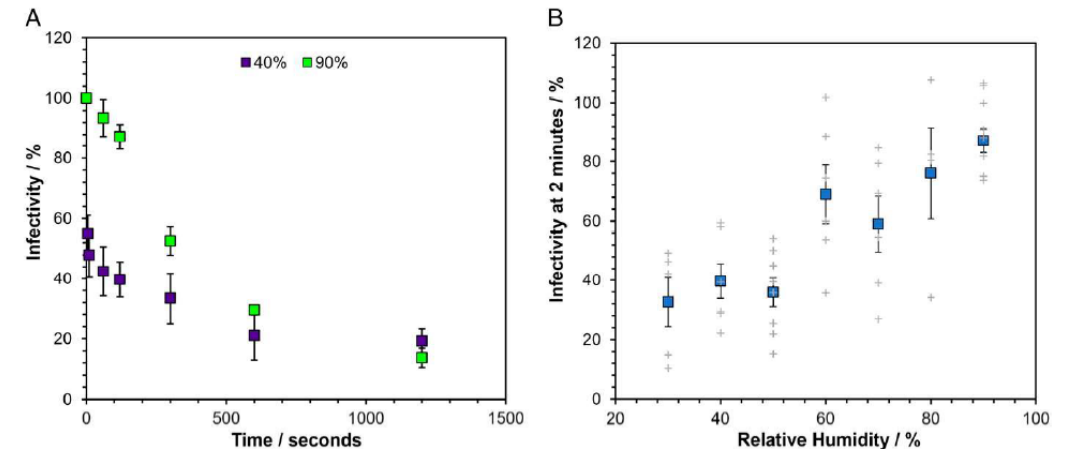


Fig. 1. The short-term airborne decay of SARS-CoV-2. Datapoints are the mean of several measurements (typically >4), and error bars show the standard error. Measurements were carried out at room temperature at 18 to 21°C. (A) The percentage infectivity of SARS-CoV-2 REMRQ0001 as a function of time levitated in CELEBS at 40% RH (purple) and 90% RH (green). (B) Curve showing the impact of RH on the percentage infectivity of SARS-CoV-2 REMRQ0001 after 2 min of levitation in CELEBS. The larger colored square points show the mean, with the error bars showing the standard error. Gray crosses show the results of individual measurements.



Ambient carbon dioxide concentration correlates with SARS-CoV-2 aerostability and infection risk

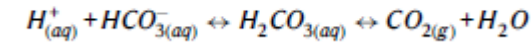
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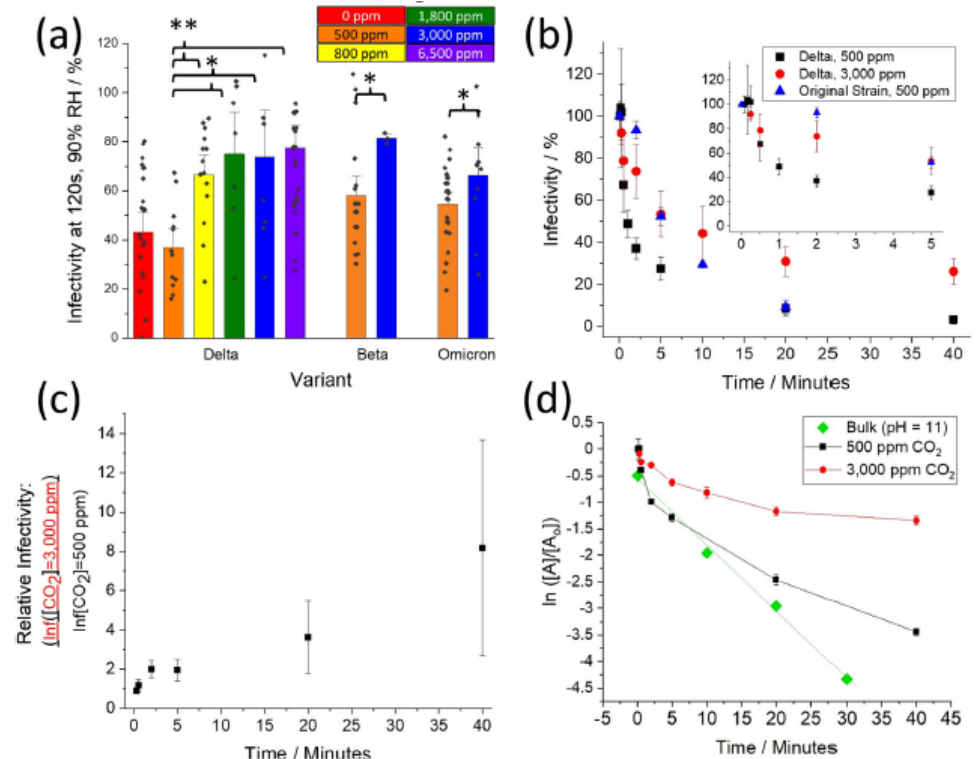
Published online: 25 April 2024

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CoV-2 infectivity. We show here that a significant increase in SARS-CoV-2 aerostability results from a moderate increase in the atmospheric carbon dioxide concentration (e.g. 800 ppm), an effect that is more marked than that observed for changes in relative humidity. We model the likelihood of COVID-19 transmission on the ambient concentration of CO₂, concluding that even this moderate increase in CO₂ concentration results in a significant increase in overall risk. These observations confirm the critical importance of ventilation and maintaining low CO₂ concentrations in indoor environments for mitigating disease transmission. Moreover, the correlation of increased CO₂ concentration with viral aerostability need to be better understood when considering the consequences of increases in ambient CO₂ levels in our atmosphere.



pH rise after exhalation



OPEN

DATA DESCRIPTOR

Global monthly gridded atmospheric carbon dioxide concentrations under the historical and future scenarios

Wei Cheng^{1,2}, Li Dan³, Xiangzheng Deng^{1,2,4}, Jinming Feng³, Yongli Wang³,
Jing Peng³, Jing Tian¹, Wei Qi⁵, Zhu Liu⁶, Xinqi Zheng^{7,8}, Demin Zhou^{9,10}, Sijian Jiang^{1,2},
Haipeng Zhao^{7,8} & Xiaoyu Wang^{9,10}

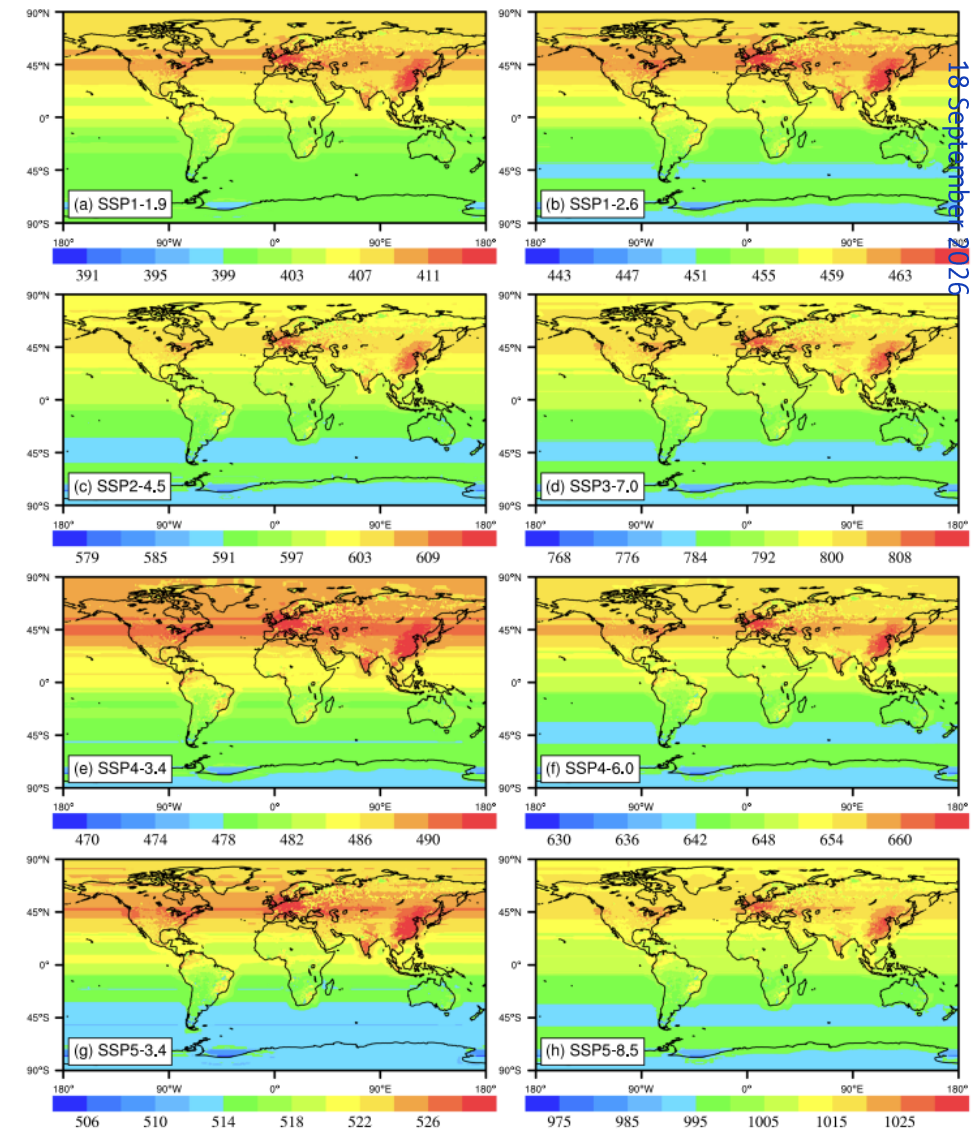
Atmospheric CO₂ concentrations (ppm) in 2081-2100

Fig. 5 The maps of global atmospheric CO₂ concentrations (ppm) averaged during 2081–2100 in the SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP4-3.4, SSP4-6.0, SSP5-3.4 and SSP5-8.5 scenarios. The period of 2081–2100 in the Fig. 5 chosen is for the average state at the end of this century.



Expiratory aerosol pH is determined by indoor room trace gases and particle size

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ventilation performance [1]. Additionally, elevated CO₂ concentrations have been demonstrated to increase the airborne stability of pathogens such as SARS-CoV-2 [6,7], because of its influence of the pH of respiratory aerosol. Although, under real world conditions this effect may be complicated by the presence of other acidic gases [8].

<https://doi.org/10.1016/j.indenv.2025.100101>

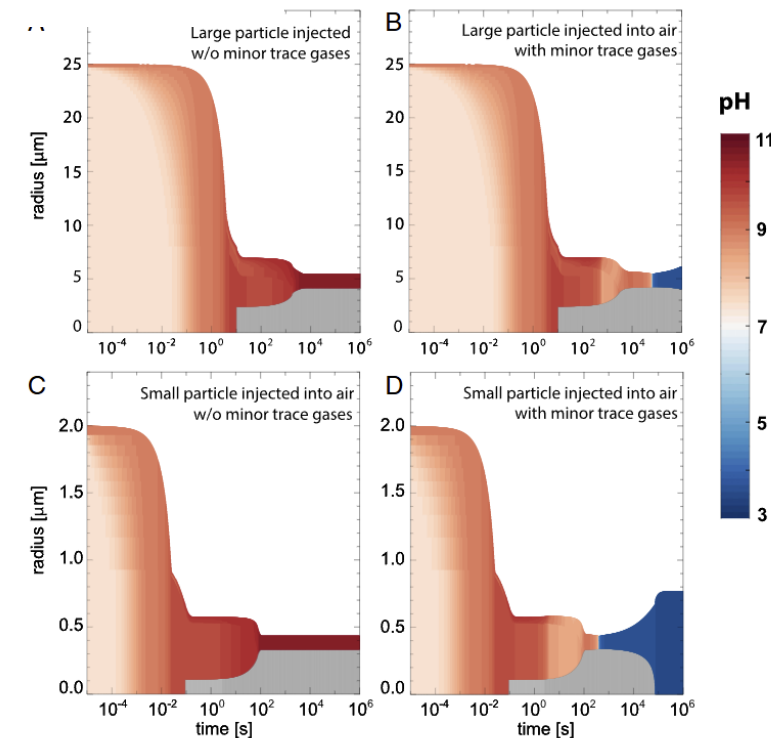


Fig. 1. The pH evolution of simulated MEM particles with initial radii 25 μm (A and B) and 2 μm (C and D), at $t = 0$ in equilibrium with 99.4% relative humidity (RH) and 5% CO₂, subsequently injected into air with 50% RH and 400 ppm CO₂. (A and C) Laboratory air without minor trace gases (HNO₃, NH₃, HCl, CH₃COOH), and (B and D) typical indoor air containing trace gases. Colors indicate the pH inside the MEM droplets as a function of time. Dark gray regions are effloresced NaCl. At $t = 0$, pH is 7.4 as in the experiments of ref. 1, with particle composition 0.19158 m (molal) Na⁺, 0.17383 m Cl⁻, 0.0057 m nonsodium and 0.0037 m nonchloride ions, 0.0168 m organics, and $\text{Na}^+ / (\text{CO}_{2,\text{aq}} + \text{HCO}_3^- + \text{CO}_3^{2-}) = 9.15$. Assumed trace gas concentrations of indoor air are 0.27 ppb HNO₃, 36 ppb NH₃, 0.23 ppb HCl, and 46.7 ppb CH₃COOH (3).

Airborne SARS-CoV-2 in aircraft cabins: new inactivation data significantly influences infection risk predictions

Florian Webner^{1,2}  · Andrei Shishkin¹  · Daniel Schmeling¹  · Claus Wagner^{1,2} 

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Abstract

We predict the SARS-CoV-2 infection risk in aircraft cabins by simulating the aerosol transport with computational fluid dynamics and taking medical parameters into account. A recently presented new measurement technique allows us to measure the rapid virus inactivation after exhalation with high temporal resolution. In addition, much higher airborne SARS-CoV-2 inactivation rates than in previous studies were obtained. This raises the question of how the new knowledge of SARS-CoV-2 stability affects the prediction of infection risk. To answer this question, we evaluated 70 Lagrangian particle simulations with an index person sitting in all possible seats in an aircraft cabin. We then estimated the infection risk for the other passengers based on the old and new SARS-CoV-2 stability data. For typical transmission events, we found that the predicted infection risk is reduced by about 50% for the new stability data at low CO₂ (500 ppm). However, elevated ambient CO₂ concentrations of 3000 ppm protect the virus from inactivation and increase infection risk by about 50% compared to low CO₂. In addition, a high relative humidity of the ambient air, e.g., from exhaled breath, delays the rapid inactivation by a few seconds, increasing the risk of infection for immediate neighbors.

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