CO2 exacerbates oxygen toxicity

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French research team at the Laboratoire de Chimie Bacterienne has demonstrated that carbon dioxide (CO_2) plays a role in the formation of oxidative damage *in vivo*. Under conditions of oxidative stress, certain types of damage (cell death, some DNA lesions, mutation frequency, etc.) affecting the model organism *Escherichia coli* tend to increase depending on the level of atmospheric CO_2. The CO_2 levels studied range from 40 ppm(1) to the current projections for 2100 (1,000 ppm). The results indicate that the predicted increase in atmospheric CO_2 should have a direct effect on living organisms. A paper on this work will be published in the February 25, 2011 issue of *EMBO Reports*.

Air pollution, tobacco smoke, chemical products, food additives, physical stress and even the normal use of oxygen by the body all contribute to the production of Reactive Oxygen Species (ROS). These compounds are involved to varying degrees in the different types of cellular oxidative damage: genetic mutations, cancerization, protein oxidation, etc.

The Bacterial Viability and Oxidative Stress team, led by Sam Dukan of the Laboratoire de Chimie Bactérienne, a CNRS lab at the Institut de Microbiologie de la Méditerranée (Mediterranean Institute of Microbiology, CNRS / Université de la Méditerranée) has been investigating the involvement of various ROS in the process of cell death . Their latest findings on the model bacteria Escherichia coli reveal the importance of a new factor involved in the formation of oxidative damage in vivo: carbon dioxide (CO_2).

The researchers asked the Jacomex company to develop a prototype "glove compartment" that would make it possible to control the level of atmospheric CO_2 while maintaining a fixed oxygen concentration (20%, as in the Earth's atmosphere). Reproducing the atmospheres of yesterday, today and tomorrow (in terms of oxygen, nitrogen and carbon dioxide levels), this tool was used to measure the effects of an oxidative stress (hydrogen peroxide, H_2O_2) on *E. coli* at different levels of atmospheric CO_2 (from 40 to 1,000 ppm, the current atmospheric concentration being 389 ppm). The results show that an increase in CO_2 is accompanied by an increase in various parameters, including cell death, DNA mutation frequency and the number of DNA lesions.

The authors of the paper suggest that this phenomenon may be due to in vivo reactions between CO_2 and various ROS, which could induce the formation of various free radicals, in particular the carbonate radical ($CO_3^{\bullet-}$). In fact, this reaction had already been demonstrated in vitro. Interestingly, this radical is especially target-specific. For example, in relation to DNA it seems to react primarily with guanine, a target that the researchers found to be affected by the CO_2 concentration. In addition, the team has shown that the physiological characteristics of *E. coli* (intracellular pH, metabolic pathways, defenses against ROS, speed of protein degradation, etc.) were not modified by the CO_2 level, thus excluding all other possible interpretations of the damage observed.

Considering the range of CO_2 concentrations examined, this study suggests that the projected increase in atmospheric CO_2 (1,000 ppm by 2100) could have direct effects on living organisms such as bacteria (increase in certain DNA lesions, mutation frequency, etc.).

The team at the Laboratoire de Chimie Bactérienne plans to continue its research on *E. coli* in order to characterize the different mutations associated with DNA lesions. They also intend to examine the possible role of carbonic anhydrase in the defense against oxidative stress, and

hope to collaborate with other research teams to study more evolved organisms like mice. Their objective is to investigate the link between the concentration of atmospheric CO_2 and the occurrence of pathologies known to be linked to oxidative stress (neurodegenerative diseases, cancers, etc.).

More information: CO2 exacerbates oxygen toxicity. Benjamin Ezraty, et al. Aix Marseille Université - Laboratoire de Chimie Bactérienne (UPR 9043) - Institut de Microbiologie de la Méditerranée (IFR88) - CNRS, 31 Chemin Joseph Aiguier, 13402 Marseille, France. *Embo Reports*, February 25, 2011.

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