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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "A fate for organic acids, formaldehyde and methanol in cloud water: their biotransformation by micro-organisms" *by* P. Amato et al.

**P. Amato et al.**

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First, the authors would like to thank the reviewer for reading and commenting the manuscript. We acknowledge the fact that some parts of our manuscript may be unclear to the reader and will require some rewriting. This may have led to some misunderstanding and we believe the referee did not fully understand the concept of our study. We will try to explain it better in the following answers.

1. Concerning the incubation of the bulk cloud water sample and measurements of ATP and concentration of cells along the time, we may have to clarify the chemical composition of the sample by providing the related data in the manuscript. The related event, which occurred in January, was clearly not under anthropogenic influence. Tem-

perature averaged -3.2°C during the sampling time, pH was 6.8, and the total organic carbon content was 2.8 mg L-1. The latter almost exactly corresponds to the amount of substrate required for the noticed cell multiplication, as given by the reviewer calculation. It has to be precised that cells themselves represent less than 0.01% of that value of organic carbon at the beginning of the incubation. Ammonium NH4+ and nitrate NO3- were respectively about 50$\mu$M (900$\mu$g L-1) and 25$\mu$M (1550 $\mu$g L-1) in the sample. Also required elements such as P, S, Fe, MgĚ are present and can sustain cell growth. Regarding the data, we agree with the reviewer and C concentration is supposed to be the limiting factor for cell multiplication in clouds.

2. Concerning the second part of the paper, we think the formulated comments relevant, but maybe due to a lack of emphasis on what such results imply, we think that the real purpose of the paper was not clearly understood. For example, we were not interested in modifications of biomass during the incubation time, since we considered resting cells (defined as non-dividing cells) as biocatalysts able to induce chemical transformations. Our intention was to check their enzymatic potential and clarify the pathways used to compare with photochemical reactions that transform the same compounds. We also do not agree with the criticism saying that such investigations can be made using routine commercial tests. We have used NMR spectroscopy as it is a quantitative and qualitative method to investigate biotransformation processes. In our case it allowed us to measure the efficiency of degradation of every single substrate by each bacterium under the same conditions and also to give evidence of some intermediates of reactions. None of the commercial kits used mainly to identify bacteria (and not study biotransformation) such as API galleries can be used for this purpose, they give no quantitative results and no indication about intermediates. They are mainly used for common bacteria in medical and nutrition sciences and are not adapted to investigate the metabolism of environmental bacteria. In addition no test exists for formate, formaldehyde, methanol, the two forms of lactate (they do not discriminate L and D lactate). NMR experiments gave very interesting results about the intermediates formed, for instance we showed the formation of pyruvate and fumarate which



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are present in clouds. Also, the use of 13C-labelled formaldehyde clearly showed that methanol can be both produced and consumed by bacteria. All these data support the idea that bacteria can be a source but also a sink for organic acids and alcohol in cloud water.

Although experiments were performed under model conditions in the lab, we have used real bacteria isolated from clouds, so that they were alive in clouds. We have chosen conditions which are compatible with cloud environment: we have respected the ratio number of cells/ number of molecules of interest that take place in clouds. We have chosen a pH 7 to simulate conditions corresponding to pH of non polluted clouds collected at the puy de Dôme. This value clearly is high in the natural environment but is regularly found for marine air masses. The experimental time was 24h: clearly, it is difficult to estimate how long a bacterium could remain active in a cloud environment. However, many modelling studies on cloud reactivity are performed with a similar time frame. In any case, results from the 24h period can be scaled down to shorter times. The main goal of this paper was to determine whether the living microbial content of cloud is involved in the chemistry within this environment. So, rather than having precise kinetic constants under conditions encountered in clouds but for a limited number of strains, we chose to investigate a large variety of microbes isolated from clouds all along the year and under various atmospheric situations. In that way, we provide a good general picture of the capacities of the population to interact with organic compound present there in relatively large amounts. To our mind, such demonstration has to be the first step to figure out if research should go further, and what are the hints to follow. Then, since results show a great implication in cloud chemistry that should still be qualified as “potential”, limiting factors for the metabolic activity such as low temperature and acidic pH can be added in our “model” experiments. This kind of experiments is currently running in our laboratory.

In conclusion, we believe that our results constitute an important step in cloud chemistry and its interactions with microbiology in clouds. We hope that the referee now



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better understands how this research project was conceived and we certainly will take into account his / her comments to improve the manuscript. So we will add, if allowed by the editor, a discussion paragraph pointing the limits in extrapolating our results to a real cloud water environment.

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Interactive comment on Atmos. Chem. Phys. Discuss., 7, 5253, 2007.