FINAL REPORT PROGRAM LEFE

Program LEFE/ OA	**Project Title** FeDRE : Fe, DMSP uptake and DMSO reduction	**Years 2019-2022**
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Context

Dimethylsulfide (DMS) is a volatile sulfur compound that participates in cloud formation, Earth planetary albedo and climate cooling. It is produced by enzymatic dimethylsulfoniopropionate (DMSP) cleavage and dimethylsulfoxide (DMSO) reduction. Diatoms and cyanobacteria are generally considered low DMSP and DMS producers.

Objectives / scientific questions

In the FeDRE project, we proposed to re-evaluate the role of diatoms and cyanobacteria in the biogeochemical cycle of DMS/P/O, focusing on their DMSO-reducing abilities, which were to be compared to heterotrophic bacterial DMSO reduction rates.

Main results

Measurements on three axenic *Synechococcus* strains showed that they all have the ability to produce DMS after DMSO addition (Fig. 1). Their production is significantly higher than the abiotic DMS production by the sterile medium (control). This increase after addition of DMSO followed a Michaelis-Menten type curve, consistent with an enzymatic process as described in Spiese et al. (2009) and Spiese and Tartakov (2014). Comparison with the literature shows that *Synechococcus* produced DMS 2-70 times more rapidly than the other phototrophs, except for the diatom *Thalassiosira oceanica* (Fig. 2). This indicates that *Synechococcus* exhibit a high ability to produce DMS from low DMSO concentrations, compared to other autotrophic species.

In order to find candidate genes that might explain the ability of these strains to produce DMS from DMSO, we explored the genomes of the 56 *Synechococcus/Cyanobium* of the Cyanorak *v2.1* database (www.cyanorak.sb-roscoff.fr/cyanorak/), which notably includes the three strains used in the present study, to check for the presence of a putative DMSO reductase using characterized DMSO reductases as baits. Like for *T. pseudonana* (Spiese et al., 2009), there was no homolog of typical DMSO reductases. Absence of obvious candidates for DMSO reduction suggests that marine *Synechococcus* might use a different and yet unknown pathway for this function. As for *T. pseudonana*, the most probable candidates for the DMSO reductase function are members of the MsrA family, which are usually thought to reduce *S*-methionine sulfoxide into peptides. All marine *Synechococcus* possess two MsrA homologs and two MsrB homologs and one or several of those could have a DMSO reduction function, although this hypothesis would need to be checked experimentally.

To better evaluate the significance of DMSO reduction by phytoplankton, including cyanobacteria, DMSO reduction rates also have to be measured in heterotrophic bacteria. Sixteen strains of heterotrophic bacteria representative of key marine phyla were screened for their ability to transform DMSO into DMS. Thirteen over sixteen were tested positive, including members of dominant bacterial phyla in marine ecosystems that have never been tested for DMSO reduction before, such as *Bacteroidetes* and *Ɣ-Proteobacteria* (Giovannoni and Stingl 2005). Their ability to produce DMS from DMSO varied widely, their DMSO reduction rates ranging from ~ 75 to 14,000 nmol DMS (cell volume)$^{-1}$ s^{-1} (median ± STD = 1,320 ± 4,500 nmol DMS (cell volume)$^{-1}$ s^{-1}, n = 13).

Cyanobacteria DMSO reduction rates were more constrained (median ± STD = 1,850 ± 550 nmol DMS (cell volume)$^{-1}$ s^{-1}, n = 3).

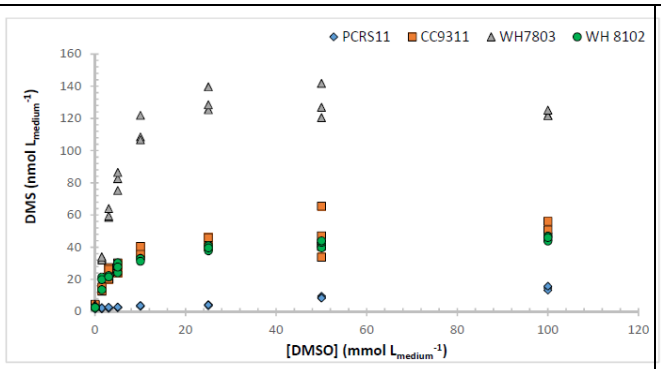

Fig. 1: Production of DMS in the culture medium PCRS11 (control) and in triplicate cultures of *Synechococcus* CC9311, WH7803 and WH8102 in presence of increasing concentrations of added DMSO (FeDRE, Bucciarelli, Ferrieux et al., in prep).

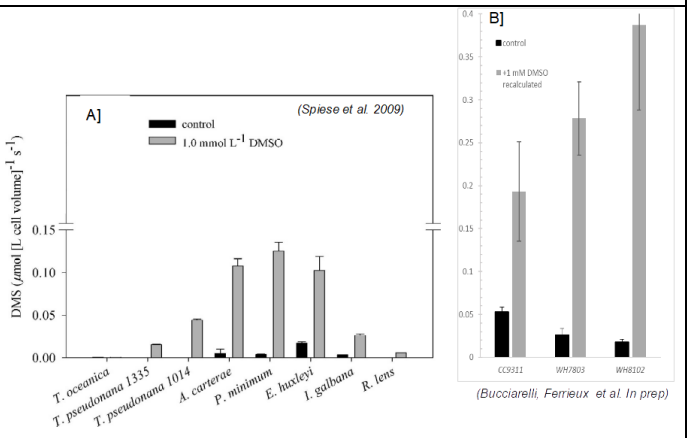

Fig. 2: Comparison of DMS production rate by reduction of 1 mM DMSO from A) eight phytoplankton species other than cyanobacteria (Spiese et al. 2009), and B) three cyanobacterial species (FeDRE, Bucciarelli, Ferrieux et al., in prep).

Future of the project :

Further experiments on heterotrophic bacteria will be conducted to better understand their ability to reduce DMSO not only into DMS, but also into other sulphur compounds (e.g., methanethiol, Gonzalez et al. 1999). All results on heterotrophic bacteria will be published together (Bucciarelli and Baudoux, in prep.)

Number of publications, communications and theses

Eva Bucciarelli, Mathilde Ferrieux, Louison Dufour, Morgane Ratin, Frédéric Partensky, Laurence Garczarek. Marine *Synechococcus* are able to produce DMS via DMSO reduction. To be submitted to Environmental Microbiology.

THèse: (1)

Mathilde Ferrieux. 2022. Adaptation to temperature and iron limitation in a major representative of marine phytoplankton, the picocyanobacterium *Synechococcus*. Sorbonne University PhD thesis. Defended on September 9th 2022 (https://www.theses.fr/2022SORUS302).

Data availablility

Data will be made fully available in the scientific publications.