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Foreword

Foreword to the special issue on 'Biological and environmental chemistry of DMS(P) and related compounds'

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In a seminal paper published in 1948, Challenger and Simpson[1] reported that some marine algae contain dimethylsulfoniopropionate (DMSP) in such stunning amounts that it accounts for a significant fraction of their dry weight. Challenger also observed shortly thereafter that this compound is degraded to volatile dimethylsulfide (DMS).[2] Twenty years later, Lovelock detected DMS ubiquitously across the Atlantic Ocean, estimated its ocean-to-atmosphere flux and postulated that it was the missing piece in the jigsaw of the global sulfur cycle, the one that returned sulfur from the oceans to the continents.[3] But it was not until the 1980s that dimethylated sulfur became of interest to a broader audience: Shaw in 1983[4] and Charlson et al. in 1987[5] proposed that oceanic DMS affects the Earth's radiation budget by seeding and brightening marine clouds, thereby setting-up a feedback mechanism between the oceanic biosphere and climate. Triggered by this intriguing hypothesis, over the last three decades many marine biologists and chemists, atmospheric chemists and climate researchers have attempted to understand the processes that would build up such a complex cycle. One might argue that research approaches have often been confined within disciplines and such a truly cross-displinary hypothesis is very difficult to tackle by experimental work.

Even though the significance to climate of the DMS-feedback mechanism, and even its existence, has been strongly challenged,[6] such intensive research activity has yielded important advances in topics as wide-spanning and fundamental as:

- Physiological, trophic and signalling roles of DMS(P) and related compounds in marine microbes, plants and metazoans; e.g. biosynthesis and catabolic pathways, their genes and enzymes, cellular regulation processes, physiological functions and responses to stress factors, chemotaxis, mutualisms.
- DMS(P) cycling processes and controlling factors, from laboratory to ecosystems; e.g. photolysis, ventilation, microbial production and consumption, environmental regulation.
- Mapping and modelling DMS(P) and related compounds; e.g. distribution in under-sampled regions and across scales, remote sensing, local to global ocean modelling.
- Oceanic emission of volatile sulfur, aerosols, clouds and climate; e.g. air–sea transfer coefficients and emission fluxes, atmospheric chemistry, aerosol formation, growth and composition, aerosol–cloud interactions, atmospheric & Earth System modelling, climate feedbacks, paleo records.

This Special Issue contains a selection of papers presented at the International Symposium on Biological and Environmental Chemistry of DMS(P) and Related Compounds, held at the Institut de Ciencies del Mar (ICM-CSIC) in Barcelona, 26–30 May 2014. The Symposium was the 6th of a series that started in 1995 in Mobile, Alabama, and continued with meetings in Groningen, Rimouski, Norwich and Goa. These meetings provide an open and collaborative atmosphere across the interdisciplinary community that investigates the processes underlying the production and cycling of DMS, DMSP and related compounds, and their relevance in physiology, ecology, global biogeochemistry and climate. In addition to the Symposium participants, other research teams in the field that could not attend the meeting were also invited to contribute to this Special Issue.

Lyon et al.[7] break the ice by exploring the physiological role of DMSP as a compatible solute in sea-ice diatoms; changes in DMSP concentrations are compared with other physiological indicators across salinity shifts representative of sea-ice formation and melt. On similar lines, Kinsey et al.[8] investigate the separate and synergistic effects of iron and light on DMSP and its transformation products dimethylsulfoxide (DMSO) and acrylate in an Antarctic alga. Lavoie et al.[9] build up a numerical simulation of process and diffusion rates for dimethylated sulfur in a model algal cell, and conclude that either intracellular DMSO concentrations have hitherto been overestimated or DMSP production and oxidation occurs in the chloroplast. Moving on to multicellular organisms, Van Alstyne et al.[10] report that changes in the DMSP content and DMS emission of seaweeds in response to hydration, salinity and temperature shifts are species-specific and cannot be reduced to one straightforward behaviour. Hill and Dacey[11] describe that some molluscs accumulate and retain DMSP from the diet exceptionally well, yet with large variability among individuals of the same species. No doubt corals are the best studied metazoans for their ability to produce DMSP and transform it to DMS. Deschaseaux et al.[12] review the biogeochemistry of dimethylated sulfur compounds in coral reefs and discuss the potential consequences of ongoing environmental changes on their biogenic cycle in these fragile ecosystems. Frade et al.[13] revisit the issue of DMSP-content regulation in zooxanthellate corals, and, using quantitative measurements of microbial taxonomic affiliation and gene abundance, explore the DMSP-mediated interplay between corals and their associated microbiome.

The complexity of the DMS(P) cycle in the surface ocean increases as we gain new or deeper knowledge of the processes and actors involved. Li et al.[14] and Motard-Côté et al.[15] report the existence of a non-bioavailable pool of dissolved DMSP, partly accounted for by retention in bacteria and partly unknown, which, if ignored, may lead to overestimation of DMSP turnover fluxes in both coastal and open ocean waters. Lee et al.[16] conduct experiments in two contrasting open-ocean settings and show that addition of vitamin B_{12} often results in decreased DMS and DMSP concentrations; potential biochemical links between vitamin B_{12} and dimethylated sulfur are discussed. Levine et al.[17] revisit the most emblematic study site for DMS(P) cycling seasonality in the oligotrophic ocean: Bermuda; in a new, 3-year time series, they show that microbial consumption is the main driver of DMSP and DMS turnover throughout most of the year, whereas photolysis drives DMS loss in the mixed layer during the summer. Once again, this study stresses the importance of the (costly) efforts to maintain time series studies in the open ocean. Webb et al.[18] add to a handful of studies addressing the potential effects of ocean acidification on DMS(P) by using mesocosm experiments; they conclude that community responses to increased pCO_2 are difficult to predict from work with monospecific cultures because of the varying responses of DMS(P) producers and consumers and their complex interactions. A similar study by Zindler-Schlundt et al.[19] focuses on DMSO, to conclude that ocean acidification may lead to decreasing DMSO concentrations in the surface ocean, yet the reasons behind the observed decrease remain unclear. Using a totally different approach, Sela-Adler et al.[20] explore the biogeochemistry of DMS(P) in a freshwater lake; by measuring $\delta^{34}S$, they are able to discern the multiple origins of DMS in the water column sediments, including DMSP degradation and H_2S methylation.

Global seasonal distributions and emission fluxes of DMS are indispensable if we are to numerically address its potential climatic role. However, reliable mapping of DMS is heavily hampered by the paucity of data in some regions and seasons. In this issue, Espinosa et al.[21] report the first winter DMS(P) measurements in the southern Gulf of Mexico, and relate the results to the hydrodynamics of the area. Taking the challenge of incorporating the recent wave of high-resolution (quasi-continuous) measurements into the classical datasets made with sparse measurements, Jarníkova and Tortell[22] present an updated summertime DMS climatology in the Southern Ocean, one that better represents regional variability. Moving to the subtropics, the modelling exercise presented by Masotti et al.[23] suggests that a lack of phosphorus may exert a more important control on surface DMS concentrations than other suggested drivers such as sunlight exposure. All in all, these works highlight the need for better data coverage while we improve our ability to numerically simulate the DMS distribution, because, as pointed out by the comparative study of Tesdal et al.,[24] current semi-empirical parameterisations differ considerably in their outcomes and skills. Last but not least, Qu et al.[25] use numerical modelling to project regional DMS fluxes in the Arctic under scenarios of increased CO_2 levels in the atmosphere; large predicted increases particularly in ice-melt-affected waters could slow regional warming.

I hope that the pages of this issue will reflect the resounding success of the Barcelona DMS(P) Symposium. It was a lively Symposium that stirred up the field with new ideas while revisiting the old ones, looked across the borders into neighbouring research fields, launched new initiatives, and welcomed the newcomers to this truly international community.

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