# BACTERIAL ALKYL GLYCEROL ETHER LIPIDS (BAGELS): NEW ORGANIC TOOLS FOR TRACING ANCIENT SEA WATER TEMPERATURE CHANGES?

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In addition to acyl glycerols which are classically present in bacterial membranes, some bacteria also synthesize monoalkyl and dialkyl glycerol ether lipids (MAGEs and DAGEs, respectively). These original bacterial membrane lipids consist of non-isoprenoid alkyl chains linked to the *sn*-1 and/or *sn*-2 carbons of a glycerol by ether bridges instead of the ester bounds present in acyl glycerols. Alkyl glycerol ether lipids (AGEs) have often been considered as a specificity of extremophilic bacteria due to their chemical resistance relative to ester linkages and their systematic occurrence in (hyper)thermophilic bacteria, but the presence of such lipids in diverse mesophilic strains and non-extreme environments argue against this conceptual view. In fact, since their discovery, an increasing variety of MAGEs and DAGEs has been reported from pure strains of Bacteria with various physiological preferences and from diverse natural settings covering a large range of environmental conditions (Grossi et al., 2015; Vinçon-Laugier et al., 2016 and references therein).
Due to their widespread occurrence and apparent diagenetic stability, bacterial AGEs can thus be regarded as potentially useful biomarkers; little is known, however, on their biological precursors and modes of formation. Especially, there is a cruel lack of information on the modifications suffered by alkylglycerol-containing membranes (and AGE chemical structures) in response to changing environmental conditions. This is principally due to the fact that few studies have been dedicated to the modification of the ether lipid composition of isolated bacterial strains in response to varying growth conditions. We previously reported that the MAGE and DAGE compositions of marine anaerobic mesophilic bacteria (AMB) strongly depends on the type of carbon substrate used for growth, but that AGE-producing AMB maintain the average structural composition (i.e. average chain length and level of branching) of their lipid membranes in response to changing growth substrate (Vinçon-Laugier et al., 2016). This suggested 1) the maintenance of proper cell membrane properties whatever the carbon source and the related diversity of MAGEs and/or DAGEs produced by bacteria and, 2) that additional growth factors such as environmental parameters probably exert a significant influence on the alkyl glycerol composition of bacterial membranes, as commonly reported for other bacterial and archaeal lipids involved in membrane homeoviscous adaptation.

Here, we investigated the influence of growth temperature on the qualitative and quantitative ether lipid composition of the aforementioned AMB. Comparison with a thermophilic strain allowed characterizing specific changes in the chemical composition of ether-containing bacterial membranes in relation to temperature physiological preferences. For all studied strains, growth at different temperatures induced little changes in the total lipid content and relative abundances of the different classes of (hydrolysed) lipids (FAs, MAGEs and DAGEs). Strains rather adapted to temperature by modifying the average structural composition of their membrane lipids. Structural changes specifically concerned the chain length and branching pattern (position and proportion of methyl branch) of alkyl and acyl chains, as well as the position of the alkyl chain on the glycerol backbone of MAGEs (*sn*-1 *vs* *sn*-2). Interestingly, some of these adaptive traits appeared linearly correlated with growth temperature. Depending on the quality of the linear regressions describing these correlations and on the initial AGE composition of the strains (mesophile vs thermophile), different ratios of specific MAGEs and

DAGEs could be tentatively envisaged as new tools for tracing ancient sea water temperature changes. Additional culture experiments performed with mesophilic strains further suggested that some temperature-dependent modifications of AGEs are not significantly influenced by the salinity or the pH of the growth medium. Based on these results obtained under laboratory controlled conditions, we investigated the distributional variations in AGEs along ancient marine sedimentary settings where sea water temperatures have been previously reconstructed using well calibrated temperature proxies. Obvious co-variations of AGE distribution and known temperature proxies (e.g., $Uk'_{37}$ index) were observed, confirming the potential of BAGELS to constitute new molecular tools for tracing ancient sea water temperature changes.

**References**

Grossi V., Mollex D., Vinçon-Laugier A., Hakil F., Pacton M., Cravo-Laureau C., 2015. Mono- and dialkyl glycerol ether lipids in anaerobic bacteria: Biosynthetic insights from the mesophilic sulfate reducer *Desulfatibacillum alkenivorans* PF2803$^T$. Applied and Environmental Microbiology 81, 3157-3168.

Vinçon-Laugier A., Grossi V., Pacton M., Escarguel G., Cravo-Laureau C., 2016. The alkylglycerol ether lipid composition of heterotrophic sulfate reducing bacteria strongly depends on growth substrate. Organic Geochemistry 98, 141-154.