Bilayers at the ILL

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Apolar lipids, the membrane adaptation toolbox of extremophiles

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Most of Earth's biotopes are hold under extreme environmental conditions, namely distant from the optimal life conditions of humans. Nevertheless, a large biological diversity of organisms inhabit such environments, i.e. extremophiles. For instance, many living organisms reside at hydrothermal sources of deep oceans: temperatures above 100°C, high concentrations of reduced metals, absence of oxygen and high hydrostatic pressures, without an understanding of the molecular mechanisms enabling them to sustain such extreme conditions. The cell membrane is particularly sensitive to external conditions, but at the same time, it must maintain specific physical properties, such as fluidity and permeability, to preserve cell's integrity and functionality. This work seeks to understand how the lipid bilayer can remain functional at high temperatures and high pressures and thus, allows life under extreme conditions.

The results presented here determine novel membrane components, apolar lipids from the polyisoprenoid's family, that play the role of membrane regulators and confer stability to the lipid bilayer, along with dynamism and heterogeneity, essential properties for an optimal functional membrane. By neutron diffraction, we demonstrated that apolar lipids are placed in the midplane of the lipid bilayer, even at high temperatures and high hydrostatic pressures. Moreover, they establish membrane lateral heterogeneity by inducing lipid phase separation. Furthermore, SAXS results demonstrated that polyisoprenoids adjust membrane curvature under extreme conditions, enabling essential cell functions that require high curved membrane domains, such as fusion and fission. Moreover, because their specific placement, apolar lipids modify lipid bilayer permeability and reduces proton membrane permeability at high hydrostatic pressures, as demonstrated by fluorescent approaches. All the results demonstrate experimentally a new cell membrane architecture of extremophiles in which the presence and the quantity of polyisoprenoids play a key role and constitute a new adaptation pathway to extreme conditions applicable to life origin.

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