Lipid vesicles as protocells at the origin of life in alkaline hydrothermal vents

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Vesicles formed from single-chain amphiphiles (SCAs) such as fatty acids likely played an important role in the origin of life. These bilayer membranes not only form compartments that concentrate organics, but could hypothetically drive growth through vectorial chemistry in geological ion gradients [1]. A major criticism of the alkaline hydrothermal vent hypothesis is that high temperatures, strongly alkaline pH, ocean salinity and abundant divalent cations should preclude vesicle formation [2]. But these arguments are based on model vesicles using 1-3 SCAs, even though Fischer-Tropsch-type synthesis under hydrothermal conditions produces a wide array of fatty acids and 1-alkanols, including abundant C_{10}-C_{15} compounds [3]. Here we show that mixtures of these C_{10}-C_{15} SCAs form vesicles in aqueous solutions between pH ~6.5 to >12 at modern seawater concentrations of NaCl, Mg^{2+} and Ca^{2+}. Adding C_{10} isoprenoids improves stability even further. Vesicles form most readily at temperatures of ~70 °C and require salinity and strongly alkaline conditions to assemble. We also investigated the formation of FeS clusters coordinated by single amino acids. These mixtures form 4Fe4S clusters similar to those found in the active centres of many enzymes in modern living organisms and may represent their abiotic precursors. Incorporation of these clusters into membranes may bring us closer to understanding how proton gradients in alkaline hydrothermal vent systems could have been harnessed by protocells at the origin of life.

[1] West *et al.* (2017) *Philos. Trans. R. Soc. B Biol. Sci.* 372, 20160419 [2] Deamer (2017) *Life* 7, 5 [3] McCollom *et al.* (1999) *Orig. Life Evol. Bios.* 29, 153-166