Formation and stability of model membranes in geochemical environments

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Minerals have played key roles in various processes and stages of prebiotic chemical evolution. It is, therefore, assumed that the first life forms (protocells) may have originated at the mineral/water interface. We have determined the effects of minerals relevant to early Earth geochemical environments, on the critical vesicle concentration (CVC) of a decanoic acid/decanol (DA/DOH) mixture, by the fluorescence spectroscopy and by dynamic light scattering. We have also studied whether minerals can affect membrane integrity by determining the permeation of water soluble dye across the membranes of DA/DOH, as well as of oleic acid (OA) and palmitoyl-oleoyl-phosphatidylcholine (POPC) vesicles, for comparison.

The negatively charged minerals may interact with DA/DOH vesicles by H-bonding, but adsorption is insufficient to affect CVC. A greater amount of lipid is adsorbed on γ-Al_2O_3 because of electrostatic attraction between its positively charged surface and lipid vesicles in addition to H-bonding. Hence, more lipid has to be added to solution in order to form vesicles in the presence of γ-Al_2O_3 thus shifting the CVC value to higher concentration range relative to DA/DOH alone. OA and POPC are more impermeable than DA/DOH, because OA has a longer chain and a double bond in the tail, which creates closer tail-tail interactions in the bilayer, and phospholipid membranes are more stable as the tail has two fatty acid chains and is more hydrophobic. Thus, the self assembly of vesicles from SCAs in different geochemical environments is a robust phenomenon and serves as a model for protocell formation from abiotic building blocks during the origins of life.