

Antibubble as a Model Protocell

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A central question in evolution is how simple protocells first arose and began the competitive process that drove the evolution of life. Membranes are essential components of even the simplest cells. Membrane or lipid vesicle supports the inside vs outside asymmetry of concentration of various ions in a living cell. The gradients of concentrations are the driving forces of life processes. In this work we show that such vesicles with a lipid bilayer could be formed spontaneously from antibubbles in sea water in the surf zone.

An antibubble is a droplet of liquid surrounded by a thin film of gas. They are formed when liquid drops or flows turbulently into the same or another liquid contained a surfactant [1]. The molecules of the surfactant form two lipid layers on the air-water surfaces divided by thin air film. The hydrophobic tails of surfactant molecules are in opposition so the two lipid layers differ from the cell membrane just by the presence of the air film between the layers. The gravitational thinning of the air film result in it bursts because of van der Waals forces [2]. The published antibubbles lifetime [2] varies up to 10 min and more, depending on the surfactant, antibubbles size and salinity of water. We believe that at some conditions between these forces, surface tension and Zeta-potential of the interfacial layer the air film may be removed without damaging the two lipid layers. The process produces somewhat like lipid vesicle.

By solving diffusion equations we show that during the vesicle formation the concentration of inner ions goes down because these are partially adsorbed at the electric double layer of the membrane. Then we have to solve the boundary problem arising from the previous step to evaluate the steady state in the vesicle. We take into account that the absorption and transparency of membrane for Na^+ ions differs from K^+ ones due to their different sizes and masses. Finally, we obtain a spherical vesicle with lipid bilayer and Na^+ vs K^+ asymmetry that may be a prototype of a living cell. Sea water contains all components needed and surf repeats the experiment for ages.

[1] A. Tufaile, J. C. Sartorelli, *Phys. Rev. E*, **66** (2002), p. 056204(7).

[2] S. Dorbolo, et al., *Europhys. Lett.*, **69** (2005), p. 966–970.