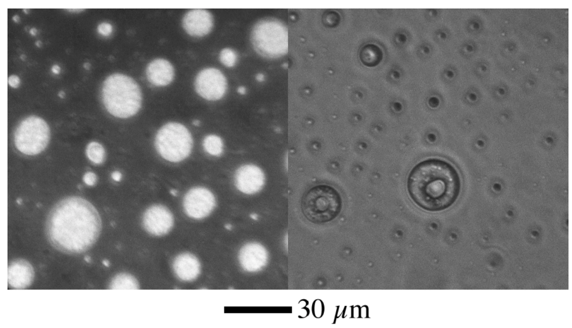
SELF-ASSEMBLING AMPHIPHILIC MOLECULES: A POSSIBLE LINKAGE BETWEEN INTERSTELLAR CHEMISTRY AND METEORITIC ORGANICS.
S. A. Sandford,[1] J. P. Dworkin,[1,2] D. W. Deamer,[3] and L. J. Allamandola[1], [1]Astrochemistry Laboratory, NASA Ames Research Center MS 245-6, Moffett Field CA, USA 94035-1000, [2]SETI Institute, 2035 Landings Dr., Mountain View CA, USA 94043, [3]Department of Chemistry and Biochemistry, UCSC, Santa Cruz CA, USA 95064.

Introduction: Delivery of extraterrestrial organic compounds may have contributed to the organic inventory necessary for the origin of life [1]. Interstellar ices tie up a large fraction of the biogenic elements available in the molecular clouds where new stellar systems are formed. We are actively involved in laboratory simulations of these ices. These studies are aimed at understanding the complex organic photochemistry that occurs when interstellar ice analogs are irradiated by ionizing radiation [2,3]. Here we discuss the production of amphiphilic materials that can spontaneously self-assemble into vesicular structures.

Experimental: Experiments were conducted by exposing realistic interstellar mixed-molecular ice analogs under vacuum to UV light from a hydrogen lamp. The analogs contained H_2O, CH_3OH, NH_3, and CO at ~10 K. After irradiation for periods of days to weeks, each ice was warmed to room temperature. The remaining organic residues were examined by a variety of analytical techniques.

Residues from the simulations were dispersed in aqueous media for microscopy. Some of the organic residue spontaneously formed 10-40 μm diameter vesicles that fluoresced at 450-500 nm under near-UV excitation. The vesicles captured ionic dye in their interiors, showing the presence of a barrier membrane. Their morphology (figure, left panel) and internal structure when exposed to UV light (figure, right panel) appeared strikingly similar to vesicles produced by extracts of the Murchison meteorite [4,5,6]. The presence of amphiphilic molecules is further confirmed by surface tension measurements. These species do not appear in controls or in unphotolyzed samples. Analysis of the residue by HPLC demonstrates that numerous amphiphilic components are present. These compounds are not solely responsible for the fluorescence, however, implying that other types of complex organics are also present.

Discussion: Together, these results suggest a link between organic material photochemically synthesized on the cold grains in dense, interstellar molecular clouds and compounds that were likely to contribute to the organic inventory of the primitive Earth. The amphiphilic properties of such compounds permit molecular self-assembly and this could play a role in the formation of early membranous boundary structures that were required for the first forms of cellular life on Earth. Furthermore, depending on the availability of water and the evolution of the pH and temperature conditions on meteorite parent bodies, such structures could potentially have formed during early aqueous alteration on these objects and they could possibly have been preserved.



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