Research

Non-terrestrial, kinetic and autonomous agents

CASTRO Juan Manuel

Keywords Bio Art, Extraterrestrial Organic Matter, Material Agency, Alien Life

1. Introduction

Formata are non-terrestrial, kinetic and autonomous agents. They are the world's first proto-aliens and the first work of art to be created with extraterrestrial organic analogs. The work is the outcome of a three-year research collaboration at the intersection of media art, chemistry and astrobiology entitled the *Proto-Alien Project* (Proto-A). These entities deform, actively move and self-divide in a miniature environment devoid of water with pools of liquid formamide and an atmosphere filled with carbon monoxide, argon and ammonia gases. *Formata* premiered on 17 December 2020 at the Art-Theque gallery of Tama Art University in Tokyo, Japan. During the exhibition of this artwork, visitors were able to watch and experience the alien mini-planet with the active agents in real time.

In order to materialize these autonomous "others", the *Proto-A* team first had to address how to synthesize and use extraterrestrial organic matter (ETOM) to create active material assemblages. On accomplishing this objective, they had to decide on what type of substances should generate the agents and how would they operate? Finally, they had to resolve how these alien agents could be sustained while being exhibited in public spaces? Addressing each of these issues informed the direction for each stage of the artwork which ended in the creation of a non-terrestrial, waterless, miniature environment for public display. This paper traces the development of this hybrid installation, highlighting its background, non-terrestrial substances, design of the mini-planet and finally an overview of the premiere exhibition.

2. Background

The *Proto-A project* is a laboratory of ideas and experiments at the intersection of astrobiology, chemistry and media art exploring the intermingling of non-human agency, degrees of aliveness and alien life. It is a collaborative research project with artist Akihiro Kubota at Tama Art University and scientist Taro Toyota at The University of Tokyo. We built the Proto-A project upon past artistic work using protocells and satellites – systems we have employed to carry out experimental art at the micro and macro scales. Through these systems, we have explored the boundaries between life and non-life, wet artificial life, extraterrestrial communication and deep space.

In the Proto-A project, we investigate the synthesis and use of ETOM as an active medium for artistic expression. By 'active medium', we mean (1) the aims of our investigations are: the morphogenetic tendencies, the ability to self-assemble and the non-linear behavior of non-terrestrial organics; and (2) we are attempting to grow soft, kinetic and intelligent agents using such substances. In 2018, this project was awarded a research grant from the Japan Society for the Promotion of Science that resulted in three years of investigation toward *Formata*.

At first, we embarked on intensive research into non-terrestrial organics inspired by the intricate substances found within meteorites. The presence of complex organic compounds in outer space suggest that these materials could have been delivered to the early Earth and could have contributed to the origin of life. Analysis of organic crusts extracted from carbonaceous chondrites, for instance, has demonstrated the presence of amphiphilic molecules that form vesicle structures (Yuen et al. 1984; Deamer 1985), non-polar substances that form droplets (Krishnamurthy et al. 1992; Monnard et al 2002;) and amino acids (Pizzarello et al. 2003; Martins et al. 2007), among others. On the other hand, simulation of ultraviolet irradiation of interstellar ices (containing water, methanol, carbon monoxide and ammonia)

produced complex organic compounds (Bernstein et al, 1995; Gerakines et al, 2000) as well as self-assembled structures that resemble cellular structures (Dworkin et al, 2001).

Although we do not have formal scientific backgrounds in astrobiology, our artistic activity was conducted in research laboratories that specialize in this field. We investigated the outer space conditions necessary to synthesize and work with ETOM. Our initial objective was to simulate the dusty and gaseous environments that surround protostars to synthetize extraterrestrial organics. However, large amounts of synthetic ETOM cannot be obtained easily and due to the COVID-19 pandemic our experiments in different laboratories in Japan were cancelled. Thus, we used chemical reagents as analogs for ETOM. In parallel, we started working on the construction of a non-terrestrial, waterless, miniature environment. One of the objectives of the *Proto-A* project was to build an alien mini-planet in which material systems composed of ETOM could act and be sustained while being showed in public spaces.

Figure 1. Image of the formamide mini-planet at the Art-Theque gallery of Tama Art University.

3. Non-terrestrial organic analogs

Recent discoveries have led astrobiologists to believe that planets and moons with water are the most favorable places for alien life to exist in the cosmos. Europa, the smallest of the Galilean moons of Jupiter, for example, is thought to contain a salty ocean hidden beneath its surface. Researchers believe that this ocean is rich in dissolved ions, mainly sodium, potassium, magnesium and chlorine. In our planet, life thrives in ion-rich solutions, thus there is a good probability that this moon might have some kinds of organisms. However, these may not be the only conditions under which 'weird life' (Baross et al. 2007: 8) or active material assemblages could evolve in the universe. Alien life might use as their material basis compounds other than deoxyribonucleic acid and fats, for example, or they might exploit liquid methane or ammonia as a solvent.

In the Proto-A project, we focused as a first approach on formamide ($HCONH_2$), a substance ubiquitous in the universe. Formamide is formed under extreme conditions via photolysis and the energetic processing of interstellar ices with high-energy protons. It has been detected in the long period comet Hale-Bopp, around young stellar objects (W33A, IRAS 16293), in galactic centers (Sgr A and Sgr B) and in the interstellar medium. But besides its abundance and diffusion in the cosmos, our main interest in formamide lied in its fluid and versatile nature. This substance is liquid under a wide range of temperatures. This property makes it particularly suited for its concentration in high-temperature or desert-like environments. The existence of formamide reservoirs opens, thus, the intriguing probability of non-water-based metabolisms and waterless active worlds elsewhere in the universe.

In our first prototype of the alien mini-planet, we simulated the conditions of an environment devoid of water and oxygen with liquid formamide. Using this substance as a solvent, we found that mixtures of non-terrestrial hydrocarbons spontaneously generate soft bodies. Depending on their composition, these molecules self-assemble and produce round-shaped aggregations of about 0.5–30 mm in diameter.

Moreover, we found that the internal state of these soft bodies can be affected by their interaction with other non-terrestrial organics. When heterogeneous mixtures

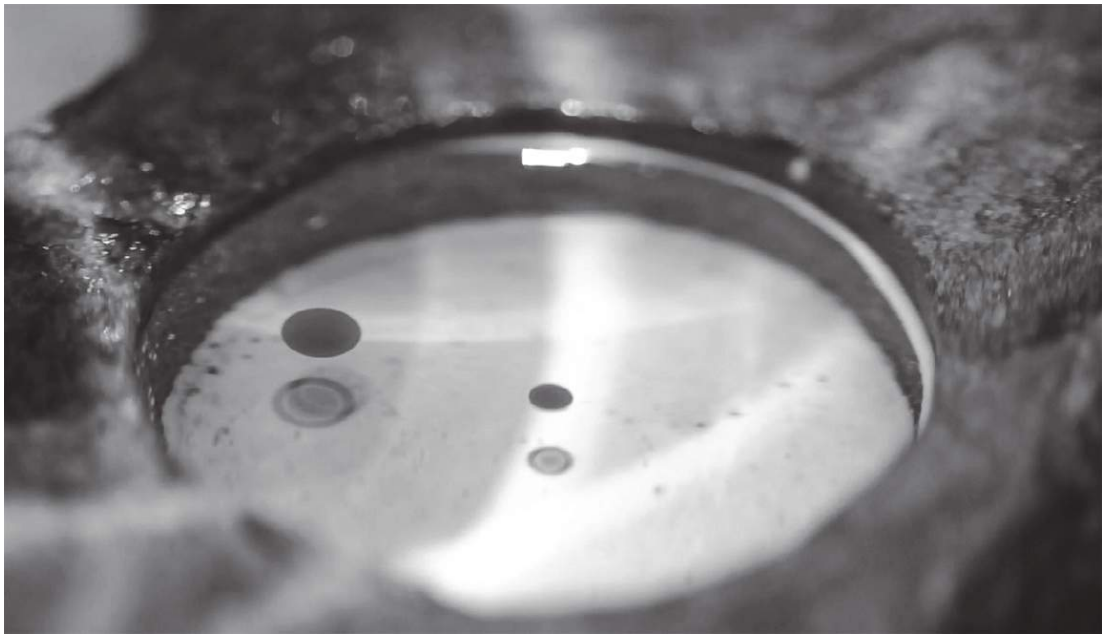

Figure 2. Image of the non-terrestrial, kinetic and autonomous agents in liquid formamide.

of non-polar molecules and amphiphilic substances are included in the solution the blobs deform and actively move and self-divide. Establishing and optimizing the protocols to allow the formation of these alien material assemblages in liquid formamide, so that they were active enough to become non-equilibrium entities and act for several hours, was one of the major challenges of this artwork. Scientific papers or protocols describing such non-terrestrial material systems could not be found, which led to a extensive process of trial and error.

4. Formamide mini-planet

In this hybrid installation, the sculptural object that shelters the proto-aliens is a planetary-simulation chamber: a high-vacuum, high-pressure/temperature reactor capable of reproducing atmospheric compositions and surface temperatures of most planetary objects. To simulate the atmosphere of a formamide planet in this chamber, carbon monoxide, ammonia and argon gases are mixed and constantly monitored with sensors. Likewise, the temperature of a small rock with formamide pools is regulated by a heater between 50°C to 80 °C. The chamber was designed to make the activity of the alien aggregations visible 360 degrees, while at the same time being a functional instrument. A great amount of time was spent designing a suitable reactor for the proto-aliens that contained multiple features and was robust and modular in design.

The premiere of *Formata* took place on 17 December 2020 at the Art-Theque gallery of Tama Art University, Tokyo, Japan. During the exhibition of this artwork, visitors were able to watch and experience the formamide mini-planet as well as the physical transformation and dynamic behavior of the agents in real time. For reasons of safety, ammonia was not used in the gallery and carbon monoxide was replaced by carbon dioxide.

For the Proto-A team it was important that the audience experienced how the alien aggregations become operative and autonomous in a non-terrestrial environment. The intention was to reveal how their ability to act is rooted in their materiality, without the need for genetic information or complex mechanisms. An embedded protometabolism, the capability to deform, move and self-divide are all present within these aggregations in the form of compositional agency.

With all the challenges and impediments posed by the COVID-19 pandemic and the complexity of *Formata*, it was nothing short of a miracle that the *Proto-A* team accomplished and exhibited the artwork. The exhibition was not only successful but went beyond the expectations of the team.

5. Alien performativity

In this work, alienness and the perception that these agents are not yet living but already more or less alive confronted visitors in multiple ways. By way of material actions that become operative, autonomous and construct reality these soft agents become performative rather than figurative. This physical encounter between the audience and alien material assemblages is critical to our project. ETOM helps us to materialize the 'other' and the unknown, but also to reassess our place in an active universe. That alien matter can be experienced as performative can not only help us understand how matter itself behaves, but also allow us to rethink the basis for how we perceive and relate to materials and objects. It involves embracing the morphogenetic tendencies, non-linear logic and active behavior of matter, regardless of its structural identity and place in the universe.

We live in a time when our understanding of life is changing rapidly, when the discovery of new extrasolar planets and moons is accelerating, and when fundamentally new macro and micro-scale insights are changing our view of humanity and life on Earth. This artwork aims, thus, to contribute to new means of encountering and understanding non-human materiality, the 'other' and alien life.

References:

1. Yuen, G. U. & Kvenvolden, K. A. Monocarboxylic acids in Murray and Murchison carbonaceous meterorites. Nature 246, 301–303 (1973)
2. Deamer, D. W. Boundary structures are formed by organic components of the Murchison carbonaceous chondrite. Nature 317, 792–794 (1985)
3. Krishnamurthy, R. V., Epstein, S., Cronin, J. R., Pizzarello, S. & Yuen, G. U. Isotopic and molecular analyses of hydrocarbons and monocarboxylic acids of the Murchison meteorite. Geochim. Cosmochim. Acta 56, 4045–4058 (1992)
4. Monnard, P.-E. & Deamer, D. W. Membrane selfassembly processes: steps toward the first cellular life. Anat. Rec. 268, 196–207 (2002)
5. Pizzarello S, Huang Y. Carbon isotopic analyses of individual Murchison amino acids. Geochim Cosmochim Acta Suppl. 2003; 67:380.
6. Martins Z, Alexander CMO'D, Orzechowska GE, Fogel ML, Ehrenfreund P. Indigenous amino acids in primitive CR meteorites. Meteor Planet Sci. 2007; 42:2125–2136.
7. Bernstein, M. P., Sandford, S. A., Allamandola, L. J., Chang, S. & Scharberg, M. A. Organic compounds produced by photolysis of realistic interstellar and cometary ice analogs containing methanol. Astrophys. J.454, 327–344 (1995)
8. Gerakines, P. A., Moore, M. H. & Hudson, R. L. Energetic processing of laboratory ice analogs: UV photolysis versus ion bombardment. J. Geophys. Res. 106, 33381–33385 (2000)
9. Dworkin, J. P., Deamer, D. W., Sandford, S. A. & Allamandola, L. J. Self-assembling amphiphilic molecules: synthesis in simulated interstellar/precometary ices. Proc. Natl Acad. Sci. USA 98, 815–819 (2001)
10. Baross, John A., Benner, Steven A., Cody, George D., Copley, Shelley D., Pace, Norman R., Scott, James H., Shapiro, Robert, Sogin, Mitchell L., Stein, Jeffrey L., Summons, Roger and Szostak, Jack W. (2007) The Limits of Organic Life in Planetary Systems, Washington, D.C.: National Academies Press.

Abstract

Non-terrestrial, kinetic and autonomous agents

Formata are non-terrestrial, kinetic and autonomous agents. They are the result of a three-year research collaboration at the intersection of media art, chemistry and astrobiology entitled the *Proto-Alien Project*. These agents deform, actively move and self-divide in a miniature environment devoid of water with pools of liquid formamide and an atmosphere filled with carbon monoxide, argon and ammonia gases. A self-assembled body, an embedded protometabolism and the capability to act are all present within these agents in the form of compositional agency. This report introduces this hybrid installation highlighting its background, non-terrestrial substances, design of the alien mini-planet and premiere exhibition.