Self-replicator that is simultaneously created and destroyed may lead to better understanding of life

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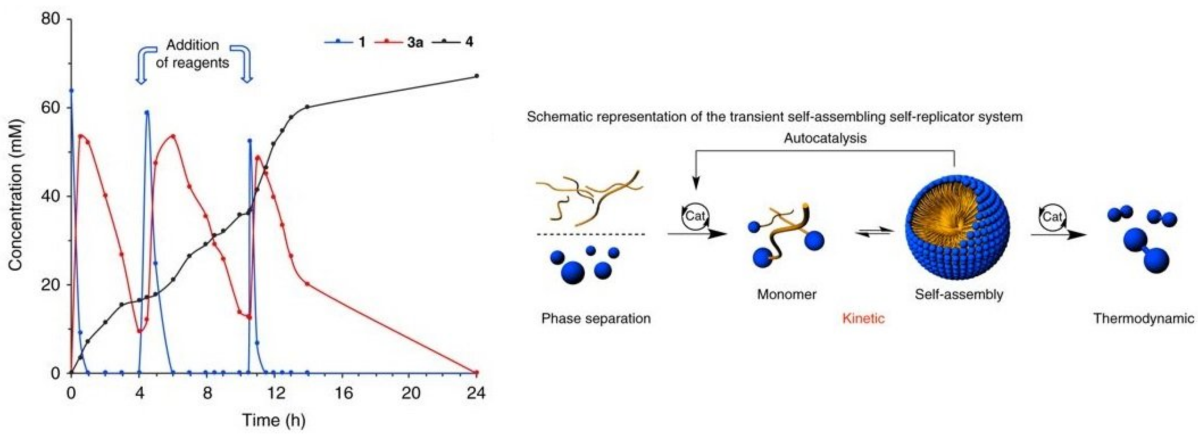

(Left) Concentration of different compounds: raw materials (blue), product (red), waste product (black). (Right) Self-replication process. Credit: Colomer et al. Published in *Nature Communications*.

As living organisms eat, grow, and self-regenerate, all the while they are slowly dying. Chemically speaking, this is because life is thermodynamically unstable, while its ultimate waste products are in a state of thermal equilibrium. It's somewhat of a morbid thought, but it's also one of the characteristics that is common to all forms of life.

Now in a new study, researchers have created a self-replicator that self-assembles while simultaneously being destroyed. The synthetic system may help researchers better understand what separates biological matter from simpler chemical matter, and also how to create synthetic life in the lab.

The researchers, Ignacio Colomer, Sarah M. Morrow, and Stephen P. Fletcher, at the University of Oxford, have published a paper on the self-replicator in a recent issue of *Nature Communications*.

"The combination of replicator formation and destruction makes the system capable of sustained replication, which is something that only biological systems are currently capable of, and the system continues to self-reproduce as long as you keep feeding it," Fletcher told *Phys.org*.

The self-replicator consists of a system of small molecules composed of hydrogen and carbon (hydrocarbons). Initially, the system contains two types of hydrocarbons, hydrophobic (which repel water) and hydrophilic (which dissolve in water), which serve as the raw materials or "food" for the system. The two types of hydrocarbons are separated by an interface, but with the help of a ruthenium catalyst they are able to react across the interface to form an amphiphilic product, which has both hydrophobic and hydrophilic properties.

Similar to how living organisms grow and regenerate new cells, the amphiphilic product is an autocatalyst that has the ability to self-assemble, thereby increasing its concentration or "growing." As the product both self-assembles and continues to be generated from the raw materials until they run out, the product concentration grows exponentially, at least for a while. But—like life—this product is thermodynamically unstable, so that at the same time that the product is being created, it is also decomposing into a thermodynamically stable waste product. Once the raw materials run out, the decay rate overtakes the growth rate, and eventually the entire system becomes waste product, reaching a state of thermal equilibrium.

The researchers then added a twist to the experiment by adding more raw materials to the system after they initially ran out. The addition of this chemical fuel caused a temporary rise in the level of the amphiphilic product, although waste product was also still being created. When the researchers stopped sustaining the system with raw materials, the self-assembling product was eventually completely destroyed.

Overall, the creation of a self-replicating, out-of-equilibrium system that inevitably moves toward thermal equilibrium provides a physical model for scientists to study the same characteristics of life. In the future, this may help researchers to understand how to create minimal life in the laboratory.

"Making synthetic life is simply not currently possible," Fletcher said. "I believe that this is because we still don't really understand exactly what life is, and developing even primitive models of living systems is still challenging. The design and study of synthetic models, where relatively simple building blocks are used to make complex functional systems, is probably necessary to understand how to make mimic the kind of far-from-equilibrium behavior seen in living systems and allow realistic attempts at making synthetic life."

More information: Ignacio Colomer et al. "A transient self-assembling self-replicator." *Nature Communications*. DOI: 10.1038/s41467-018-04670-2