Measured Properties and Possible Applications of Far-From-Equilibrium Systems

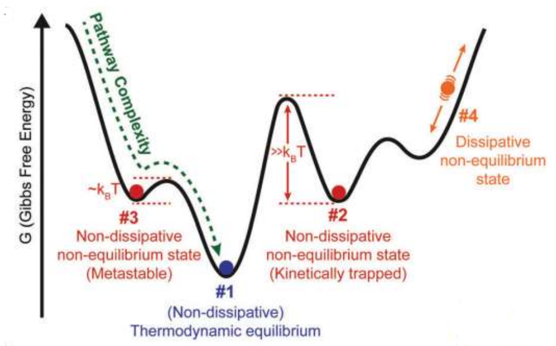
Ryan Maguire and Lauren Stoops

Advisor: UD Department of Chemistry

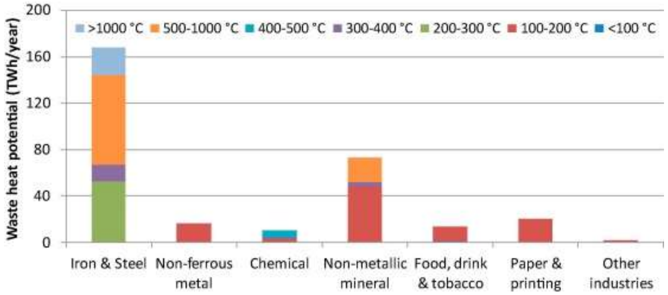
University of Dayton

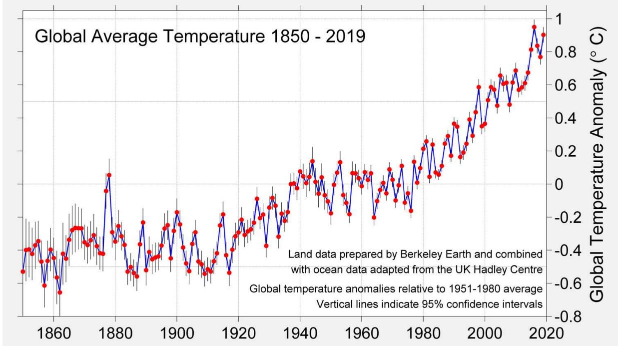
Motivation

Self-assembling systems, such as micelles, have a variety of applications in biological organisms. Their unique properties include an ability to achieve a relatively stable, far-from-equilibrium state.These compounds allow biological systems to conserve heat, which is critical to their survival. In the diagram below, the red particles exist in a far-from-equilibrium, kinetically-trapped state.



A major problem faced by humanity is that of waste heat, in which heat is released from various human processes into the environment. This leads to a severe loss of usable energy while contributing to global warming, thus creating a significant issue for humanity to solve. The bar chart shows waste heat from different industries each year. The graph shows the exponential rise in Earth's temperature over the past 169 years.





Research Results

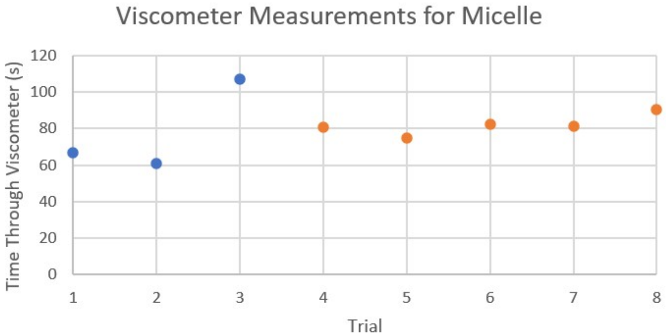
Micelles were formed using cetyltrimethylammonium chloride and decyl alcohol. These micelles were analyzed in two states, namely the equilibrium clear state and the far-from-equilibrium cloudy state.

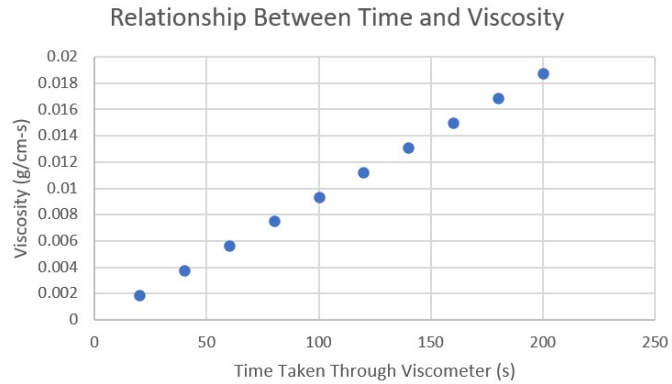
The viscosities of both states were analyzed. Each subsequent trial perturbed the solution more, so the first three trials were assumed to be for the clear state, while the last five were assumed to be the cloudy state.

The top graph shows the time taken for the sample to travel through the viscometer. Overall, the increased time for the cloudy solution to go through the viscometer implies that far-from-equilibrium solutions likely are more viscous than their counterparts at equilibrium. The third trial represents a possible outlier.

$$\eta = B\rho t$$

As time taken increases, viscosity (η) increases linearly, with $B\rho$ as the slope. The bottom graph shows this relationship for a sample with a density of 0.997 g/cm^3 and an instrument constant of 0.0094 mm^2/s^2.





Future Applications

An increase in viscosity implies increased strength in intermolecular forces within a system. If intermolecular forces are stronger, a larger amount of energy is required to break them apart, leading to a higher amount of heat that the system can take in before its state is impacted.

This property gives a possible solution for the waste heat issue that plagues humanity. If far-from-equilibrium systems can absorb more heat, they could be used as heat sinks, thereby transporting energy that would typically have been lost, thus making this energy usable and eliminating a major cause of global warming.

Emails for Contact: maguirer1@udayton.edu
stoopsl1@udayton.edu

Sources: Sorrenti, A., et al. Non-equilibrium Supramolecular Polymerization. *Chemical Society Review*, 2017, *46*, 5467-5680.
Papatrou, M. at al. Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country. *Applied Thermal Engineering*, 2018, *138*, 207-216.
Global Temperature Report for 2019. *Berkeley Earth*, 2020.