Abstract:

"Bio-inspired energy conversion processes in non-equilibrium nano-systems

In our current work we try mimic energy conversion in nature which is fundamentally different than in artificial, centralised one-compartment systems (like cars, mobile phones, etc.). In living systems all reactions take place far from equilibrium and depend heavily on maintaining these conditions, typically in the form of steep chemical gradients. In nature energy is stored in these gradients throughout our body and can be readily converted, on demand and continuously. Typically, when energy is required, APD is converted to ATP, an energetic uphill reaction. This is facilitated by coupling to a downhill reaction where ATPase uses energy released when protons flow along a gradient (across the inner mitochondrial membrane). Using artificial (nano) materials in a similar way is a largely unexplored field. We want to mimic this concept using nanomaterials in non-equilibrium compartmentalised systems. While nature has an advantage in terms of modular diversity, nanomaterials have a distinct advantage in customizability and furthermore allow for direct electronic transport (via the metallic state). Allows for creation of artificial energy conversion systems which in essence are much more biocompatible than traditional power sources and could see potential applications in hybrid or bio-interfacing systems.

There are two key foci of this research. The system itself, which stores chemical energy by maintaining a stable gradient and the active nanomaterial component, which enables the usage of this energy. To achieve this experimentally, non-equilibrium conditions needs to be established and maintained. This is done using simple compartmentalized systems such as aqueous droplet based emulsions, stabilised by chemical surfactants. Without external interaction, the system is maintained in a local energy minimum, and potential chemical energy is stored. By introducing active nanomaterials capable of controlled phase-transfer and with some transport capacity (ions, electrons, molecules, etc.), the energy can be released, but only by a controlled mechanism which creates a product, reduces a compound or similar 'useful work'

I will present preliminary work on the basic principles of energy conversion using crown-ether stabilized gold nanoparticles for controlled $BaSO_4$ precipitation. This process can be gated by controlling overall electric charge, e.g. via redox couple concentration across the gradient. I will also present snippets of the work carried out in our group, all centralised around gold nanoparticles. This will include charge-transfer across membranes in 3D printed electrochemical-cells, self-propelled alloyed nanoparticle motors and nanoparticle superlattice investigations using environmental SEM."