Solar portable tapes work by generating electricity from captured photons, which means that electricity is only generated when the sun is shining. More so, peak energy usage tends to happen at late afternoon or evening, when people are home. Thus, energy conversion does not adequately meet demands. There is a need for effective solar energy storage. In her seminar, Dr. Jillian Dempsey from UNC Chapel Hill discussed her research, which tries to address the challenges associated with solar energy conversion and storage.

She briefly discussed the possibility of using heat or electrochemical energy storage to address the issue, but ultimately focused on the possibility of storing solar energy within chemical bonds. She believed storing energy within chemical bonds was intuitively worth pursuing, because plants supply a natural model for the process; plants store solar energy in the chemical bonds of the sugar or starch they produce. The process could be mimicked artificially; solar energy could hypothetically be stored in small, energy dense molecules such as hydrogen, methane, or methanol, for example.

Catalysts would be needed to aid the solar to chemical energy conversion process. As one example, she detailed proton reduction to dihydrogen via a cobaloxime catalyst. The reaction involves proton coupled electron processes that form a cobalt hydride species as an intermediate, which then in turn goes on to release H2. While it was known that a PCT reaction formed the metal hydride, she explained that not much was known about the details of the proton coupled electron processes in the reaction. Several potential reaction mechanisms could involve either a reduction and then protonation of the catalyst, a protonation and then reduction of the catalyst, or a concreted proton-electron transfer (CPET) process - where a proton and electron are transferred together to the catalyst. Though the CPET process has a high kinetic barrier, it can bypass high energy intermediates that would form in the other two pathways. Furthermore, there are ways to lower the kinetic barrier. Dr. Dempsey was therefore interested in developing efficient catalysts that operated through CPET pathways.

Dr. Dempsey and several undergraduate students used the previously detailed electrochemical concepts in studying the reaction mechanism involving their cobalt catalyst. Cobalt (II) can be reduced to cobalt (I), after which protons are added to solution. High acid concentrations result in more positive potentials, which shows that reduction to cobalt (I) is followed by a fast protonation to form a cobalt (III) hydride, which is reduced to cobalt (II) hydride, which then forms a cobalt (II) H2 complex. They expected the second protonation to be slow and were able to observe a rate constant and use that to get information about the second step. They also found a third step, which they posited to be an H2 released, in the mechanism that was pH dependent. The goal in finding factors influencing the reaction mechanism was make a CPET reaction possible under the right conditions. They found that the electron transfer, proton transfer mechanism occurs constantly, under a wide range of conditions. Changing conditions simply changed the kinetics of the reaction, not the mechanism itself.

They next looked at a model system where of a cobalt (III) hydride that was non-reactive after formation. The reaction mechanism here was found to be reduction of cobalt (II) to cobalt (I) followed by protonation to form the cobalt (III) hydride. Both concentration and the steric bulk of various acids used was found to affect the mechanism, and they found the pathway may include structural changes, namely tautomerization. They also focused on a step that preceded the formation of the cobalt (II) species, which involved the loss of acetonitrile from a cobalt (III) species. Eventually, they discovered a barrier to direct protonation of the metal to make the metal hydride. Currently, the group is trying to understand the kinetic barriers that influences PCT mechanisms, such as the one that caused an indirect protonation of the metal.

After discussing their efforts in forming small molecules that could be used in fuels, she briefly discussed how sunlight was used to drive the reactions. She explained their goal was to bring together the fuel forming catalysts with light absorbing, charge separating semi-conductors. In the future, she expects the use of cascade catalysis – where multiple catalysts will work together to synthesize a multi-carbon lipid fuel. She detailed a few of their accomplishments and challenges in this endeavor, as she wrapped up.

Overall, the talk was well structured, sufficiently detailed, and interesting. Dr. Dempsey was able to explain her research in a way that was comprehensible to non-experts in the field, while also managing to keep the talk educational and informationally dense. The one major criticism I can think of is that she could have more evenly prioritized the first part, where she discussed molecular synthesis, with the second part, where she discussed the way light was used to drive the reactions. She could have summarized their research into catalytic mechanisms with a bit less detail. It seemed like the discussion of integrating fuel formation (through cascade catalysis) with use of light absorbing semi-conductors was more relevant to the topic introduced in the introduction, and that it was hastily discussed in only the last ten minutes or so. She may have just had too much information to present in a one-hour talk.