NDSEG Summary of Goals

Matthew Campbell

Prompt:

In your own words, provide a summary of your educational program objectives and your long-range professional goals. As part of this statement, we are interested in your ideas about: (1) the kinds of research in which you would like to be engaged during your graduate study or in the longer term; or (2) specific research questions that interest you and how you became interested in them. Please discuss these research interests in sufficient detail for an expert who is technically competent in your field to judge your understanding of the questions to be addressed. This includes relevant hypotheses and approaches one might take to answering the questions, and other research principles required to investigate the research area you identify. However, we do not want this to look like a grant submission. We are interested in not only the science, but also your longer-term goals and how the science fits into your life as an individual. Your response will be limited to 3,000 characters, including spaces. There is no extra space for citations. If you are writing this text elsewhere and copy-pasting it into this box, be aware that some word processing programs will transfer spaces and returns differently.

Essay:

I am disheartened to recall the rise and fall of a promising alternative fuel, biodiesel (BD), during my tenure at Duke. In 2004, the school began fueling busses with BD rather than fossil diesel (FD). The switch was made to avert the well-known challenges of FD combustion, including NOx and particulate matter (PM) emissions, carcinogenic soot, stricter emissions regulations, and US dependence on finite imported petroleum supplies. This contrasts BD combustion, which, in heavy trucks, is known to reduce PM, hydrocarbon, and CO emissions by ~50%.

In 2007 the university discontinued the use of BD due to maintenance issues associated with the fuel, representing a step away from the school's goal to use cleaner energy. Other well-documented BD combustion challenges include slightly lower fuel economy, impacts on ignition timing, and an increase of NOx of ~10% for B100 which is

still not fully explained. I believe that the challenges posed by alternative fuels should not be averted, but must themselves be challenged through scientific study.

In order to design engines which capitalize on BD's benefits without compromising in performance and emissions, we need a fundamental understanding of BD ignition timing and exhaust formation. However, few kinetic studies have been performed on methyl esters like those of BD, because their 16-18 carbon (C) atom chain lengths make mechanism development complex and also make them difficult to vaporize. Comparable work consists of testing/modeling on a shorter 4 C-chain molecule. Numerous researchers have cited the lack of shock tube studies and/or called for more extensive studies of BD and its surrogates.

I want to perform time-history measurements on methyl decanoate, a 10 C-chain BD surrogate, in order to better understand its kinetics and develop better combustion models. Through these models, I hypothesize that I can recommend engine tuning and fuel blending such that emissions are minimized and performance is maximized.

Working in the Hanson Group at Stanford, I can perform these studies in a high-purity aerosol shock tube. A shock tube is a long pressure vessel designed to allow sensitive gaseous temperature, pressure, and optical measurements in a spatially uniform environment. A pressure wave propagates down its length, vaporizes a fuel aerosol, reflects off the end wall, and causes the now-gaseous fuel to explode in the reflected pressure wave.

I fear that the scenario at Duke will take place on a much larger scale – that America will avoid biodiesel because of the difficulties it presents and in so doing remain dependent on foreign oil and continue producing toxic diesel soot. I want to get a PhD in thermoscience and perform energy research which can alleviate this and other pressing problems. I also want to teach younger generations so they will be equipped to face these difficult problems too. Perhaps biodiesel will return to Duke one day to stay, due to research funded by the NDSEG.