SUMMARY/ABSTRACT FOR PUBLIC RELEASE

Name of the applicant: University of Kentucky Research Foundation

Project director/principal investigators: Dr. Eduardo Santillan-Jimenez (Project Director/PI); Drs. Rob Pace, Chad Risko, Jacob Kruger (co-PIs)

Project title: Robust Engineered Catalysts for the Conversion of Algae and Waste Oleaginous Biomass Feedstocks to Fuel-like Hydrocarbons via Decarboxylation/Decarbonylation ($deCO_x$)

Objectives of the project: The project has 7 main objectives, namely:

1. Develop an engineered $deCO_x$ catalyst.
2. Test the engineered catalyst to produce and collect spent and regenerated catalyst samples.
3. Characterize the fresh, spent, and regenerated catalyst to gain insights on the deactivation mechanism(s) and inform computational work.
4. Perform computational studies designed to probe and understand deactivation phenomena.
5. Leverage insights gained to develop an optimized version of the engineered $deCO_x$ catalyst.
6. Test the optimized engineered catalysts in a continuous fixed-bed reactor with multiple heating zones for 500 hours in a bio-stream with no more than 2 on-stream regenerations.
7. Use the data acquired to assess the fuel cost and emissions of the technology developed.

Description of the project: The hydroprocessing of esters and fatty acids (HEFA) is a mature pathway to produce fuel-like hydrocarbons that is mostly reliant on the hydrodeoxygenation (HDO) reaction. However, an alternative technology based on $deCO_x$ offers many advantages over HDO (viz. higher feedstock flexibility, less problematic catalysts, lower H_2 requirements). In this project, an engineered $deCO_x$ catalyst will be prepared by supporting Ni and Cu on alumina extrudates by excess wetness impregnation. An abundant, inexpensive, waste, and inedible bio-derived stream composed almost exclusively of free fatty acids – brown grease (BG) – will be converted to fuel-like hydrocarbons over the engineered $deCO_x$ catalyst in a fixed-bed continuous reactor with a single heating zone. This will afford the catalyst deactivation profile as well as samples of the fresh, spent, and regenerated catalyst. Characterization of the samples collected using multiple techniques will provide insights regarding structure-activity relationships, which will inform computational work designed to probe and understand the deactivation mechanism. The insights gained will be leveraged to develop an optimized version of the engineered $deCO_x$ catalyst, which will be tested in a continuous fixed-bed reactor with multiple heating zones for 500 hours in a bio-stream with no more than 2 on-stream regenerations. Lastly, technoeconomic and lifecycle analyses will assess this technology in terms of fuel cost and emissions.

Potential impact of the project: This work will yield an engineered catalyst fulfilling DOE's requirements in terms of catalyst robustness and performance as the basis of a cost-competitive $deCO_x$-based pathway to convert abundant and inexpensive biomass streams to drop-in fuel-like hydrocarbons.

Major participants: University of Kentucky, National Renewable Energy Laboratory, Saola Energy LLC, Clariant Corp.