Whitepaper

Laser Quantum lasers help investigate greener fuel

Research groups from the Universities of Dundee, Aberdeen, Bristol and Bremen have recently utilised both a ventus 532nm laser and a finesse laser in their studies into biofuel evaporation dynamics. The work, published by the American Chemical Society[1], investigated blends of ethanol/gasoline by combining an electrodynamic balance technique and an optical tweezers arrangement to study the droplets. It is known that blends create less harmful emissions than pure fossil fuels, leading to considerable environmental benefits. Full details can be found in the publication[1].

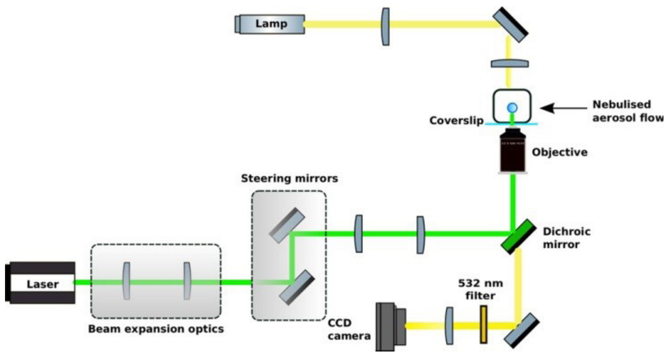

Figure 2: Optical Tweezer set up

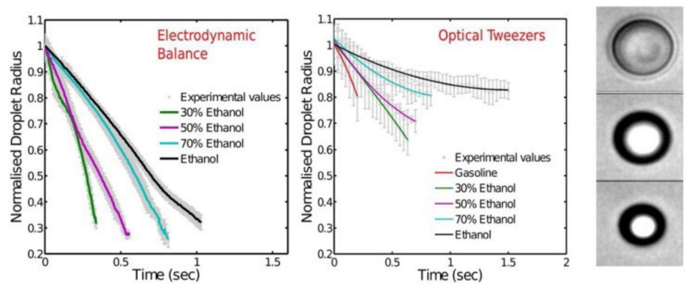

Figure 3: Evaporation trends of ethanol/gasoline droplets trapped by Electrodynamic Balance (a) and Optical Tweezers

It has long been known that automotive fossil fuel emissions contribute to greenhouse gases which in turn have been shown to have a prominent role in climate change. Consequently, there is an ever increasing need for science to look for alternatives that can be used as full or partial replacements to reduce the environmental impact as well as prolonging earth's natural reserves.

One solution is to use fuel blends to reduce the need for such vast quantities of fossil fuels. The current paper studies bioethanol/gasoline blends utilising an electrodynamic balance technique to measure evaporation of individual droplets in a controlled environment and, by using optical tweezers techniques, the behaviour of the droplets in aerosol form can be studied.

Electrodynamic Balance

The Electrodynamic Balance set up is shown in figure 1. A single droplet of the fuel blend was "trapped" in the balance by using 2 electrodes and a balance of dc and ac voltages. The dc voltage cancels the Stokes drag force which is a result of the upward flowing nitrogen gas, whilst the ac voltage cancels lateral displacements. This combination effectively traps a single droplet enabling the dynamics to be investigated by measuring the light scattered when a 532nm beam from the **ventus** laser is used to illuminate the single droplet.

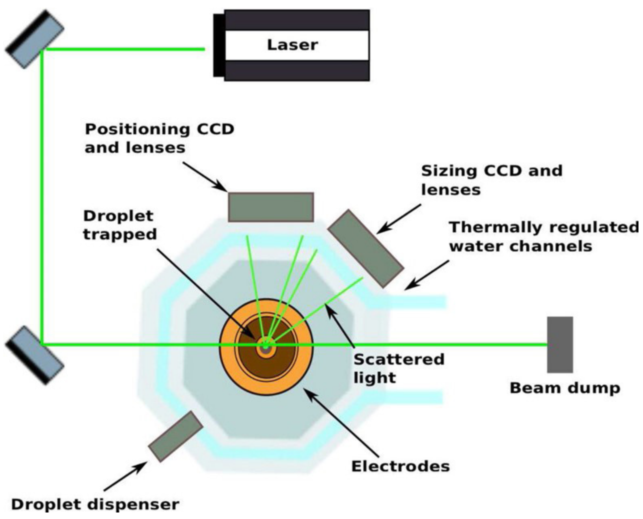

Figure 1: Electrodynamic Balance set up

The **ventus** is an ideal laser for such applications; fully power controllable, the **ventus** provides a stable, power stability of <0.4% RMS, output whilst a pointing stability of <10μrad/°C ensures that the light can be directed onto the trapped droplet accurately, even under changing environmental conditions, helping avoid reflection and interference from the surrounding trap. The light scattering was measured with a CMOS camera.

Optical Tweezers

The Optical Tweezers set up is shown in figure 2. To further investigate the fuel blends a **finesse** 532nm laser was used as the trapping beam in an optical tweezers set up. The laser is focused into a microscope set up where aerosols of the fuel blend are introduced via a nebuliser. The gradient force of the light acts on the aerosol droplet to trap and manipulate individual droplets. The trapped droplets are then imaged with a CCD camera.

Having an M^2 of <1.1, unrivalled power stability of <0.1% RMS as well as an active power feedback to ensure the aerosol particle remains trapped over significant time periods, the **finesse** is the laser of choice for many optical tweezers applications.

Results

The resultant data shown in figure 3 shows the evaporation trend of several different blends with the radius being normalised with respect to the initial droplet size. As can be seen, there is a distinct difference between the data from the two techniques which the authors attribute to the differing environments within the two traps.

The combination of electrodynamic balance and optical tweezer techniques has helped provide a better understanding of biofuels on the single droplet level. Future work will continue to advance the electrodynamic balance and the optical tweezers in conjunction with other techniques to measure high and controlled pressure environments which better reflect the nature of automotive engines.

Figure 4: Laser Quantium's **ventus** 532

Acknowledgements: Prof. J.P. Reid, University of Bristol & Dr. D. McGloin, University of Dundee

References:
[1] Corsetti S. et al 2015 Dec 24. Probing the Evaporation Dynamics of Ethanol/Gasoline Biofuel Blends Using Single Droplet Manipulation Techniques. J Phys Chem A. Vol 119(51). pp 12797-804.