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Study of Graphite Oxide and Graphene as Enhancers for NATO F-76 and Biofuel

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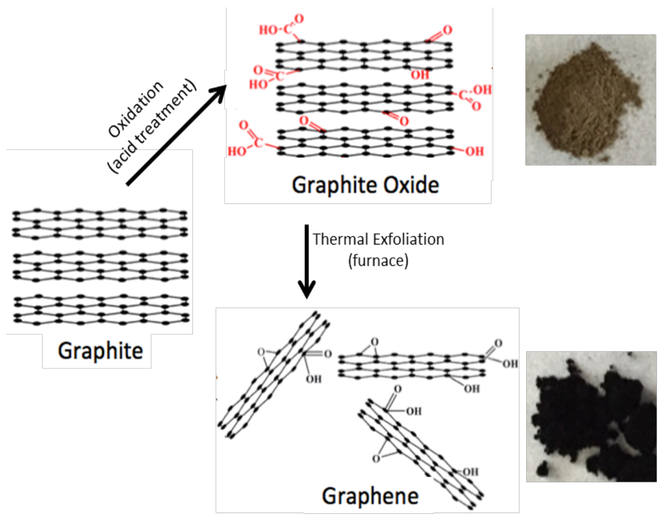
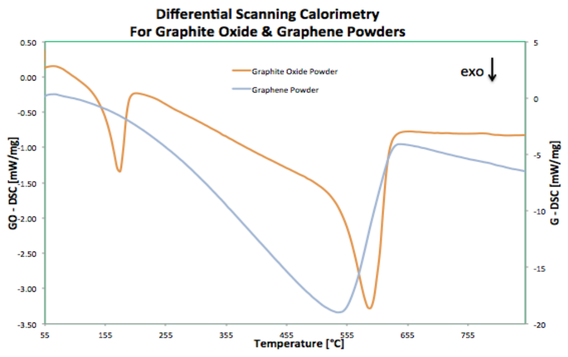
Abstract

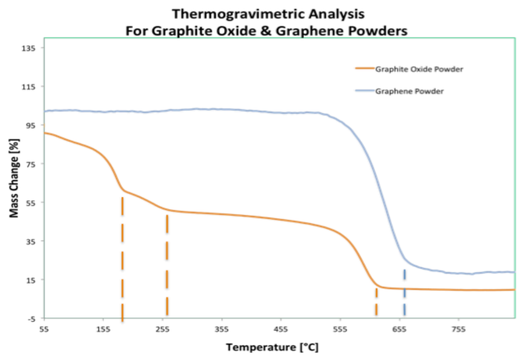
The aim of this study was to test the performance of graphite oxide (GO) and graphene as fuel additives. Both compounds are variations of the honeycomb structure found in graphite but with higher surface areas and different concentrations of oxygen functional groups. GO was considered due to its ability to release the oxygen species at moderate temperatures, while graphene could be readily dispersed and completely burned off during the combustion process. The additives were mixed with NATO F-76 diesel fuel and Biofuel in 0.01 to 3 % weight ratios. Samples were analyzed by differential scanning calorimetry and thermogravimetry to determine heat flows and mass changes, respectively. The evolved gases from all the processes were identified by mass spectroscopy. The fuel-additive mixtures were tested in a diesel engine to determine ignition delays . Cetane numbers are reported.

Experimental methods



Graphite oxide was fabricated by chemical routes and graphene by thermal exfoliation.





GO

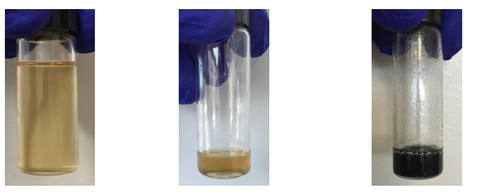
DSC: Exothermic reactions at 110 – 190°C and 525 – 630°C.

TGA: 180°C, 260°C relate to release of water, CO, CO_2. 610°C is graphene.

Graphene

DSC: Exothermic reaction at 200 – 650°C.

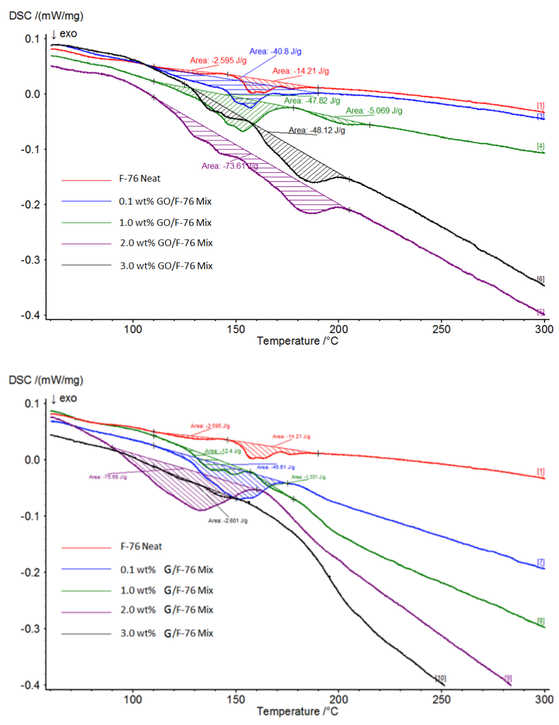
TGA: 660°C is G becoming CO_2.



F-76 | F-76 / GO | F-76 / Graphene

Heat evolution and engine performance

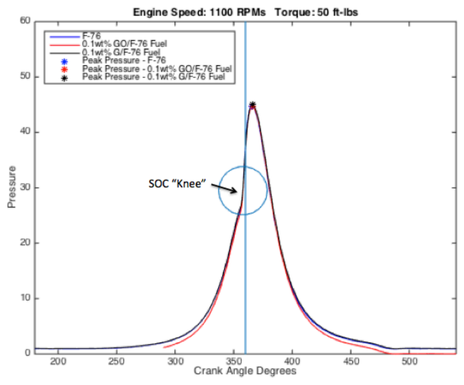
NATO F-76



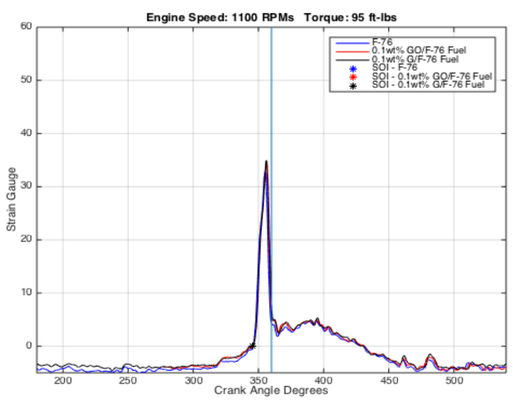
- GO containing fuels show expanded combustion ranges occurring over that of F-76.
- All GO-mixed fuels increased energy output (heat flow) compared to F-76.
- Mass Spectral data showed signatures of H_2O and CO_2 with no other contaminant byproducts.
- Graphene mixed fuels show expanded combustion ranges occurring over that of F-76.
- 0.1 wt% and 2.0 wt% G-mixed fuels increased energy output (heat flow) compared to F-76.

Peak Pressure [bars]				
Speed [RPM]	Torque [ft-lbf]	F-76	0.1wt% GO/F-76	0.1wt% G/F-76
1100	50	44.6893	44.6158	45.0151
	75	45.3844	47.5412	47.2021
	95	50.6289	49.4053	48.7165
	120	51.6421	54.3333	55.1316
1700	50	46.5396	45.5293	45.413355
	75	48.2243	46.9498	46.9215
	95	50.6147	51.33855	51.7032
	120	54.5009	53.283	53.7791

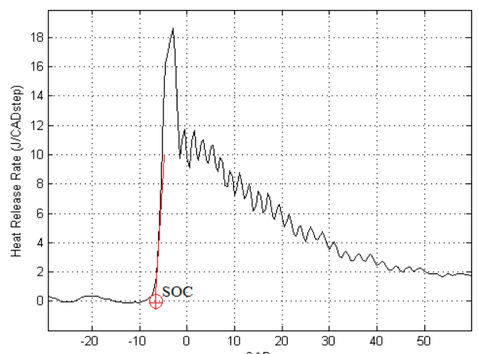
Angle of Peak Pressure [degrees]				
Speed [RPM]	Torque [ft-lbf]	F-76	0.1wt% GO/F-76	0.1wt% G/F-76
1100	50	365.5	365.875	366.125
	75	366.375	366.375	366.875
	95	367.25	367.25	367.75
	120	367.875	368	368
1700	50	369	368.875	368.875
	75	369.275	369.25	369
	95	369.5	369.75	369.5
	120	369.875	369.625	370



- Slight increase in peak pressure at higher loads
- Minimal angle of peak pressure changes
- No apparent change to SOC



- Max slope found, projected to zero baseline. Determines SOC.
- No differences determined in SOC across both mixtures compared to F-76 for all speed/ torque runs.
- SOI ~14° BTC in most runs.
- No apparent change in SOI for GO- or G-mixed fuels compared to F-76 as any speed/load run.



Cetane Number, Gross Heat, Net Heat of Combustion

NATO F-76

Test (ASTM Ref)	Units	F-76	0.1wt% GO/F-76	0.1wt% G/F-76
Gross Heat value (D240G)	MJ/kg	45.55	45.514	45.516
Net Heat of Combustion (D240N)	MJ/kg	43.122	42.702	42.709
Cetane Assessment (D613)	N/A	48.6	48.5	49.9

Biofuel

Test (ASTM Ref)	Units	Biofuel	0.01wt% GO/Biofuel	0.01wt% G/Biofuel
Gross Heat value (D240G)	MJ/kg	45.814	45.713	45.776
Net Heat of Combustion (D240N)	MJ/kg	42.981	42.896	42.924
Cetane Assessment (D613)	N/A	51.5	50.2	52.4

Cetane number relates to the ignition delay of diesel fuel. This ignition delay is determined by the time it takes between fuel injection into the cylinder and the first identifiable pressure increase due to combustion. Increasing the cetane number can reduce pollutant emissions, avoid difficulties in an engine during cold-starting, and increased combustions characteristics .

Conclusions

It was found that in all F-76 GO containing fuels (0.1, 1, 2 and 3% wt), energy output during combustion at slow burn-rates improved over that of F-76. For the Graphene F-76 mixed fuels the results were less consistent, showing improved energy output only for samples with additives of 0.1 and 2%. The cetane number of Graphene biofuel mixtures (with only 0.01% wt) seem to increase and future efforts to test greater amounts of additive are recommended.

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