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Customer:	Philip Tyson	**Report Number*:**	R140075
Company:	The Coconut Group	**Date Submitted:**	1/23/2014
Address:	1500 Global Court Sarasota, FL 34240	**Report Date:**	
Databook #:	BSP (964), DLK (556)	**Analyst(s):**	B.Palumbo, D.Keeley
Samples:	S140195, S140196, S140197	**QC (Initial/Date):**	

Characterization of Tiki Torch Fuels

Summary

Philip Tyson of The Coconut Group submitted three tiki torch fuel samples for comparative analysis of soot levels and off-gasses produced by each fuel type. Additionally, the Firefly tiki torch fuel was to be deformulated using Gas Chromatography-Mass Spectrometry (GC-MS) to identify major components.

The soot level analysis used weight difference to determine the amount of soot each fuel type produced over a fixed time interval. The soot analysis determined that Firefly tiki torch fuel produced the least amount of soot with (0.6 mg), followed by Medallion lamp oil (1.2 mg), and the Lamp Light tiki fuel with citronella (2.1 mg).

The off-gasses of each fuel type were collected over a fixed time interval and identified using GC-MS. The analysis determined that all the fuel types when burned produced a variety of aromatic hydrocarbons including benzene, 1-Propynylbenzene, naphthalene, methylnaphthalene, biphenyl, acenaphthylene. The Firefly tiki torch fuel did produce off gases not detected in the other fuel types including biphenylene, 2-Ethenylnaphthalene, and fluorene.

The deformulation analysis of the Firefly tiki torch fuel was inconclusive. When analyzed a large mixture of variuos hydrocarbons were detected by the GC-MS but no distinguishable major component could be detected.

Experimental

Sample Identification

Impact Analytical ID	*Customer ID*
S140195	Sample 1 - Firefly Tiki Torch Fuel
S140196	Sample 2 - Lamp Light Tiki Fuel with Citronella
S140197	Sample 3 - Medallion Lamp Oil

Soot Production Analysis

The customer's supplied fuel canister was filled approximately half way with the sample fuel. A customer supplied wick was placed through the lid and slid down into the fuel. The wick was left ¾" sticking out of the top of the lid. The wick was allowed to soak in the fuel for 5 minutes before it was lit and left to burn for 2 minutes and then extinguished. A pre-weighed aluminum pan was then placed 5" above the wick on a ring stand. The wick was then re-lit and allowed to burn for one minute allowing the smoke and soot to collect on the aluminum pan. The wick was extinguished and the pan removed. This was repeated two more times for a total of three pans. Each sample was tested in this manner. The pans were then weighed and the average soot amount was calculated and the results can be seen in Table I.

GC-MS Off-gas Analysis

Off-gases were collected for each fuel using the setup illustrated in Figure 1. The wick was lit on the fuel canister and placed under the inverted funnel w/glass wool in stem for 10 minutes. The inverted 20 mL vial resting over the funnel stem was removed after the 10 minute burn and capped while still inverted. The vial was turned right side up and immediately a conditioned 100 µm Polydimethylsiloxane coated solid phase micro extraction (SPME) fiber was inserted and exposed for 10 minutes. After 10 minutes the SPME fiber was retracted and analyzed according to Impact Analytical standard operating procedure SOP-MOL-013. The following chromatographic conditions were used for this analysis.

Capillary Column: DB-5MS, 30 m x 0.25 mm x 0.25 µm
Inlet: 250 °C
Carrier Gas (He) Flow: Constant Flow at 1 mL/min
Manual Injection: 1 min SPME exposure time, Split mode 5:1
Temperature Program: 40 °C (1 min hold) increased at 5 °C/min to 170 °C (1 min hold) increased at 25°C/min to 300 °C (no hold)
Transfer Line: 325 °C
Detector: MSD at 250 °C, EI SCAN Mode m/z 40–700

GC-MS Deformulation Analysis

The Firefly tiki torch fuel (S140195) was prepared by transferring 100 µL to a 20 mL glass vial and diluting it with 9.9 mL of n-hexane. An aliquot of the solution was transferred to an auto sampler vial and analyzed according to the Impact Analytical standard operating procedure SOP-MOL-013. The following chromatographic conditions were used for this analysis.

Capillary Column: DB-5MS, 30 m x 0.25 mm x 0.25 µm
Inlet: 250 °C
Carrier Gas (He) Flow: Constant Flow at 1 mL/min
Injection: 1 µL injection, Split mode 100:1
Temperature Program: 40 °C (no hold) increased at 20 °C/min to 60°C (1 min hold) increase at 5 °C/min to 170 °C (1 min hold)
Transfer Line: 325 °C
Detector: MSD at 250 °C, EI SCAN Mode m/z 40–700

Results and Discussion

Soot Production Analysis

The weights measured and the averages calculated for each sample are listed in Table I below.

Sample ID	Pan 1	Pan 2	Pan 3	Average
S140195	Tare 2.2155g	Tare 2.2070 g	Tare 2.2166 g	0.0006 g
	2.2159 g	2.2075 g	2.2175 g	
	Soot 0.0004 g	Soot 0.0005 g	Soot 0.0009 g	
S140196	Tare 2.2204 g	Tare 2.2520 g	Tare 2.2079 g	0.0021 g
	2.2219 g	2.2547 g	2.2100 g	
	Soot 0.0015 g	Soot 0.0027 g	Soot 0.0021 g	
S140197	Tare 2.2193 g	Tare 2.2226 g	Tare 2.2524 g	0.0012 g
	2.2204 g	2.2235 g	2.2537 g	
	Soot 0.0015 g	Soot 0.0009 g	Soot 0.0013 g	

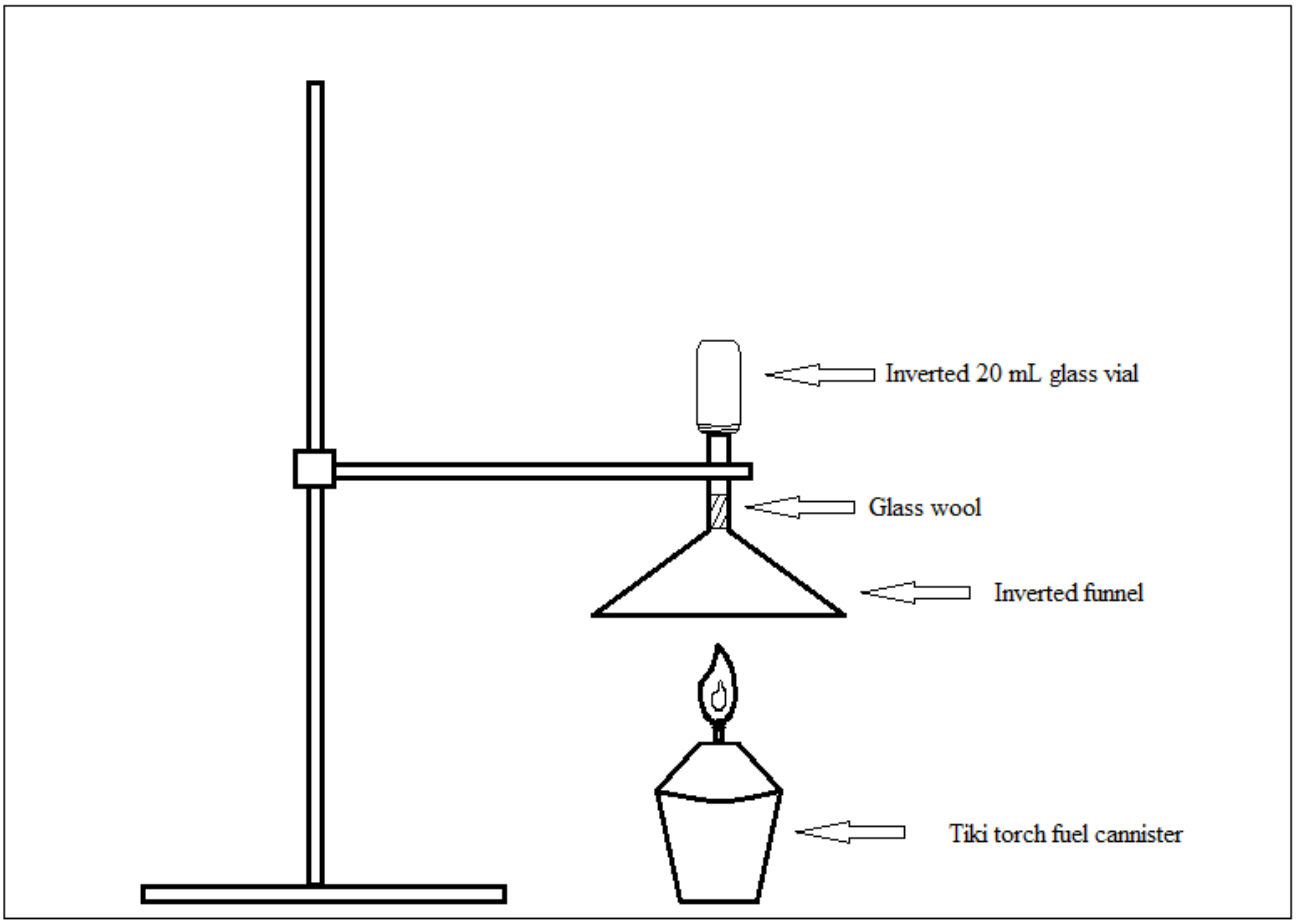
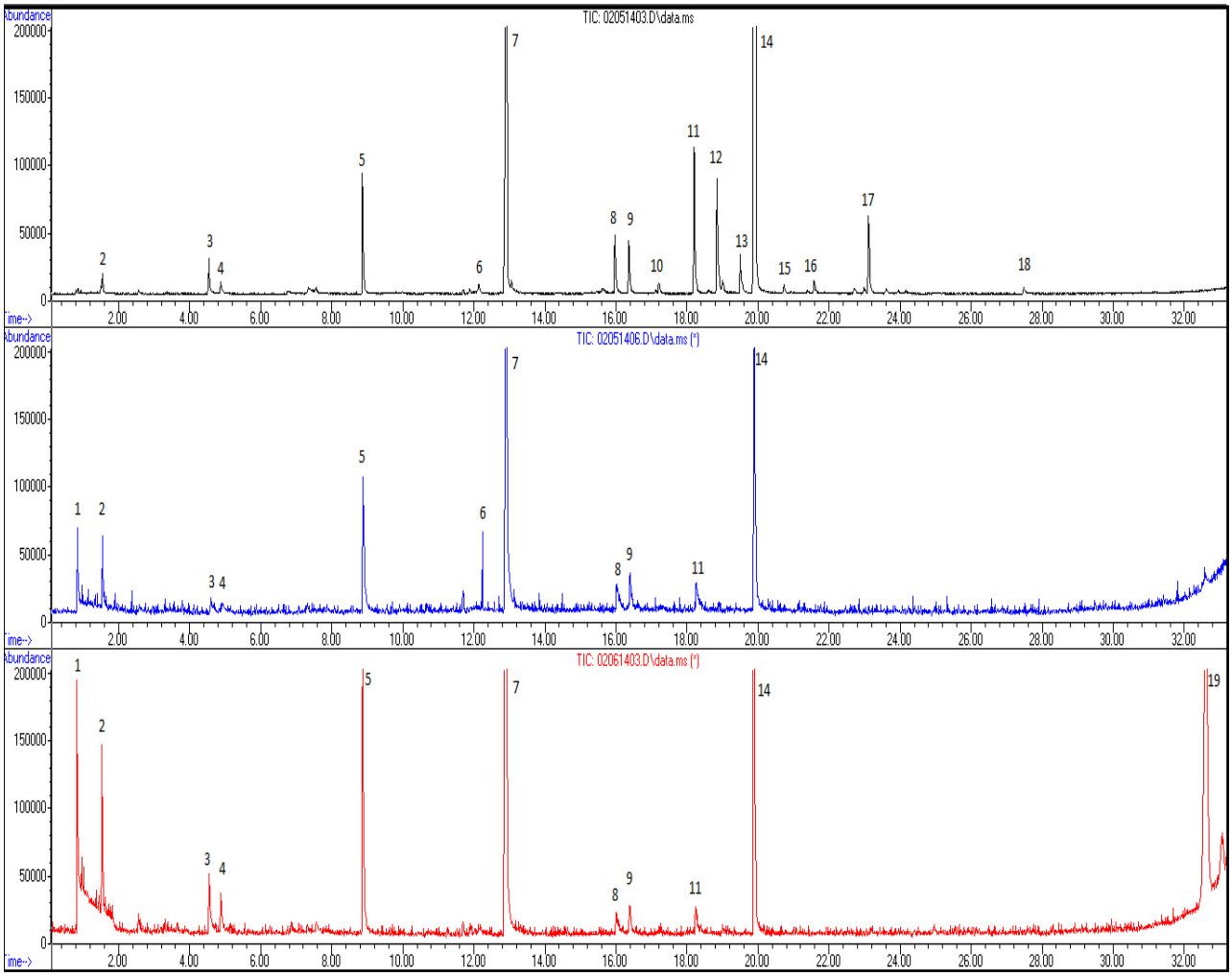


Figure 1. Setup used for off-gas collection of burning tiki torch fuels.



1	Air
2	Benzene
3	Aromatic hydrocarbon
4	Aromatic hydrocarbon
5	Benzene, 1-propynyl-
6	Aromatic hydrocarbon
7	Naphthalene
8	Naphthalene, methyl-
9	Naphthalene, methyl-
10	Aromatic hydrocarbon
11	Biphenyl
12	Biphenylene
13	Naphthalene, 2-ethenyl
14	Acenaphthylene
15	Aromatic hydrocarbon
16	Aromatic hydrocarbon
17	Fluorene
18	Aromatic hydrocarbon
19	Siloxane (fiber bleed - not from sample)

Figure 2. Stacked TIC chromatograms of off-gassing from lit torches (top) Firefly tiki torch fuel (S140195), (middle) Lamp light tiki fuel with citronella (S140196), (bottom) Medallion lamp oil (S140197).