

EFFECT OF POWER LEVEL ON THE YIELD OF TOTAL AEROSOL MASS AND FORMATION OF ALDEHYDES IN E-CIGARETTE AEROSOLS

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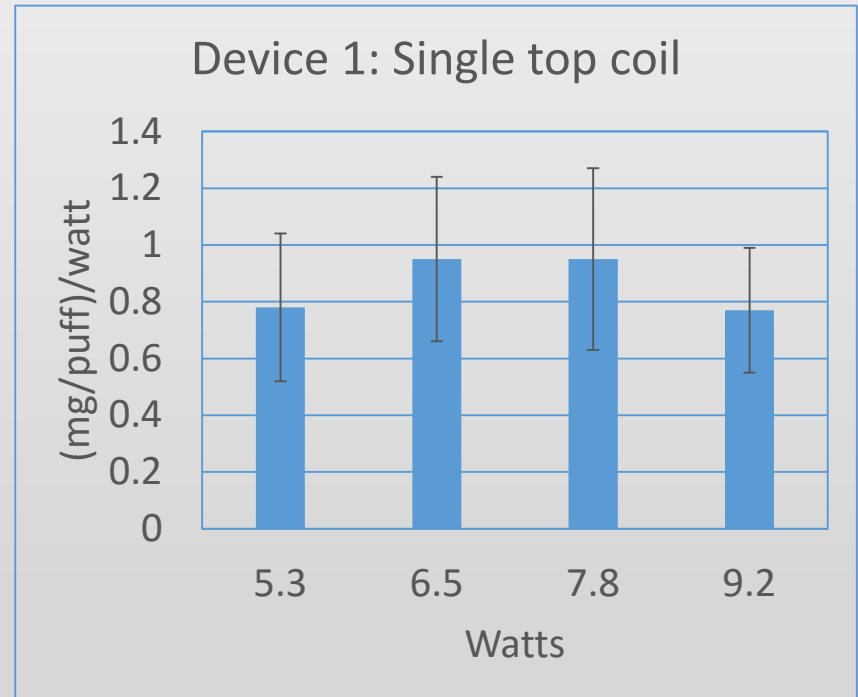
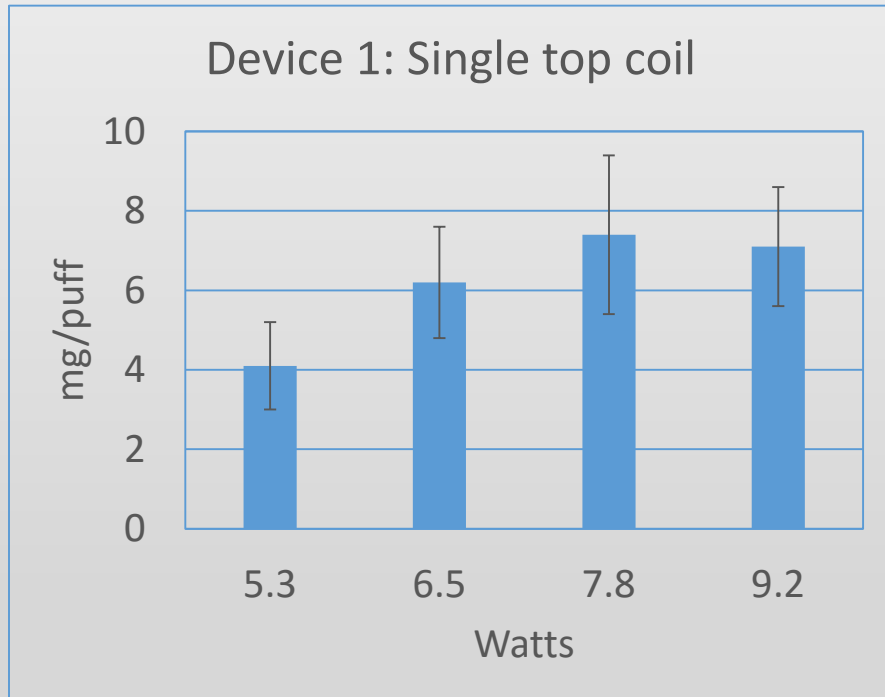
Experimental Design

- Aerosol was collected using automatic “button pusher” using a 55 mL constant flow puff over 4 seconds every 30 seconds.
- 50:50 PG/VG liquid with 2% nicotine was used with all samples.
- Samples were collected from three separate coils, for each devices.
- Duplicate samples were collected at 3.8, 4.2, 4.6 and 5.0 volts. Sub-ohm samples were collected at 10, 15, 20 and 25 watts.
- Aerosol was analyzed for aldehydes (formaldehyde, acetaldehyde and acrolein) production.

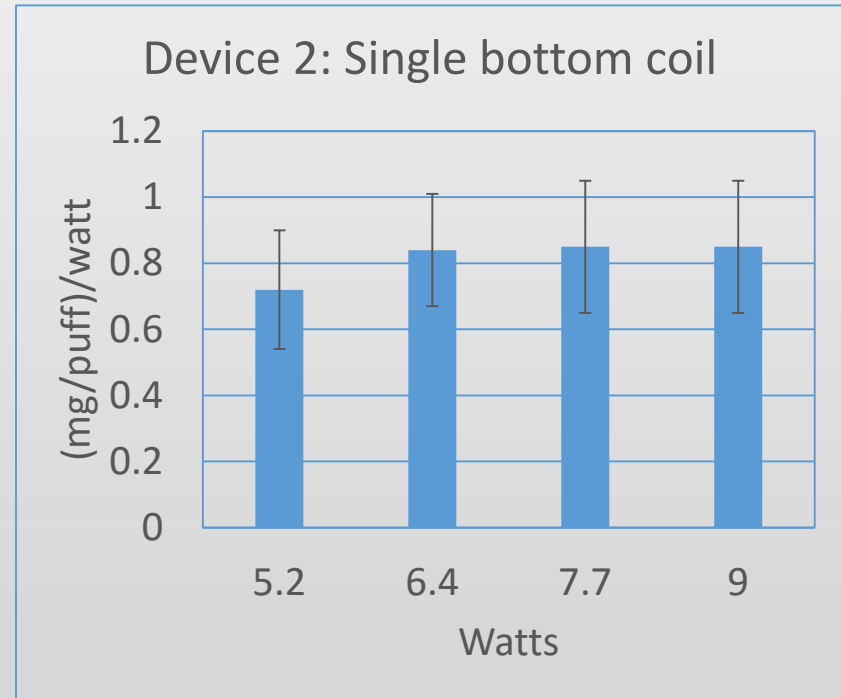
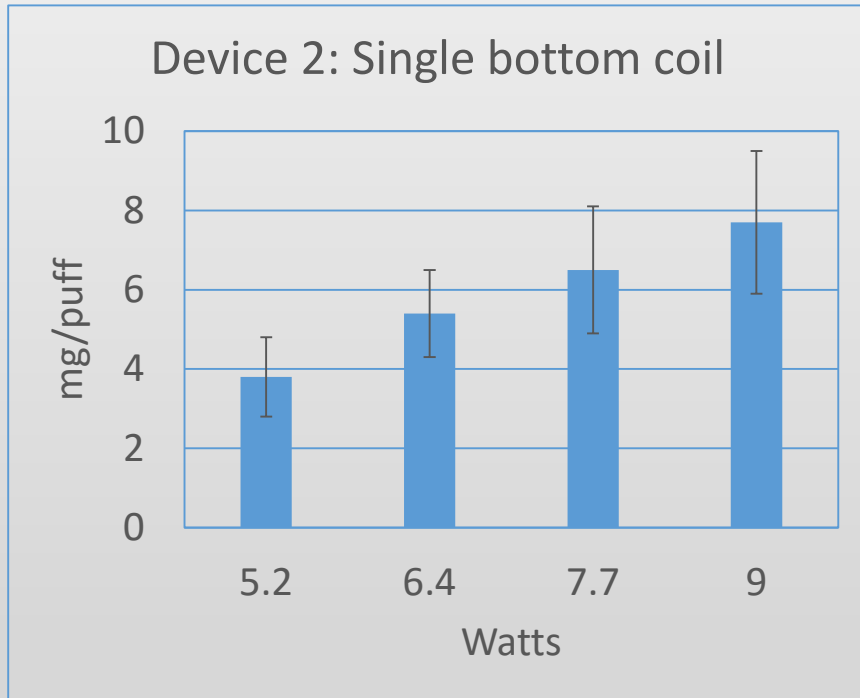
Test Items

- Device 1: Single top coil, 2.8 ohm, CE4 “top-coil” tank-style
- Device 2: Single bottom coil, 2.7 ohm, Protank 1 by KangerTech
- Device 3: Dual bottom coil, 2.8 ohm, Gladius by Innokin
- Device 4: Single bottom coil, 2.2 ohm, Nautilus by Aspire
- Device 5: Single bottom coil, 0.72 ohm, SubTank by KangerTech

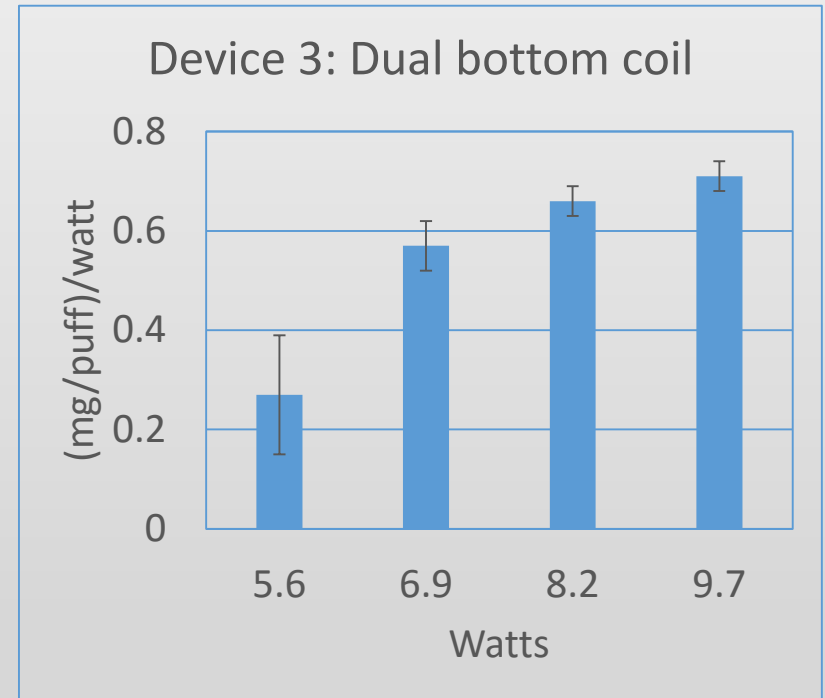
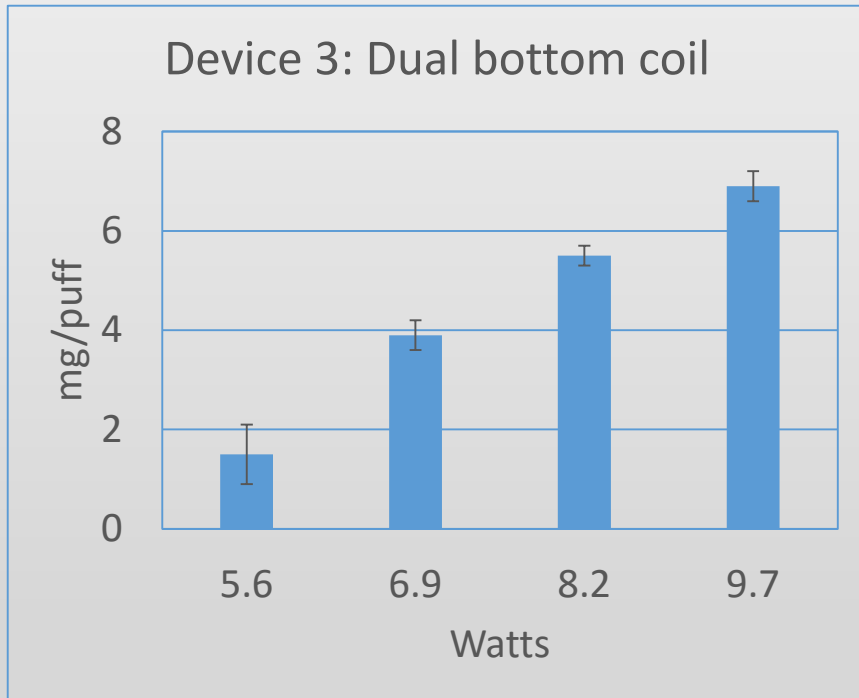
Yield Versus Power



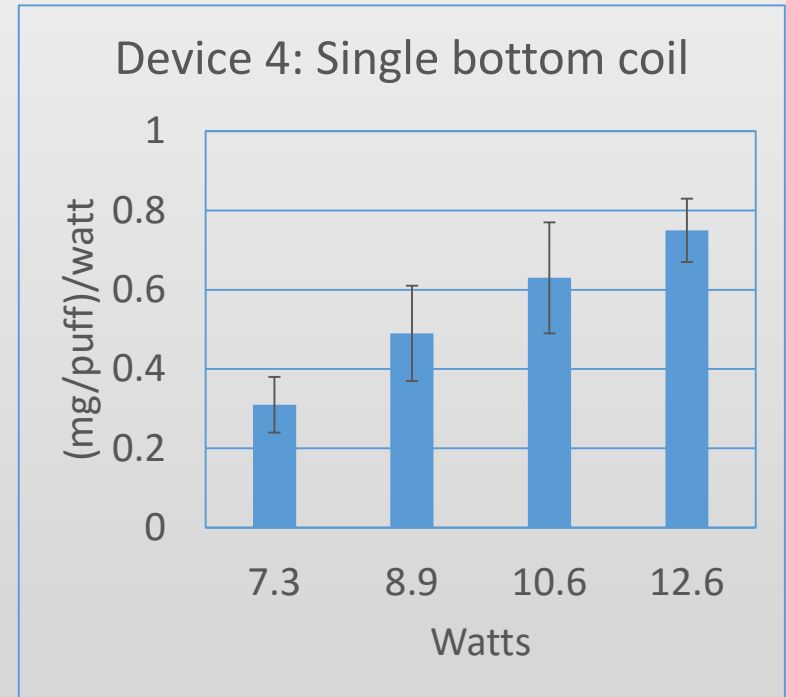
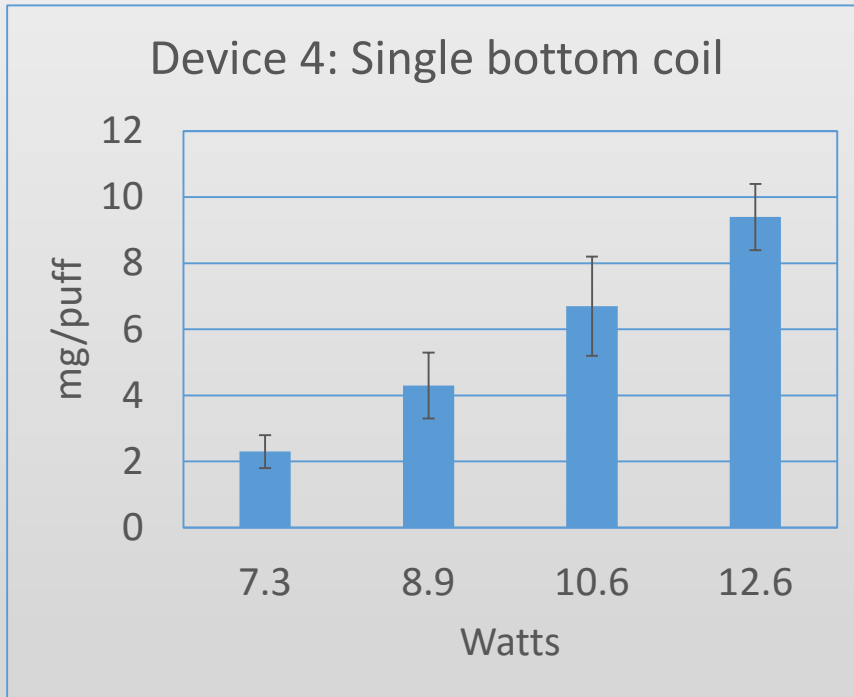
Yield Versus Power



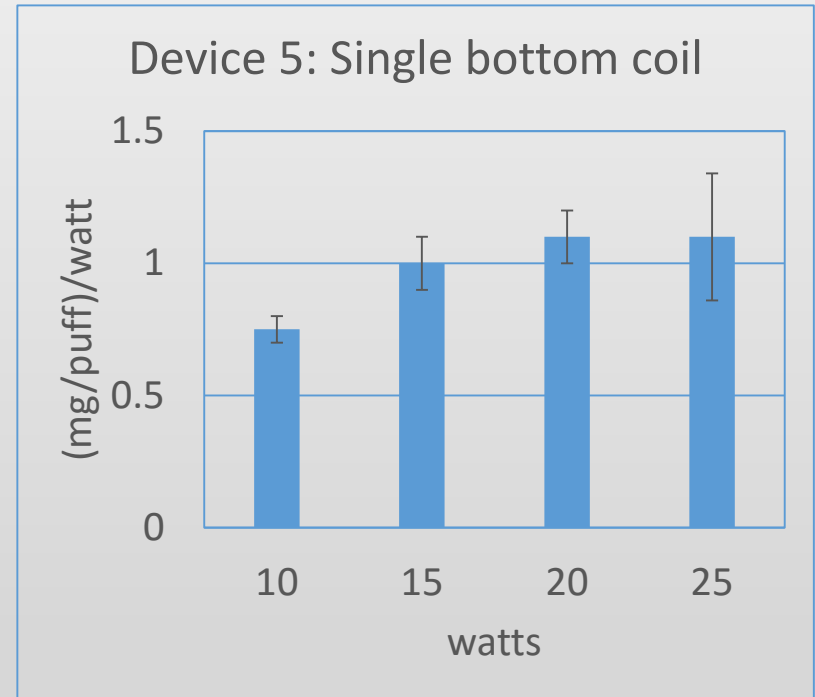
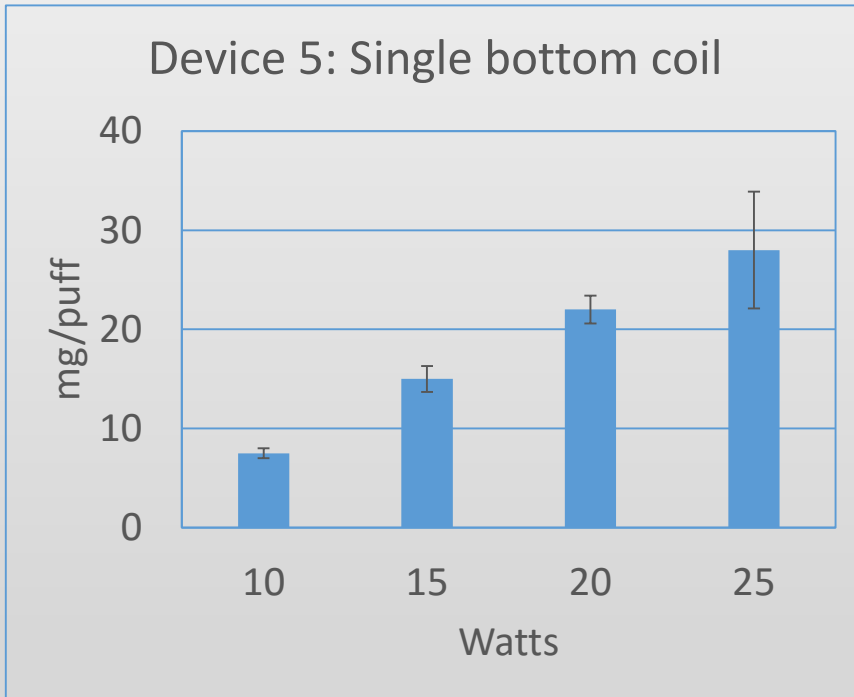
Yield Versus Power



Yield Versus Power

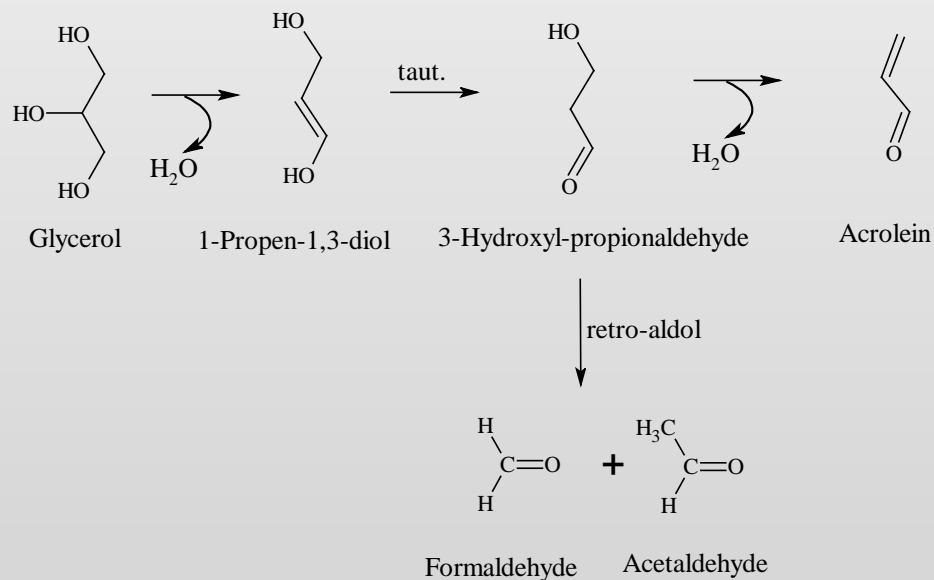


Yield Versus Power



Formation of Decomposition Products

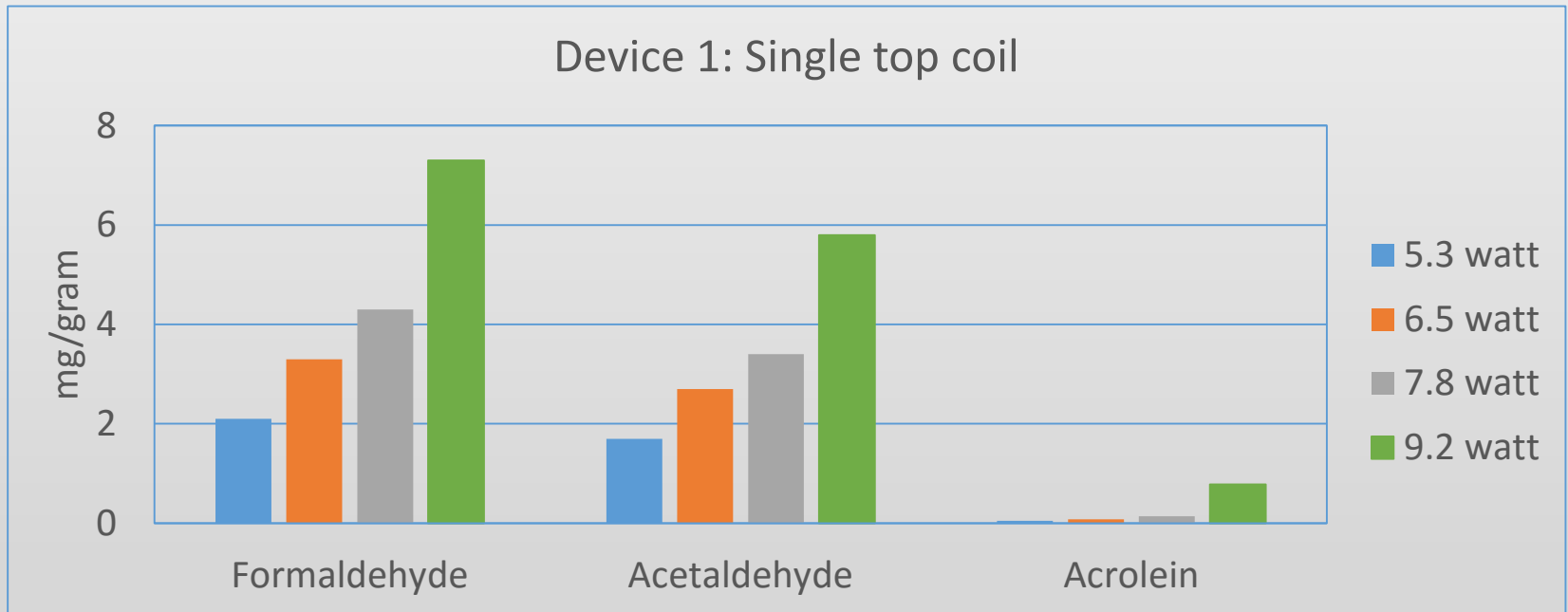
Heating of propylene glycol and glycerol may produce thermal decomposition products



Aldehydes in Aerosol

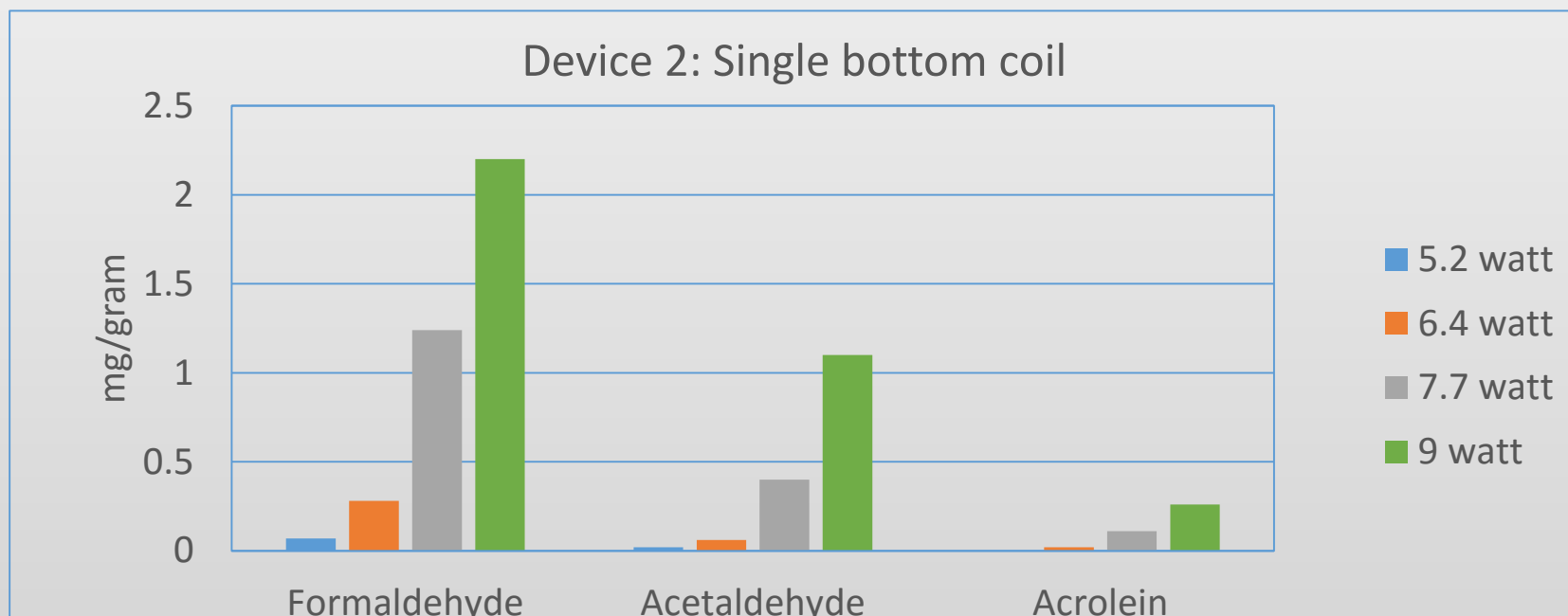
- Aerosol samples were collected in DNPH trapping solution and analyzed for DHPH-aldehyde adducts.
- Acidic DNPH reacts with both free and hydrated forms of aldehydes.
- Results of formaldehyde, acetaldehyde and acrolein are presented corrected for the total amount of aerosol produced (mg/gram).

Aldehydes in Aerosol

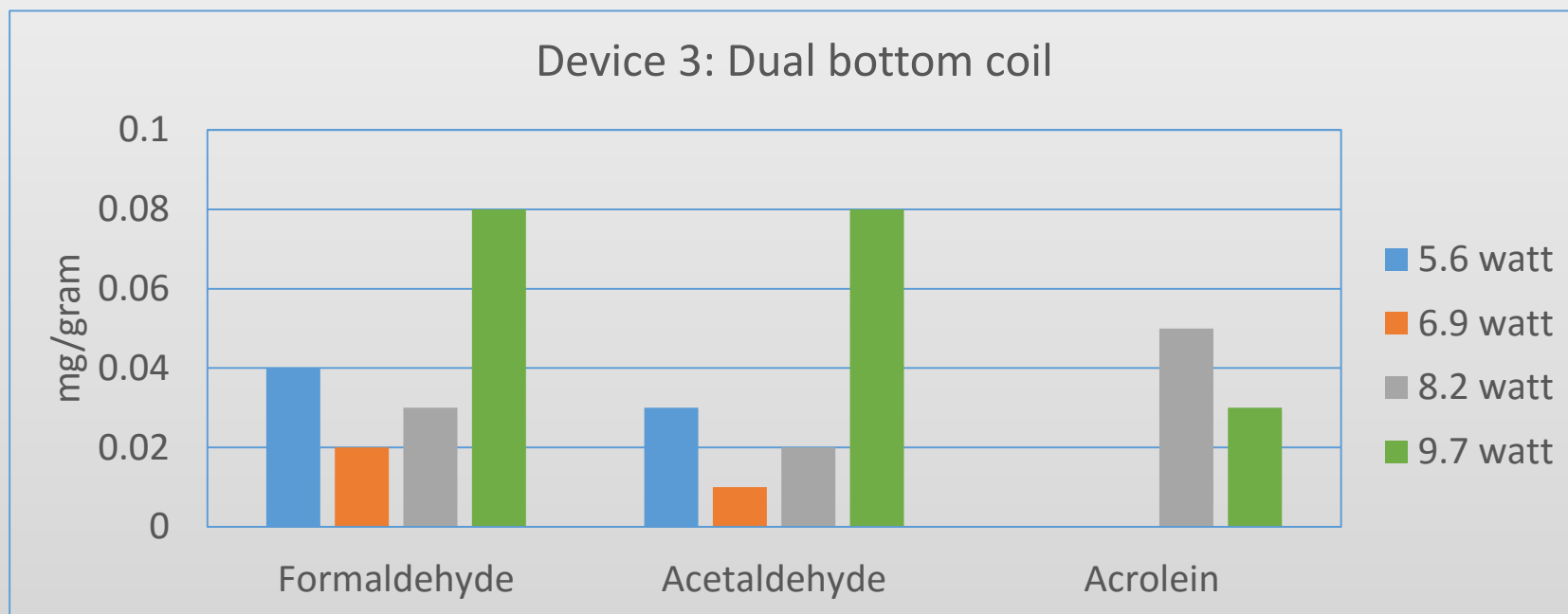


The highest power level tested may have exceeded the wicking rate, leading to coil overheating

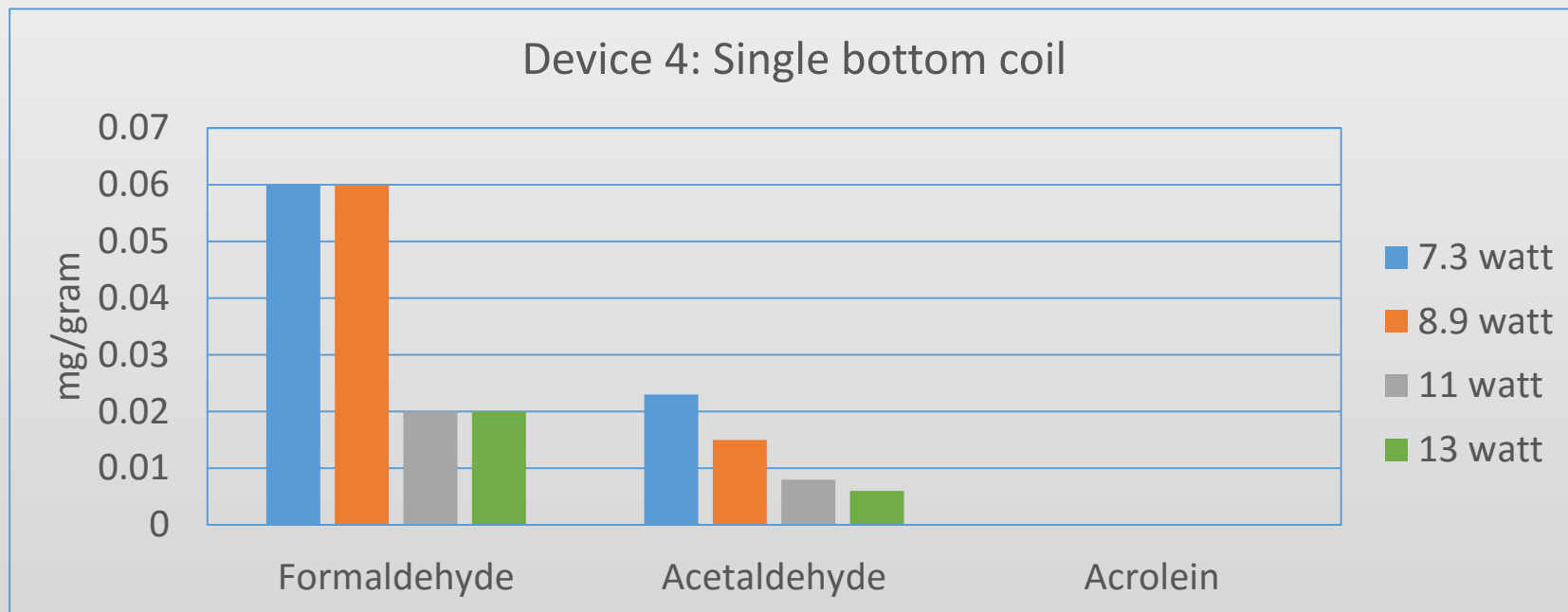
Aldehydes in Aerosol



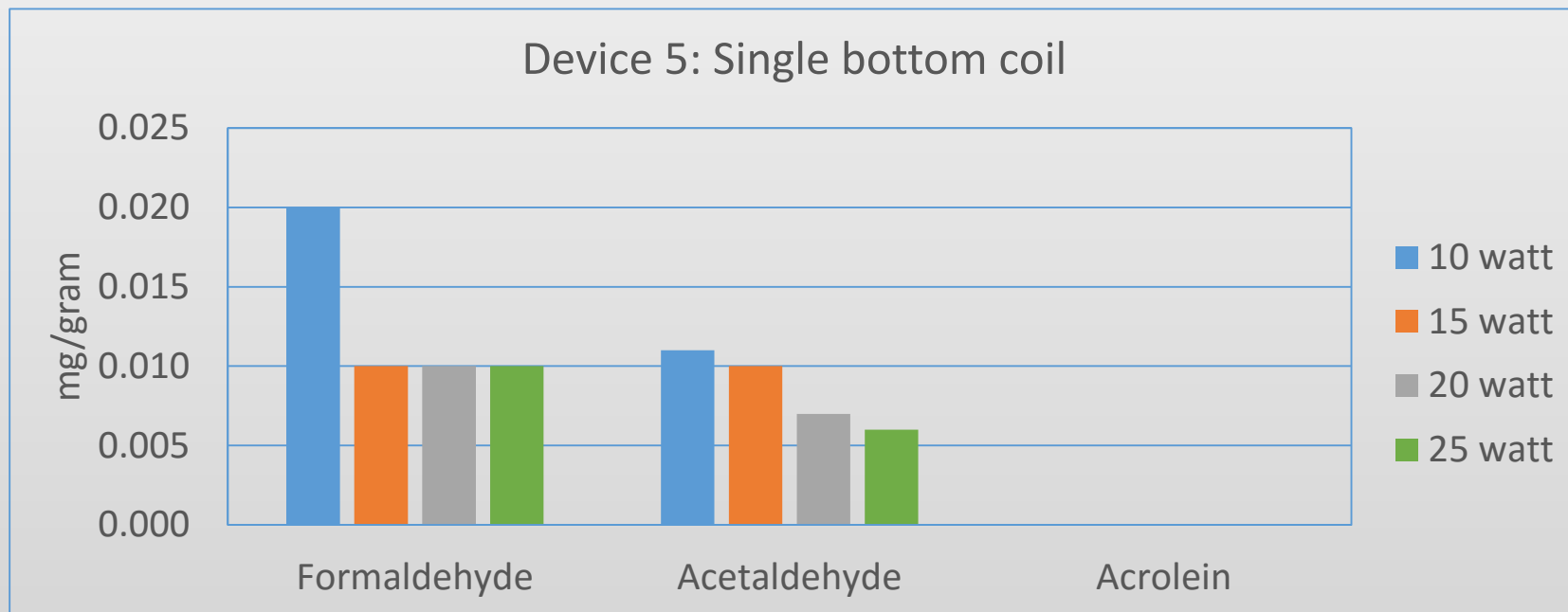
Aldehydes in Aerosol



Aldehydes in Aerosol



Aldehydes in Aerosol



Estimated Daily Exposure to Aldehydes

- Results from the aldehyde measurements were used to estimate daily exposure to the user.
- Results on a per gram basis were converted to a per day basis assuming the use of ~3 ml of liquid per day.
- Aldehyde results varied by coil tested and the data presented represent the average of three unique coils tested.

Farsalinos, K., Romagna, G., Tsiapras, D., Kyrzopoulos, S., Voudris, V., 2014. Characteristics, Perceived Side Effects and Benefits of Electronic Cigarette Use: A Worldwide Survey of More than 19,000 Consumers. *International Journal of Environmental Research and Public Health*. 11, 4356-4373.

Estimated Daily Exposure to Aldehydes

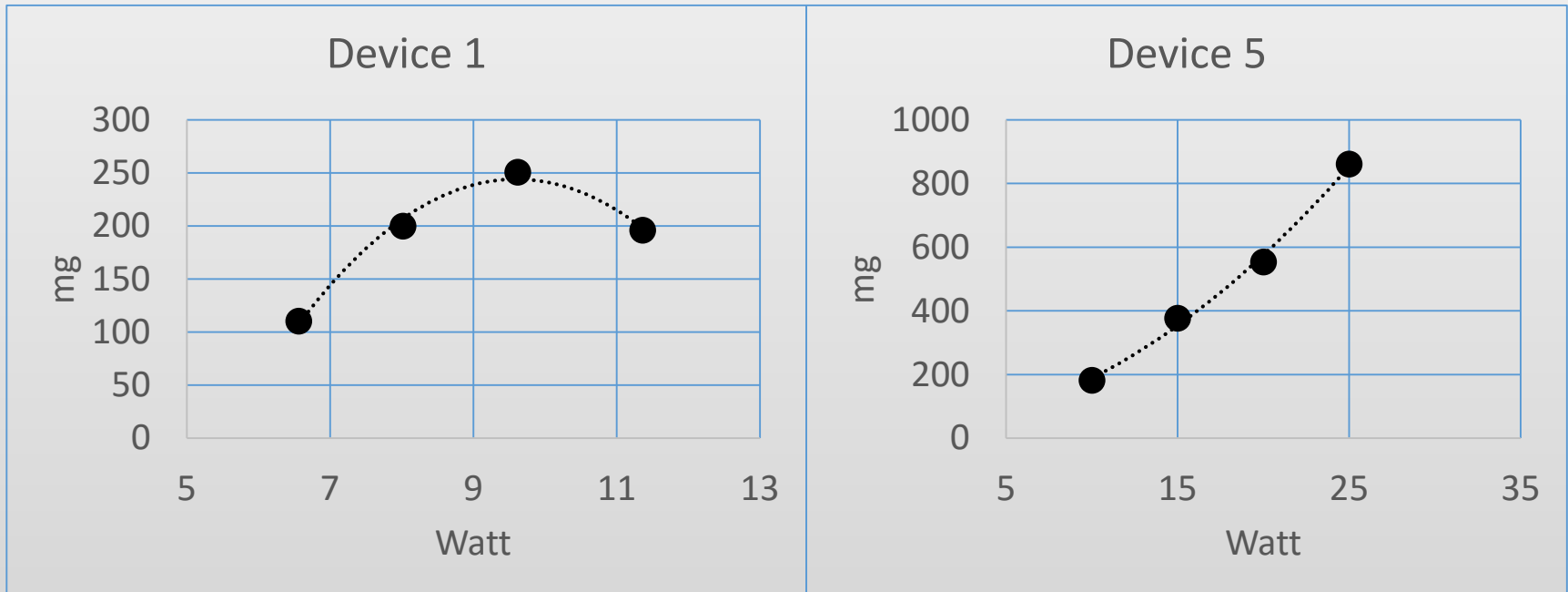
Device 1: Single top coil					
	Power	Form	Acet	Acrol	Total
	Watts	mg per day	mg per day	mg per day	mg per day
Average	5.3	6.2	5.0	0.2	11
SD	1.0	6.7	5.6	0.2	9
Average	6.5	10	8.0	0.2	18
SD	1.3	8.1	7.1	0.3	11
Average	7.8	13	10	0.4	23
SD	1.5	6.0	5.1	0.2	8
Average	9.2	22	17	2.3	41
SD	1.8	14	11	3.8	18

The highest power level tested may have exceeded the wicking rate, leading to coil overheating

Estimated Daily Exposure to Aldehydes

Device 5: Single bottom coil					
	Power	Form	Acet	Acrol	Total
	Watts	mg per day	mg per day	mg per day	mg per day
Average	10	0.05	0.03	<0.009	0.09
SD	NA	0.03	0.03	NA	0.04
Average	15	0.04	0.03	<0.003	0.08
SD	NA	0.01	0.01	NA	0.02
Average	20	0.04	0.02	<0.003	0.07
SD	NA	0.01	0.01	NA	0.01
Average	25	0.04	0.02	<0.003	0.06
SD	NA	0.009	0.01	NA	0.01

Yield Profiles



Summary of Results

- The devices tested produced from 38 mg to over 692 mg of aerosol in 25 puffs or 1.5 to 28 mg/puff.
- The mass of aerosol produced per puff/watt ranged from 0.27 to 1.1 (mg /puff)/(watt).
- The mass of formaldehyde, acetaldehyde, and acrolein produced per gram of total aerosol produced ranged from 0.01 to 7.3 mg/g, 0.006 to 5.8 mg/g, and <0.002 to 0.78 mg/g, respectively.

Conclusion

- Reporting power applied to the coil in watts instead of volts corrects for differences in coil resistance.
- Reporting aerosol mass results in $(\text{mg/puff})/(\text{watt})$ allows for direct comparison of aerosol formation efficiency.
- Evaluation of yield versus profiles may be useful to understand coil wicking and maximum aerosol production rates.