Waterpipe bowls and heaters: Does the ISO standard reflect what is available to consumers of waterpipe tobacco?

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Bowls and heaters – 1

- The most important thing when study bowls and heaters is to use a variety of waterpipe products in the studies
  - Blend
    - Flue-cured (FC)
    - Dark air-cured (DAC)/Burley (BUR)
  - Cut/particle size distribution (PSD)/amount and size of stem
  - Amount of glycerol (VG) versus amount and type of sugars
    - VG/sugar ratio – important as VG is primary contributor to aerosol
    - HFCS versus other sugar syrups and in situ inversion of cane sugar
  - Highly volatile flavors versus relatively nonvolatile flavors
- View that all waterpipe tobaccos are the same is incorrect
- Thus, products used in bowl and heater studies need to be well-characterized before use

Bowls and heaters – 2

- The waterpipe bowl and heater specified in ISO 22486: 2019 are not typical of those available for consumer use
  - The bowl (combination of waterpipe tobacco holder and head) is best simulated by the retail Egyptian-style bowls
    - However, these bowls are not recommended by many retailers
    - In particular, waterpipe tobaccos made from DAC tobaccos have particle sizes under 5 mm and more fluid mixtures of VG and sugars than do FC, and fluid and tobacco are lost through the holes in such bowls
  - Retail electric heaters for waterpipe tobacco bowls are not readily available in USA and possibly other countries
    - Most easily available is the large size Hady E-Shisha Smokepan
      - Heater needs to be removed from bowl before it can be used with other bowls
      - Heater is ventilated and simulates sample temperature rise with each puff
      - Requires regulated power supply with digital readout for research work

Phunnel bowls

- Phunnel bowls do not allow mechanical loss of sample due to small particle size and/or fluids
  - Original design by the late Eric Hofmann of Tangiers
  - Come in various sizes but principle of operation is the same
  - Heated air flows over the tobacco and then goes down a central passage known as the spire; it is higher than the tobacco bed
    - The height of the tower versus depth of bowl depends on design
    - Some designs have air flow passages at the top of the spire
  - Phunnel bowls are recommended by most in the waterpipe tobacco user and retail communities over other bowls
- The questions to be answered are
  - Which phunnel bowl is appropriate for small (10 g) samples
  - What heating conditions should be used

Ceramic phunnel bowls

Vapor Hookahs Utopia Bowl
2.81” outer diameter
2.50” inner diameter
0.50” depth
0.33” spire height
171 g weight

Tangiers Small Phunnel Bowl
2.60” outer diameter
2.25” inner diameter
0.50” depth
0.33” spire height
175 g weight

Vapor Hookahs Messiah Bowl
3.38” outer diameter
2.63” inner diameter
0.50” depth
0.25” spire height
215 g weight

Phunnel bowls with modified Hady heater

Tangiers Small

Vapor Hookahs Utopia

Vapor Hookahs Utopia

Experimental – 1

- Waterpipe tobacco
  - Al Fakher Two Apples Flavor, Manufactured 8/2020, Batch ID A1F26218192220
- Heater assemblies
  - Taken from Hady Large E-Shisha Smokepans (Model RYE06TL)
    - Contain metal ceramic heater (MCH), resistance 2.5 Ω at RT
    - Power supply that comes with Hady device rated at 13.5 volts
    - Hinge pin removed to separate heater from smokepan (bowl)
    - Hinge and other projection on heater housing removed so it would lay flat on the pre-punched aluminum foil covering bowl
    - Power supplies replaced with Hanmetek HM305 regulated DC power supplies with voltages set between 10. 5 and 14 volts depending on bowl and waterpipe tobacco being evaluated
    - Bowls fitted with Type K thermocouple to monitor tobacco temperature

Experimental – 2

- Preparation of bowls for emissions testing
  - Drill a 1/16" hole in the bottom of each bowl were the curved section starts upwards
  - Insert a REED Instruments TP-01 Beaded Thermocouple Wire Probe, Type K or similar sensor through the hole
  - Weigh out 10 g of waterpipe tobacco and carefully place in bowl ensuring the tip of thermocouple is covered with tobacco
  - Cover the bowl 5.5" diameter pre-punched aluminum foil, center the pre-punched area over the top of the bowl and fold foil under bowl to provide a tight, solid surface for the heater
- Preparation of Mya QT waterpipe for emissions testing
  - Fill base with 0.5 L commercial spring water
  - Affix bowl and outlet tube to glass mouth
  - Connect thermocouple to Lascar EL-GFX-TC data logger

Experimental – 3

- Preparation of glassmouth for emissions testing
  - Connect front opening of glassmouth to tube running from waterpipe
  - Connect tube from puffing machine to tube connection at bottom of throat of glassmouth
  - Add 10 mL HPLC water to bottom of glassmouth
- Preparation of modified Hady heater for emissions testing
  - Connect power cord for heater to output terminals of Hanmetek HM 305 digital power supply and set output to 11 or 14 volts
  - Place heater upside down on CorningWare (or similar) plate, connect to power supply and wait until voltage stabilizes
- HI 1413 pH electrode is prepared by inserting it through #5 one-hole rubber stopper and placing in pH 6 buffer

Experimental – 4

- Other instrumental details
  - The HI 1413 electrode is connected to a Hach H250G pH meter and data are recorded with Hach SmartLogger II software
  - Data from EL-GFX-TC goes to PC with EasyLog software to generate temperature versus time plots
  - Puff duration is controlled by BK Precision 1688B switching mode power supply that powers a STC solenoid valve set for a 3 s on-time every 20 s through pscs pc-based software
  - Flow rate is controlled by Litorange 1/4” needle valve and estimated using a Supelco 2-0427 Manual Bubble Flowmeter
  - Timings of some parts of the experimental work are critical and are shown next

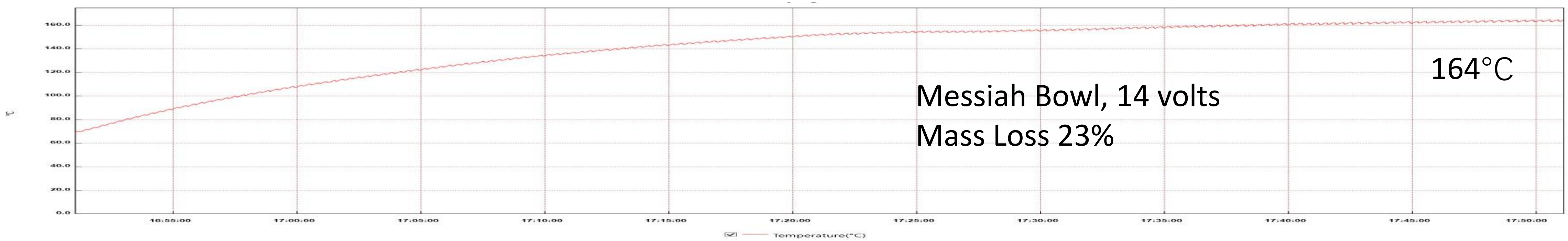
Suggested timings

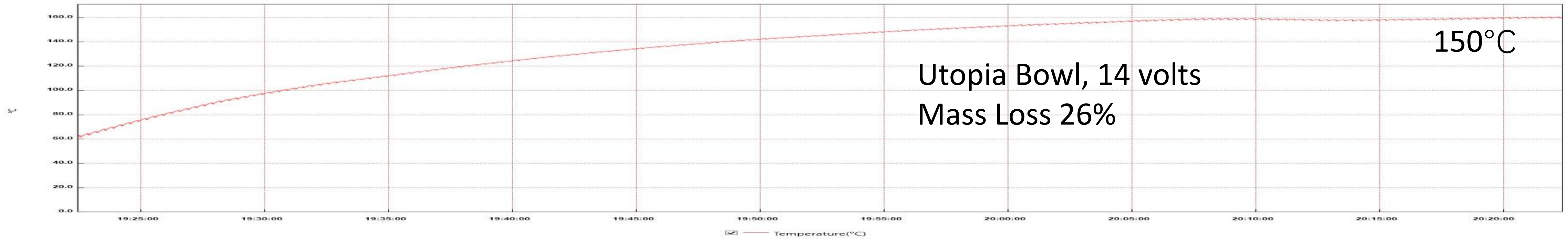
Time prior to run	Task
3 days	Empty each 200 g or 250 g package into separate 1 pint wide-mouth screwcap jars and turn over at least twice daily to thoroughly mix contents
4 hours	Turn on puffing system and PC; make sure required software is loaded and check operation of system including operation of solenoid valve, flow rate through system, with waterpipe and glassmouth with pH electrode in place
1 hour	Put fresh water in base of waterpipe, make sure programs for puffing control , recording of pH data, and collection of thermocouple data are ready to run; ensure that power supply for bowl heater is on, set to correct voltage, and bowl heater is working
30 minutes	Calibrate pH meter, weigh out waterpipe tobacco, transfer to bowl, insert thermocouple in bowl, and cover bowl with pre-punched foil
10 minutes	Add 10 mL HPLC water to glassmouth, turn on bowl heater
5 minutes	Place bowl heater on top of bowl, start 5-minute timer
1 minute	Place pH probe into glassmouth, arm EL-GFX-TC thermocouple recorder
0 minute	Start pscs, SmartLogger II software and start EL-GFX-TC record=ing
60 minutes after	Stop all data acquisition. Remove water from glassmouth and wash with 12 mL MeOH and remove

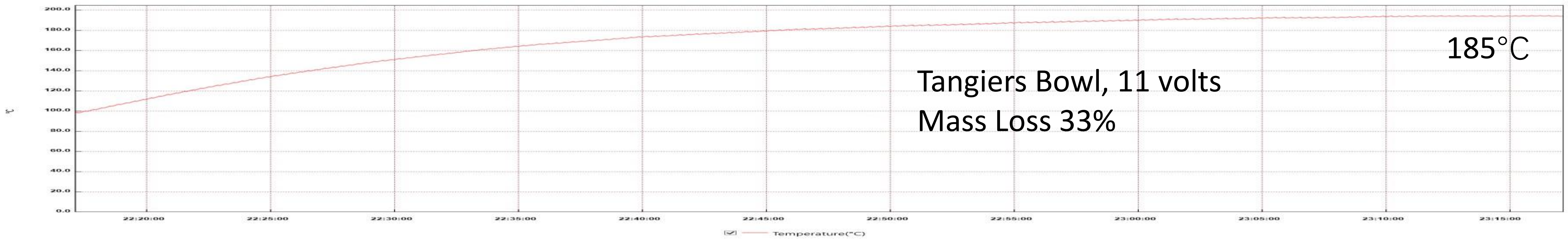
Summary of results

Sample	Bowl	Voltage (DC)	Final Temperature (°C)	Mass Loss (%)
Al Fakher Two Apples	Messiah	14	164	23
Al Fakher Two Apples	Utopia	14	150	26
Al Fakher Two Apples	Tangiers	11	185	33
Azure Black Matcha Mint	Utopia	14	150	30

Temperature-time graphs







Summary and next steps

- Our results both in terms of waterpipe tobacco consum-ption and maximum waterpipe tobacco temperature are approaching those reported for charcoal-heated systems using a similar waterpipe tobacco
- While there have apparently been no reports of waterpipe tobacco consumption and temperature for dark air-cured products such as the Azure Black Matcha Mint, our results indicate that the use of the Utopia bowl and modified Hady heater is heading in the right direction
- A heater with a diameter that matches the Utopia bowl is being developed as it may yield results equivalent results that are equivalent to those obtained with charcoal