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A Universal Smoking Machine Adaptor for Emissions Testing with Smoking/Vaping Machines: Development, Validation, and Benchmarking

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BACKGROUND

- Commercial availability of equipment for emissions testing of newer tobacco products is lagging behind product innovation, despite popular use of these products
- The adaptor that joins the tobacco product's mouthpiece to the emissions testing machine must form a leak-free seal with the tobacco product
- Existing vaping/smoking machine equipment is designed to work with single-geometry adaptors that hold tobacco products with cylindrical mouthpieces
- Very few product-specific adaptors designed to hold non-cylindrical mouthpieces are available
- A universal smoking machine adaptor (USMA) that forms a leak-tight seal with e-cigarettes, cigars, cigarillos, heated tobacco products and cigarettes is needed.

Study Aims

- Fabricate a USMA that can accommodate emissions testing of as many tobacco product geometries and weights as possible
- Benchmark its performance with tobacco products popularly used in the US
- Compare the USMA's performance to other smoking/vaping machine adaptors

What are the benefits of a USMA?

- Seals with light and heavier products that have rigid and compressible mouth ends of different geometries
- Improves the accuracy and precision of non-clinical emissions data
- Allows better determination of reproducibility of non-clinical emissions data generated by all stakeholders

What are the requirements?

- Works with existing vaping and smoking machines
- Uses industry-standard materials (ultra-high molecular weight polyethylene) wherever possible
- Seals with products that have rigid and compressible mouth ends
- Must be commercially available to all stakeholders including the tobacco industry, regulatory agencies, and public health researchers

METHODS

- Phase 1: Develop and test prototypes until vacuum tests and puffing flow rate envelopes indicate leak-tight seal; graduate successful prototype to Phase 2
- Conduct emissions testing on popular US commercial and reference products (n=10 replicates per product) with Phase 2 prototype
 - E-Cigarettes (n=7 brands, n=1 reference product)
 - Cigars (n=2 commercial, n=1 reference product)
 - Cigarillos (n=2 commercial, n=1 reference product)
 - Heated tobacco product (n=1 commercial)
 - Cigarette (n=1 certified reference product)
- Compare emissions generated with USMA to those generated with other available adaptors
- Study outcomes
 - Mainstream Total Aerosol Matter/Total Particulate Matter (TAM/TPM)
 - Mainstream nicotine
 - Product consumption
 - Number of puffs (combustible only)



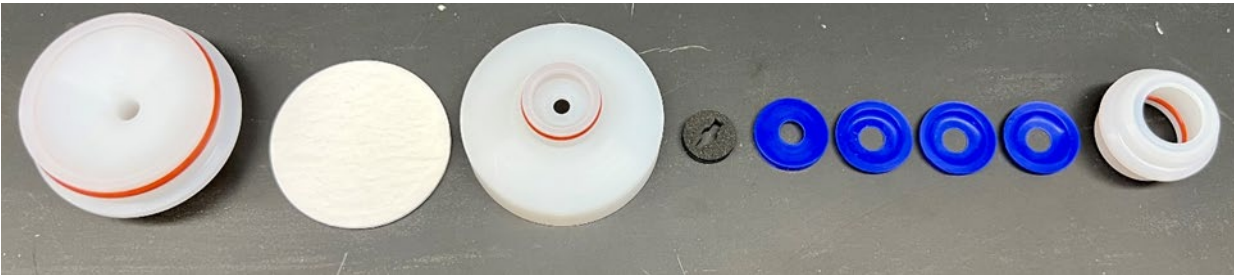
USMA



CDCA



CCA



STD

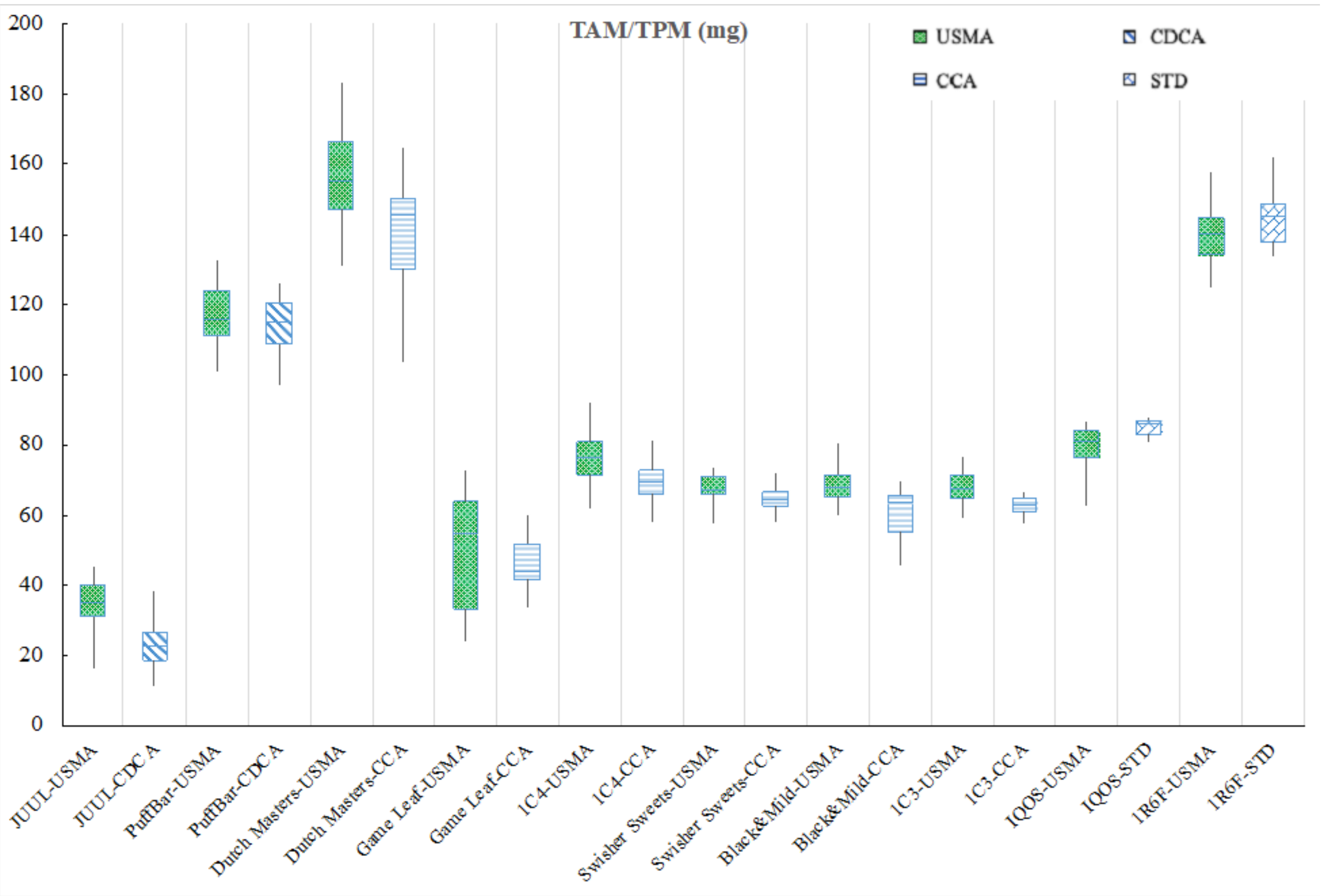
The USMA interfaces with the existing cigarette (44 mm) and cigar (55 mm) filter holders and can be used to test e-cigarettes, cigars, cigarillos, heated tobacco products and cigarettes; the CDC adaptor (CDCA) is used for testing JUUL and PuffBar e-cigarettes; the Cerulean Cigar Adaptor (CCA) is used for testing cigars, and the standard cigarette adaptor (STD) is used for testing cigarettes.

RESULTS

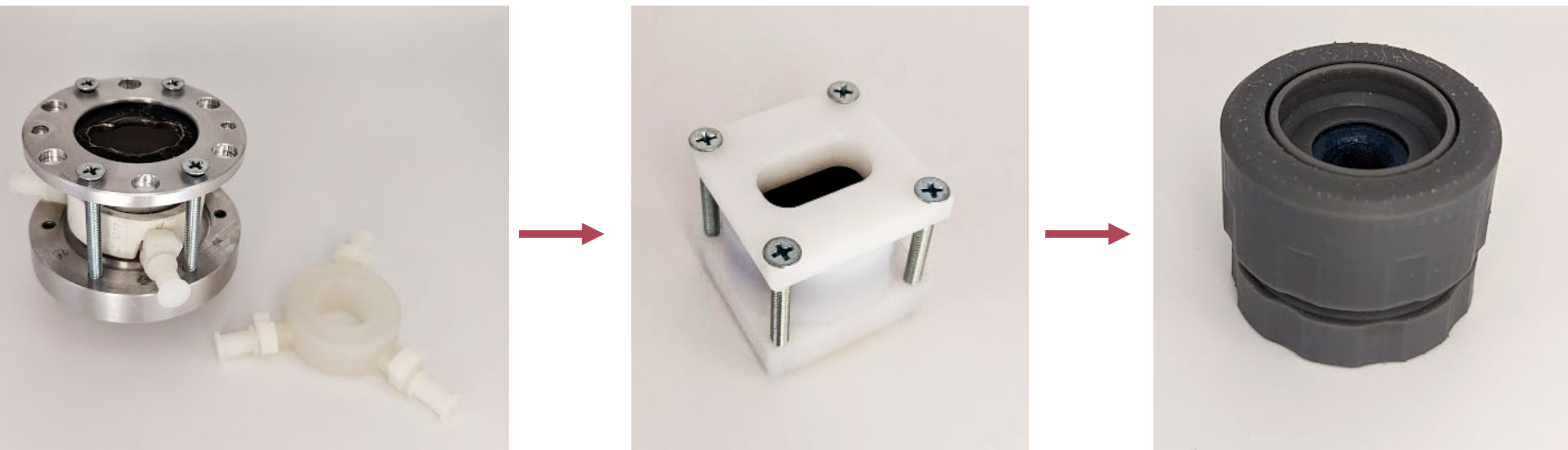
Table 1. Comparison of TPM and nicotine emissions for the Universal Smoking Machine Adaptor (USMA) and the Cerulean standard adaptor (STD) to the certified reference values for the reference cigarette (1R6F).

Analysis	1R6F		USMA		STD	
	Mean, mg/rod	Certified Uncertainty	Mean, mg/rod	Error, %	Mean, mg/rod	Error, %
TPM	46.8	3.5	46.77	-0.001	48.31	3.2
Nicotine	1.90	0.13	1.98	4.2	2.17	14.2

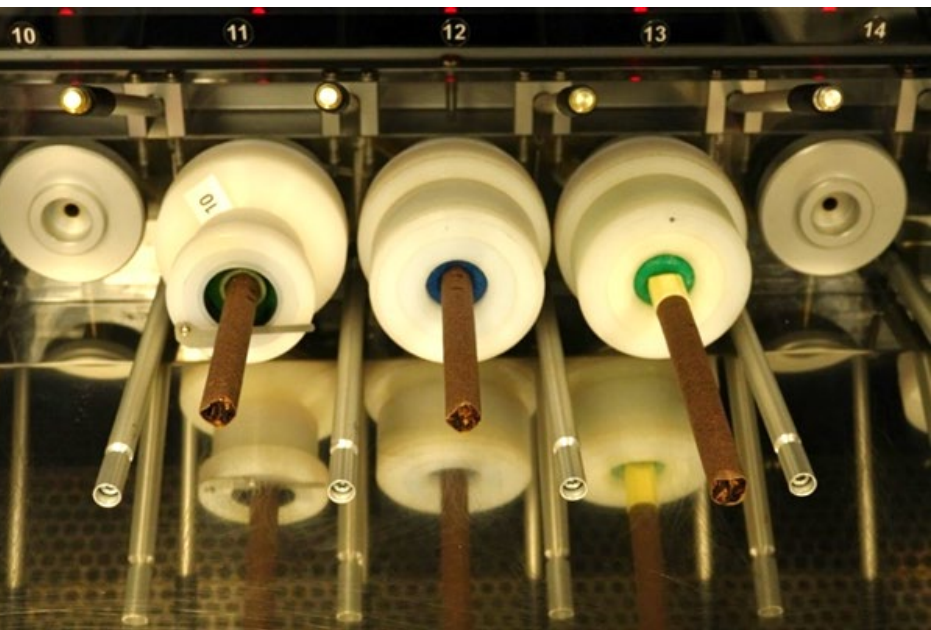
Figure 1. Box plot comparison of the average collected total aerosol matter (TAM) from e-cigarettes and total particulate matter (TPM) from cigars, cigarillos, IQOS, and 1R6F reference cigarette generated using the universal smoking machine adaptor (USMA), CDC adaptor (CDCA), Cerulean Cigar Adaptor (CCA), and Cerulean standard cigarette adaptor (STD).



- TPM and nicotine in mainstream emissions generated with the USMA agree well with the certified values for a reference cigarette.
- The USMA forms a leak-tight seal with all of the product types/brands tested
- The inert materials that the USMA is constructed from do not scavenge mainstream TAM/TPM or nicotine, nor do they increase mainstream TAM/TPM or nicotine emissions, i.e., cause contamination
- Variability within product type/brand tested with the USMA meets or is smaller than variability measured for comparison adaptors



Evolution of the Universal Smoking Machine Adaptor prototype: first prototype included costly-to-fabricate air-filled ferrule (left), second prototype included an easier-to-fabricate air-filled ferrule (middle), ergonomically optimized prototype (3D printed for evaluation, final will be made of industry-standard materials) slated for Phase 3 testing (right).



To form a leak-tight seal, the tip of plastic-tipped cigarillos must be removed to conduct emissions testing using the Cerulean Cigar Adaptor (CCA, left); the USMA can test the cigar with the tip removed (middle) and left intact (right).

CONCLUSIONS

- The USMA seals well with a variety of e-cigarette, cigar, cigarillo (tipped and untipped), cigarette, and heated tobacco products.
- Variability among replicates for all study outcomes was similar or smaller when machine smoking/vaping with the USMA vs other adaptors.
- Precision and accuracy when testing a certified reference cigarette with the USMA was excellent
- The USMA can test a greater variety of products, is more user friendly, and in some instances has fewer parts and is similar or easier to assemble/disassemble than existing commercial adaptors.

RELEVANCE to CTP REGULATORY AUTHORITIES

- A prototype USMA was fabricated and benchmarked for two mainstream semivolatile constituents
- Next steps include ergonomic optimization, quantification and characterization of target semivolatile, and volatile constituents, and commercialization of the USMA.

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Commercial products tested using the USMA had a variety of mouthpiece geometries, product stiffness, and mass; brands included (left, L to R) JUUL tobacco, PuffBar tobacco, PuffPlus Mango, NJOY tobacco, Vuse tobacco, BidiStick tobacco and mango, Reflex unflavored, (above left, L to R) Dutch Masters President cigar, Swisher Sweets untipped cigarillo, Game Leaf Garcia Y Vega cigar, Black and Mild plastic tipped cigarillo, and (above right) IQOS heated tobacco product (note: products are not to scale).

