Analysis of Per- and Polyfluoroalkyl Substances in Commercial Pans using Liquid Chromatography-Ion Mobility Spectrometry-Mass Spectrometry

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BACKGROUND INFORMATION

- Non-stick cookware is commonly coated with PFAs such as PFOA and PTFE
- Negligible amounts of PFAS can contaminate foods by migration with/without high temperature.

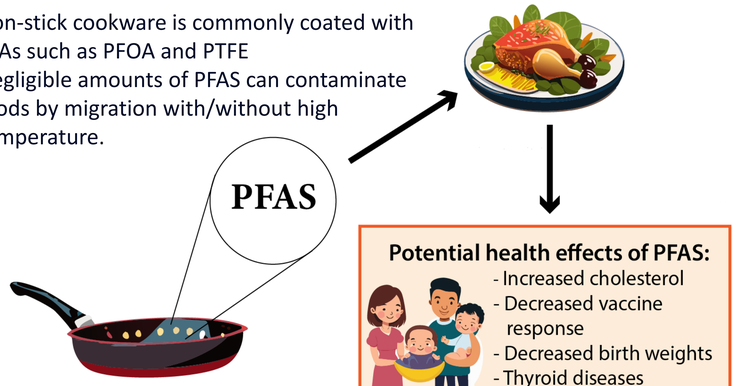

Figure 1. PFAS coatings in cookware and their potential health effects.

WORKFLOW

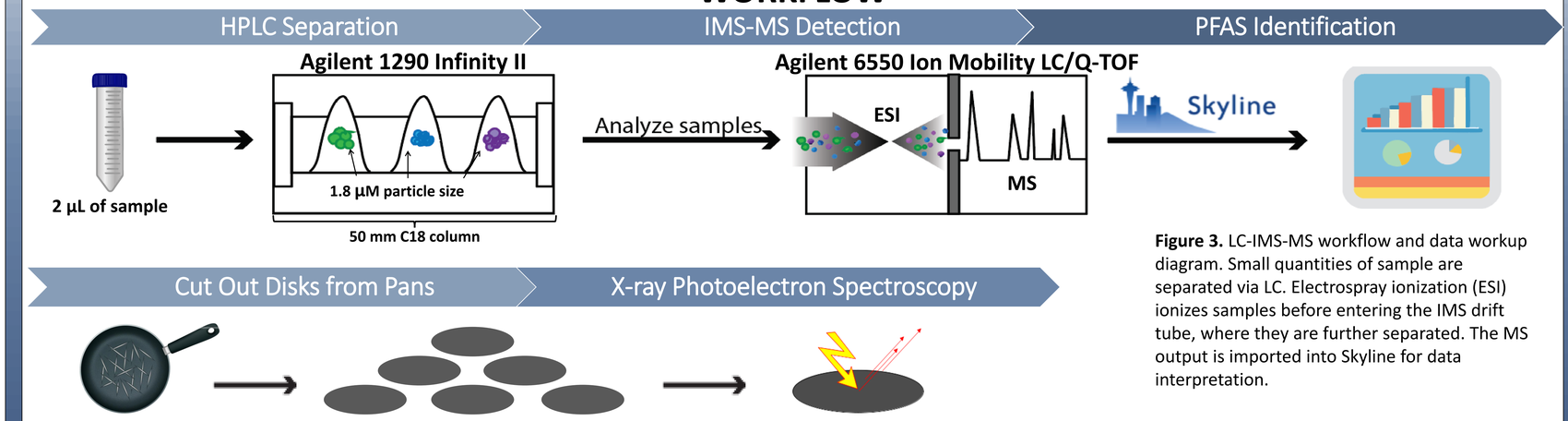

Figure 3. LC-IMS-MS workflow and data workup diagram. Small quantities of sample are separated via LC. Electrospray ionization (ESI) ionizes samples before entering the IMS drift tube, where they are further separated. The MS output is imported into Skyline for data interpretation.

Figure 4. XPS flow diagram. Small disks, represented as gray circles. are removed from each pan and ran on the XPS machine. The yellow arrow is the X-ray, and the red arrows represent ejected electrons.

SAMPLE PREPARATION

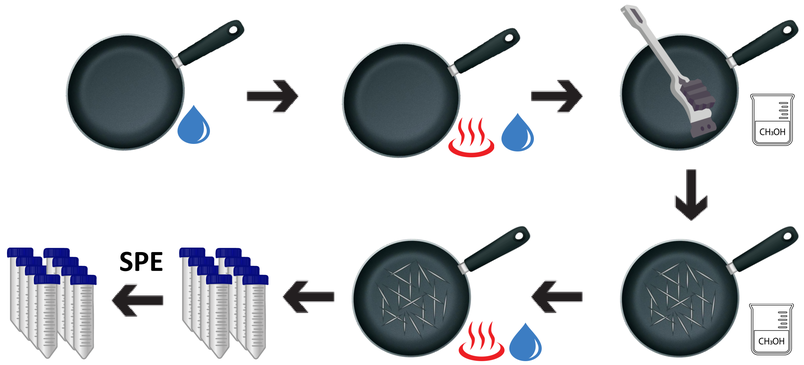

Figure 2. Sample collection flow diagram. Each pan represents a different step of sample collection (pre-heat, pre-scratched water, coating, post-scratch methanol, and post-scratched water in order).

Table 1. Summary of Study Pans and Their PFAS-Related Listing Details

No.	Pan Type	Details
1	Ceramic 10"	PFAS, PFOS, PFOA free
2	PTFE 8"	PFOA & toxin free
3	Swiss Granite 8"	PFOA, PFOS, PTFE free
4	Stone Earth 10"	No GenX, PFBS, PFOS, PFOA
5	Cast Iron 10"	PFAS & PFOA free
6	PTFE 8"	PFOA & toxin free
7	PTFE 8"	PFOA & toxin free*

*24 hours tested

RESULTS

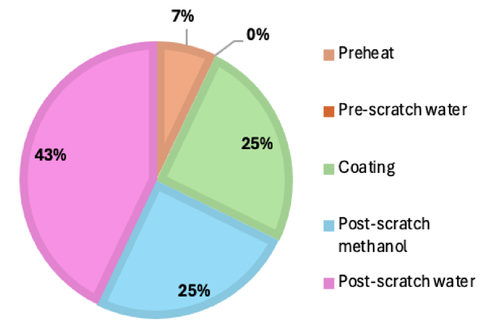

Figure 5. Percentage of PFAS detected among all samples at each stage of sample preparation. The highest percentage of PFAS detected was found in the post-scratched water samples.

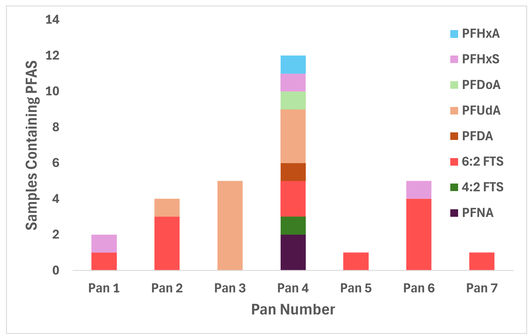

Figure 6. Stacked bar chart displaying the number of unique PFAS detected in each pan. Each color represents a unique type of PFAS detected.

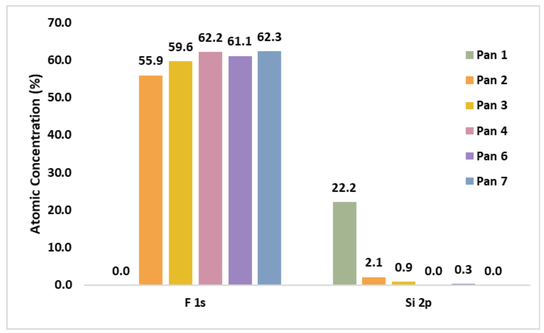

Figure 7. XPS analysis for each pan by atomic concentration.

CONCLUSION

- Wear and tear tended to release PFAS
- When a pan was advertised as free of a specific PFAS it was generally true
  - In particular no PFOA or PFOS were detected
  - Consistent with phase-out of PFOA and PFOS under 2009 Stockholm Convention
- Claims of "PFAS Free" were not always true
  - PFOA/PFOS avoided by changing chain length (e.g., PFHxS) or partial fluorination (e.g., 6:2 FTS)
  - Consistent with observed trends in population monitoring

OUTLOOK

- Quantification of detected PFAS via internal standard method
- Fluoropolymers are everywhere: Can this workflow be applied to other food contact appliances?
- Would a nonpolar solvent better simulate real food?

ACKNOWLEDGEMENT

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References:

Zheng, G.; et al. Per- and Polyfluoroalkyl Substances (PFAS) in Breast Milk: Concerning Trends for Current-Use PFAS. *Environmental Science & Technology* **2021**, *55* (11), 7510–7520. https://doi.org/10.1021/acs.est.0c06978.

MP: 5 mM ammonium acetate buffer + MeOH (10% → 100%)

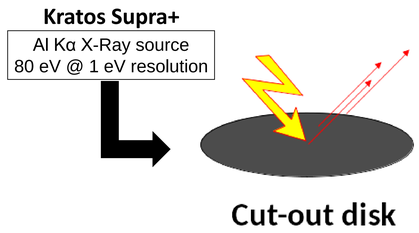
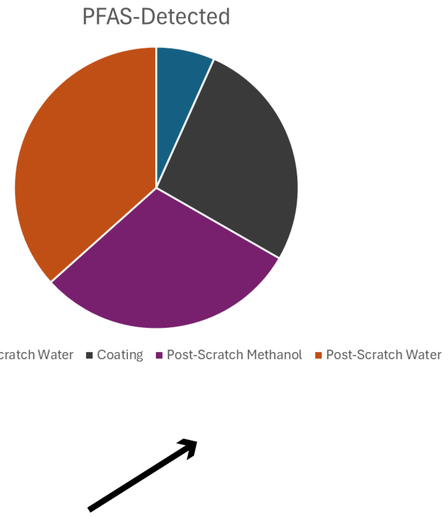
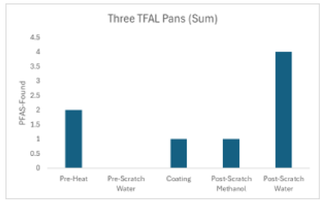
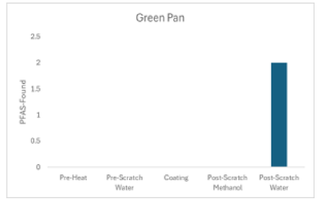
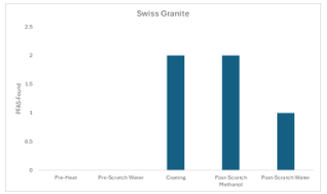


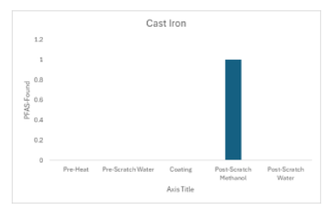
Figure 4. X-ray photoelectron spectroscopy (XPS) on circular disks taken from each pan. The yellow arrow is the incoming x-ray, and the red arrows are the ejected electrons.

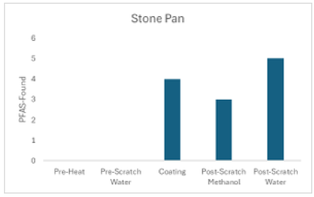












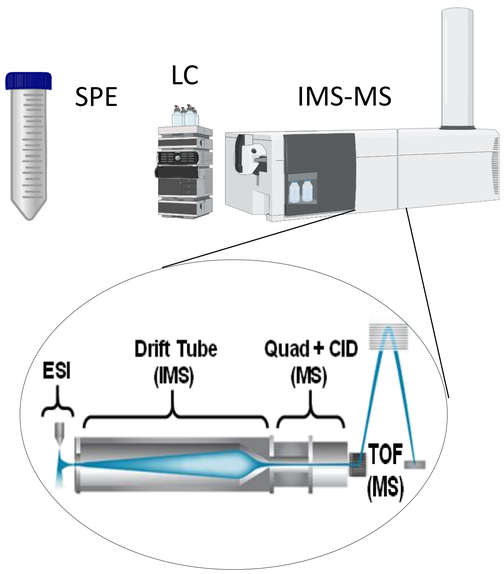


Figure 3. Sample analysis diagram. Solid phase extraction (SPE) purifies samples, which are analyzed via liquid chromatography-ion mobility spectrometry-mass spectrometry (LC-IMS-MS). A closeup of the IMS-MS structure is provided.

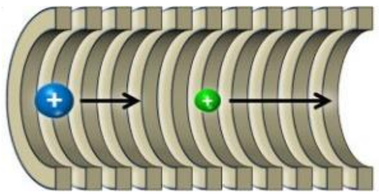
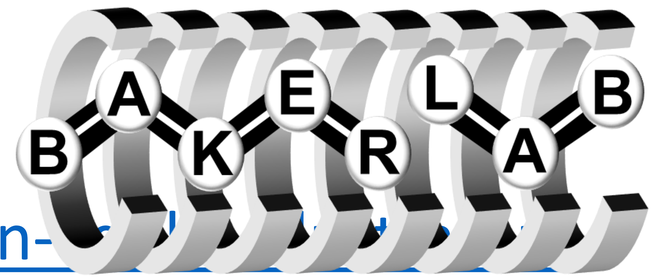


Figure 4. IMS drift tube diagram. Ions with a higher collisional cross section (CCS) travel slower under a constant electrical field.

references

Baker lab logo for use in acknowledgements only



- Pans in figure 2 --> online tutorial; https://vectorcove.com/frying-pan-in-
- All other figures under sample prep --> baker lab