

Understanding Ink Migration and Chemicals of Concern

Dr. Keith Vorst

Director

Phone: 805.305.7612

Email: kvorst@iastate.edu

IOWA STATE UNIVERSITY

Polymer and Food Protection Consortium

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Polymer and Food Protection Consortium

Funded Through Corporate
Membership *(25 companies)*

Fundamental Research & Development

Recycling and Recovery, Biobased Plastics, Shelf-life
Extension, Regulatory Compliance,

Next Generation of Technology
Development (AI sorting, End Markets)

Established in 2014 with Corporate
Engagement and Doctoral Students

- One of the largest dedicated packaging and recycling research consortiums in the US with 13 laboratory and material processing facilities
- Supported with dedicated staff, grad students, and undergraduates (23 employees)
- Greater than \$23 million in total funding since 2014
- Over 60 peer-reviewed publications
- 8 issued patents, 4 patents pending, 2 licenses
- Nationally and Globally Recognized (FDA, DOE, DOW, EPA, USDA, DRRR, Fraunhofer-Gesellschaft, ILSI)

The Polymer and Food Protection Consortium

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Polymer and Food
Protection Consortium



We ARE

- A staff dedicated research program
- Industry focused
- Linked with Iowa State University
- Privately funded
- Doctoral program ONLY

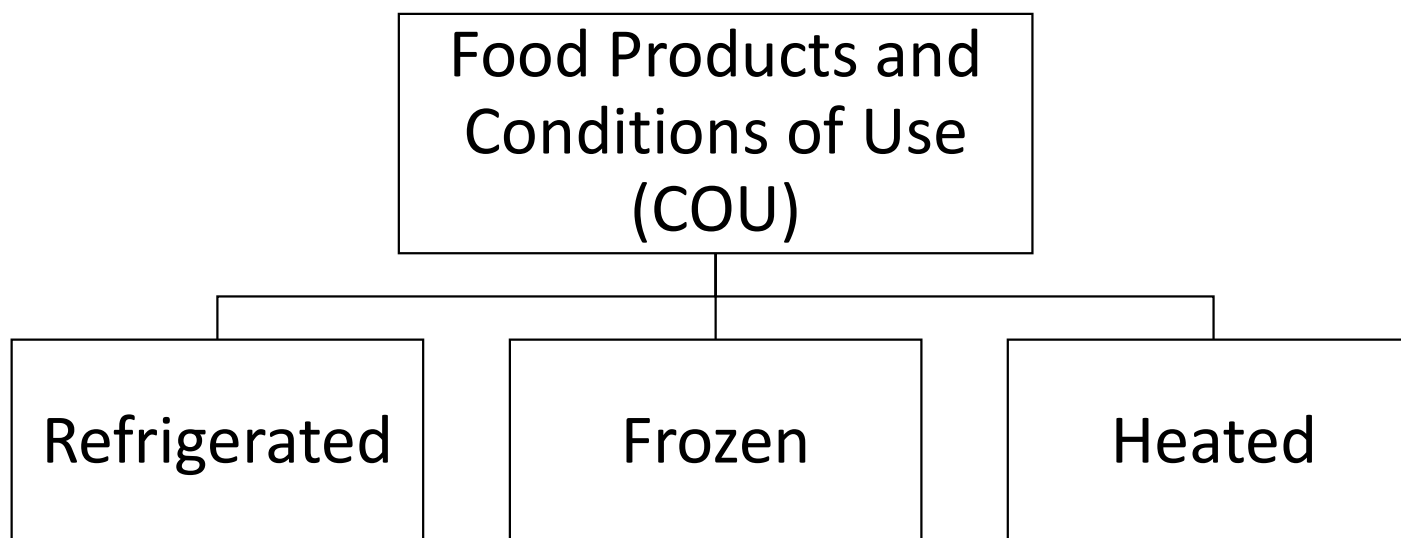
We are *not*

- An undergraduate education program
- A state or federally funded program

- **Our mission: To conduct industry relevant research and develop solutions focusing on design, safety, and function of materials for packaging and industrial applications.**

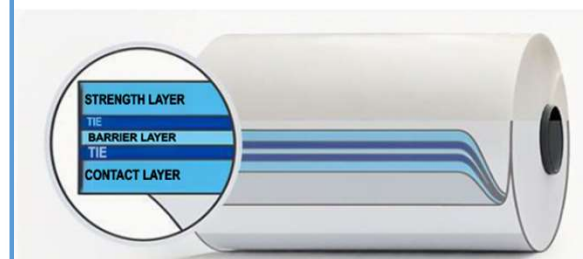
What Materials for Food Packaging?

- *What do you see in the display case?* *What is it?* *Why was it chosen?* *Is it safe?*



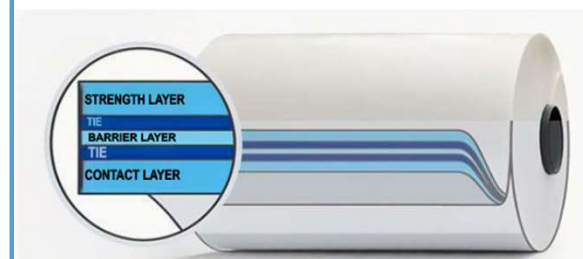
Take the PFAS Challenge

- 1) Given a multilayer structure with PFAS as part of the TIE or sealant layer to allow for adhesive flow, can PFAS migrate from the Non-Food Contact Layer to the Food Contact Layer and to the food
 - a) Yes
 - b) No
- 2) Is there a common Restricted Substance List (RSL) for PFAS in the U.S., Endocrine Modulating Chemicals, or Chemicals of Concern (CoC)
 - a) Yes, federal
 - b) Yes, state
 - c) No, varies by company
 - d) No, varies by state
- 3) The TLV for Total Fluorine (TF) in the United States is defined by
 - a) 100 ppm
 - b) 50 ppm
 - c) 250 ppb
 - d) Does not exist
- 4) What is the difference between Total Fluorine or Total Organic Fluorine (TOF)
 - a) Total Fluorine evaluates the total PFAS in a sample
 - b) Total Fluorine is the measure of Total Fluorine in the sample and Total Organic Fluorine measures the fluorine bound to organic compounds
 - c) Total Fluorine is the measure of Total Fluorine in the sample and Total Organic Fluorine is a measure of target PFAS in a compound
 - d) There is no difference between them, and both measure the fluorine content using a different method
- 5) Is there a rapid method for non-targeted PFAS
 - a) Yes, 6 hours
 - b) No, weeks
 - c) Yes, 30 minutes
 - d) There is no definition of rapid
- 6) Is there a rapid method for targeted PFAS
 - a) Yes, 6 hours
 - b) No, weeks
 - c) Yes, 1-2 hours
 - d) There is no definition of rapid



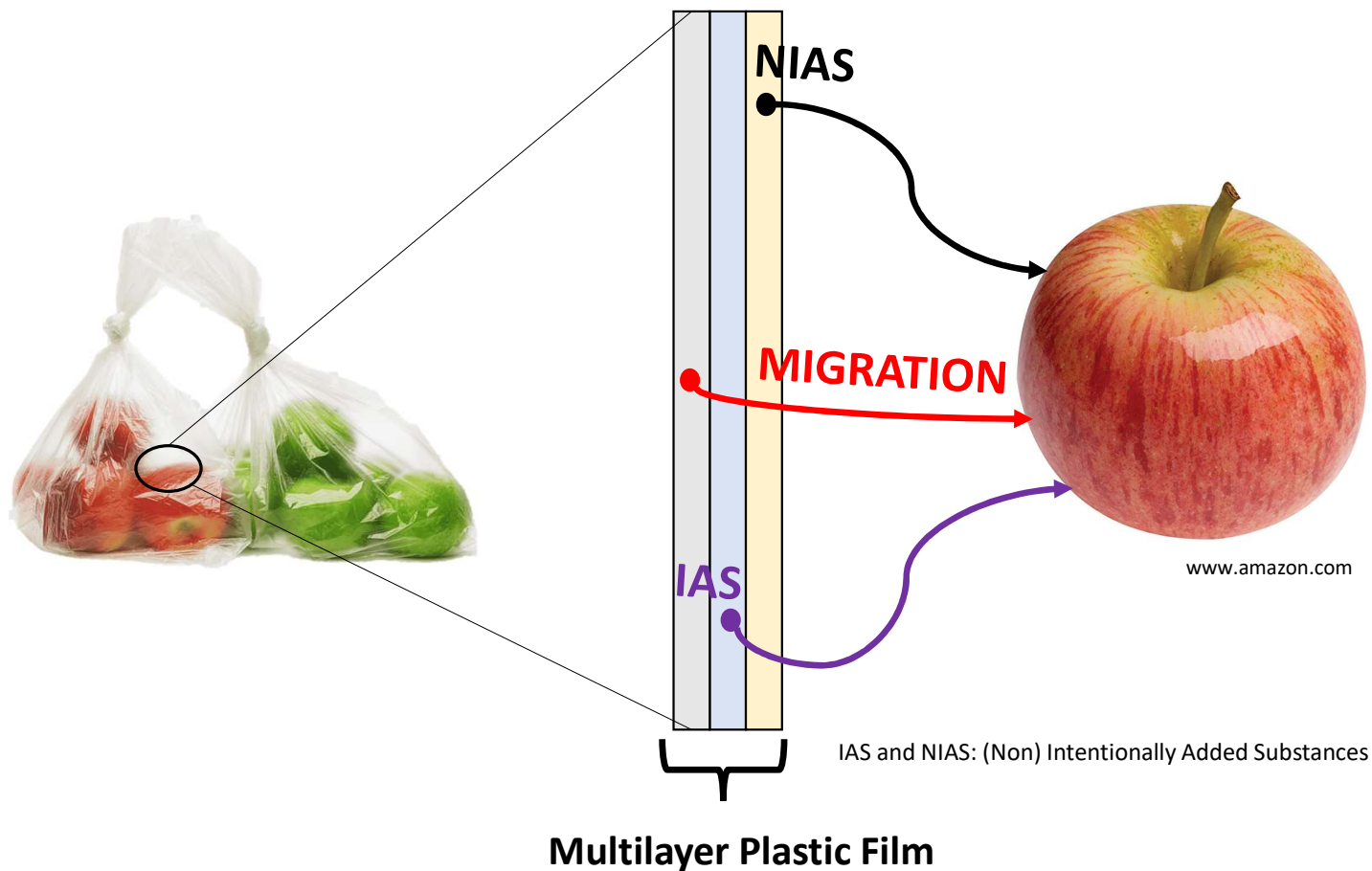
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How to
determine if
that package is
safe for food
contact?

Let's look at
film and
multilayer



Plastics/Paper and Additives

Process stabilizers/Aids (heat stabilizers, PPA, PFAS)

Environmental stabilizers (anti-oxidants, UV stabilizers)

Surface modifiers (slip agents, anti-static, anti-blocking)

Optical modifiers (pigments, nucleating agents, brighteners)

Functional additives (mechanical property enhancers)

Inks (decorating agents)

Adhesives (flow agents, sealants)



Different producers do not make the exact same polymer and laminate packaging

Case Study – It's just a WRAP?

- It's a just a WRAP?

- *A case study in packaging compliance and consumer perception*

Dangerous PFAS Chemicals Are in Your Food Packaging

CR found 'forever chemicals' in bowls, bags, plates, and wrappers, even from some companies that say they've phased them out



PHOTO: BEN GOLDSTEIN



Case Study – It's just a WRAP?

Problem Statement: Gum wrappers used by NewCo Bubble Gum Company received notice as part of a consumer advocacy group survey that wrappers contain significant levels of PFAS >100 ppm

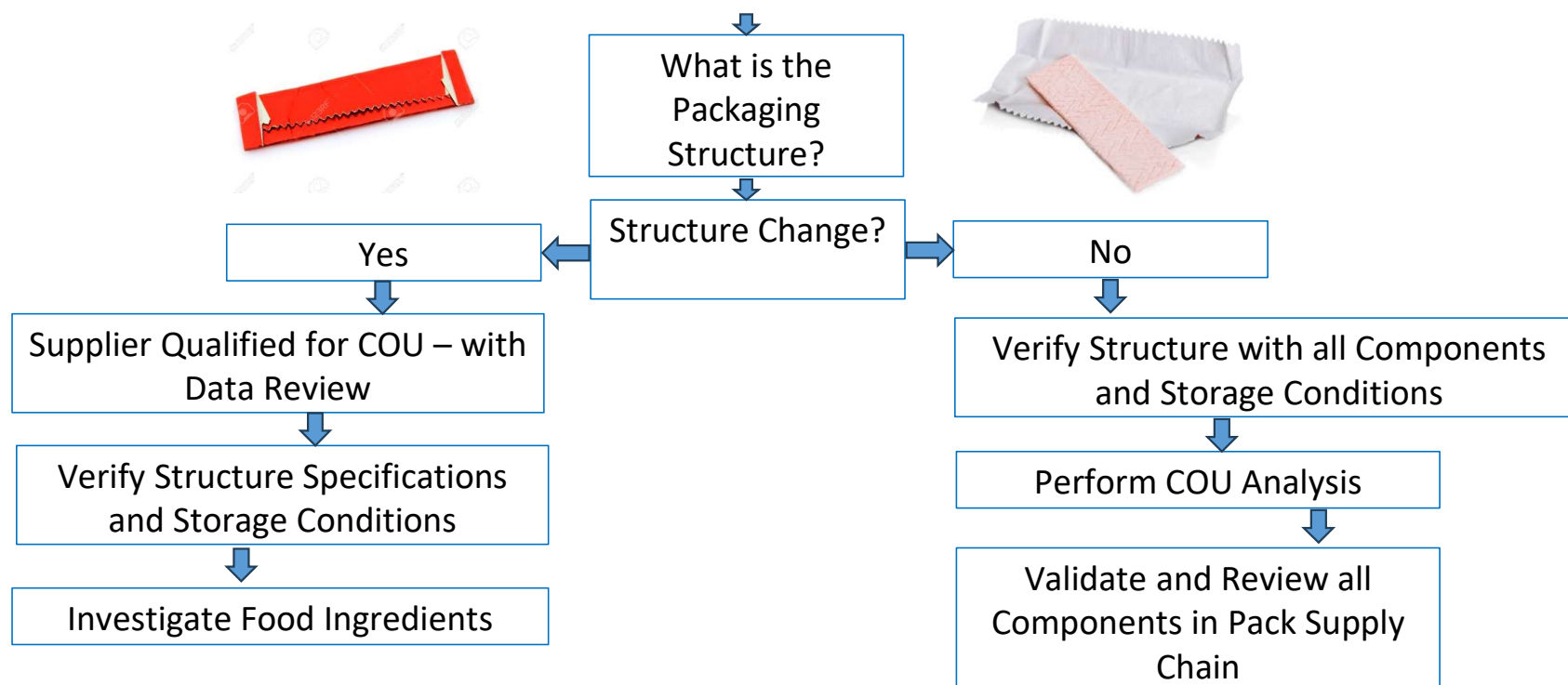
- NewCo has used the same paper, inks, and coatings from the same suppliers for years – *laminated paper with thin layer of aluminum*
- Paper does contain recycled fiber – Gum?
- PFAS identified (contract lab) by TF analysis to be >100 ppm



Case Study – It's just a WRAP?

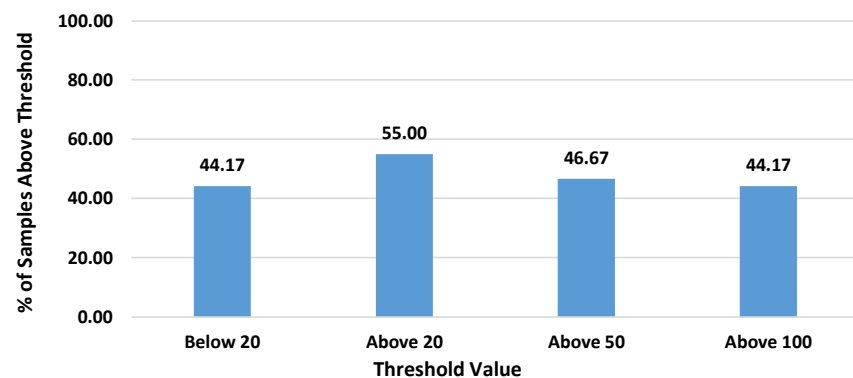
Problem Statement: *wrappers contain significant levels of PFAS*

Work our way through the problem – structure change, COU, components – where is the likely source?



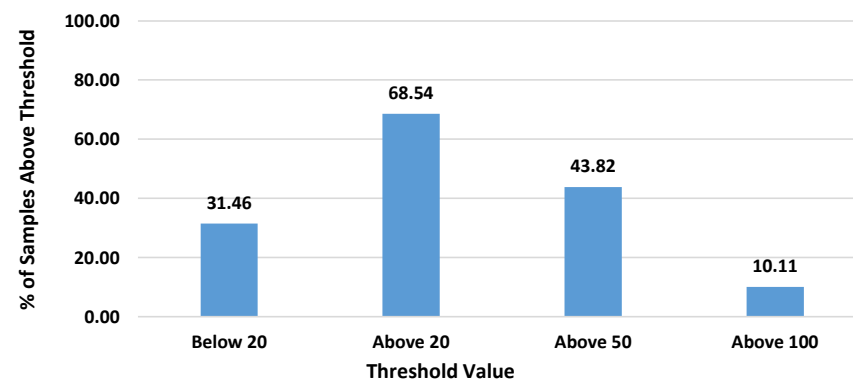
Percentage of Samples Above Specified Threshold

Paper



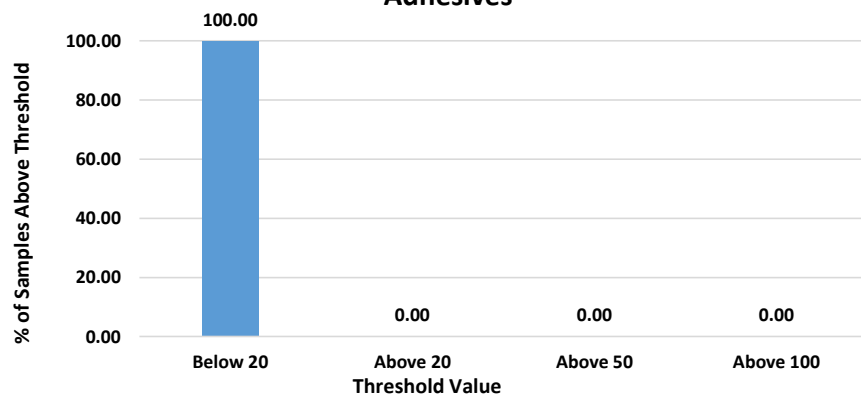
**Average total fluorine measurement: 173 ppm (mg/kg)*

Plastic



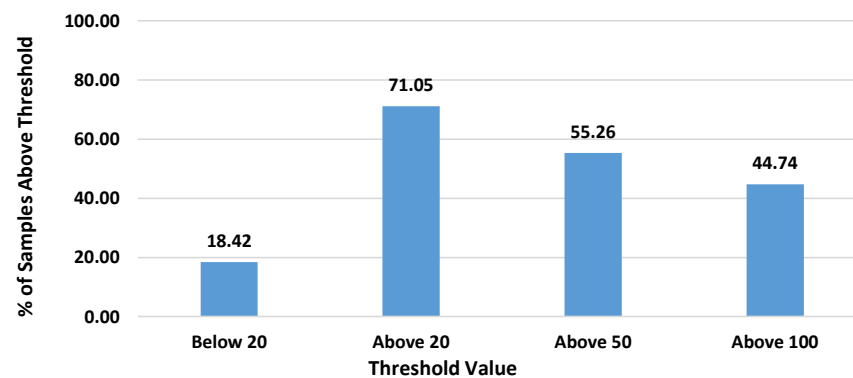
**Average total fluorine measurement: 53 ppm (mg/kg)*

Adhesives



**Average total fluorine measurement: 13 ppm (mg/kg)*

Coated Paper Popcorn Bags



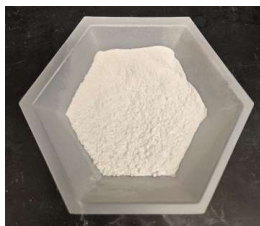
**Average total fluorine measurement: 272 ppm (mg/kg)*

*Threshold is determined by consortium member requesting analysis

Case Study – It's just a WRAP?

Problem Statement: *Do wrappers contain significant levels of PFAS?*

- NewCo gum DOES NOT HAVE PFAS Problem!
- Different labs used different methods (non targeted) and did not account for fillers that will influence signal.
- When the impact of filler (talc) was subtracted from the signal, NewCo wrappers were < MLOD of 5 ppm and thus within retailer/customer threshold limits. Thus, further targeted evaluation is not needed.
- So HOW is this a problem and what can be done?



Results

- The fluorine signal (NIR) linearly increases with measured total fluorine difference as a function of talc concentration ($R^2 = 0.9619$)
- Fillers and additives can amplify or suppress TF signal
- This has been concern has been raised with previous news stories



Conclusions

- This method is critical for determining compliance of packaging samples **CAN AND WILL RESULT IN FALSE POSITIVES or NEGATIVES**

Evaluating the influence of inorganic fillers on non-targeted total fluorine quantification in plastic using combustion ion chromatography

Journal:	Analytical Chemistry
Manuscript ID:	ac-2026-061345
Manuscript Type:	Article
Date Submitted by the Author:	27-Aug-2026
Complete List of Authors:	Cocco, Samiris; Iowa State University, Food Science Tumu, Khairun; Iowa State University Vorst, Keith; Iowa State University Curtzweiler, Greg; Polymer and Food Protection Consortium, Food Science and Technology

Matrix effects of fillers on PFAS in packaging

Dr. Keith Vorst
Polymer and Food Protection Consortium

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Study Context and Objectives

Context

- **CIC measures total fluorine (TF)** in plastics.
- Filled plastics contain **fillers**.
- Fillers may **impact fluorine signal or affect recovery**.
- Measured TF may not reflect only the **fluorinated material**.

Why it matters

- Matrix effects can **over- or underestimate TF signal**.
- Reliable TF screening helps identify **fluorinated materials**.
- Understanding fillers improves **CIC result interpretation**.

Objective

- **Assess filler effects on TF signal**
- **Compare filler type and source.**
- **Identify TF enhancement or suppression.**

Experimental design

Raw materials



Virgin PP Powder

Talc
(4 Sources)



Calcium Carbonate
(2 sources)



Calcium
Silicate



Kaolin (2
sources)



Titanium
Dioxide



Compounding

using the SJ25 mini
single-screw extruder



Extruded formulations



Results

Key findings

- **TF varied substantially** among filler-containing LDPE formulations.
- **Filler type and source strongly** influenced the measured TF concentration.
- Some fillers increased TF, while others showed values close to the LDPE control.
- These differences highlight **important matrix effects in CIC analysis.**

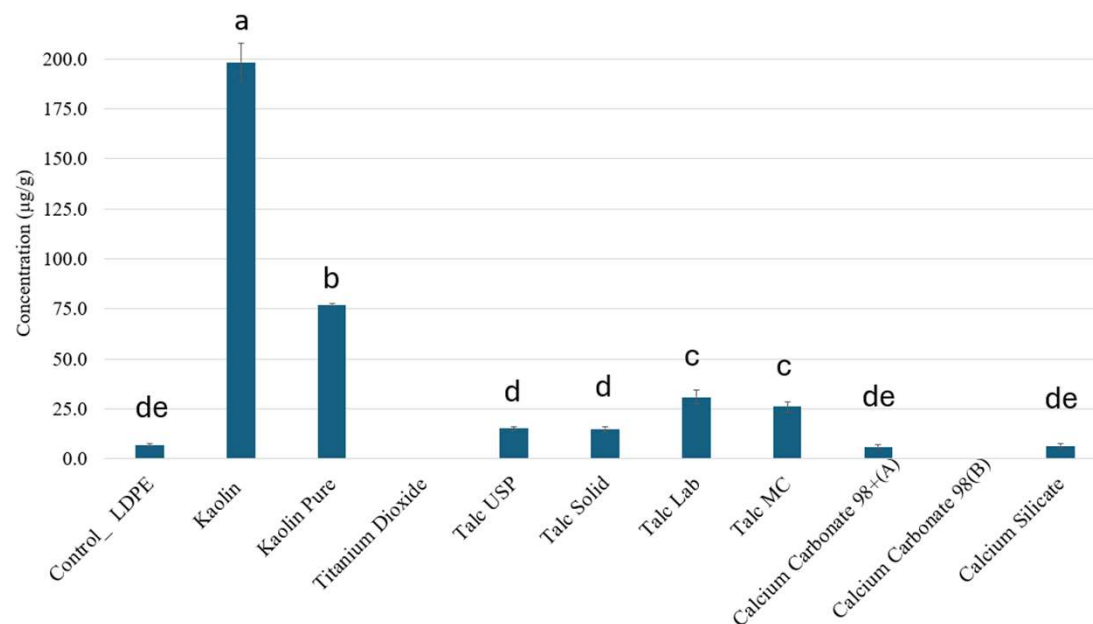


Figure 1. Effect of inorganic fillers on TF in LDPE

Sustainable Ink in the Packaging System

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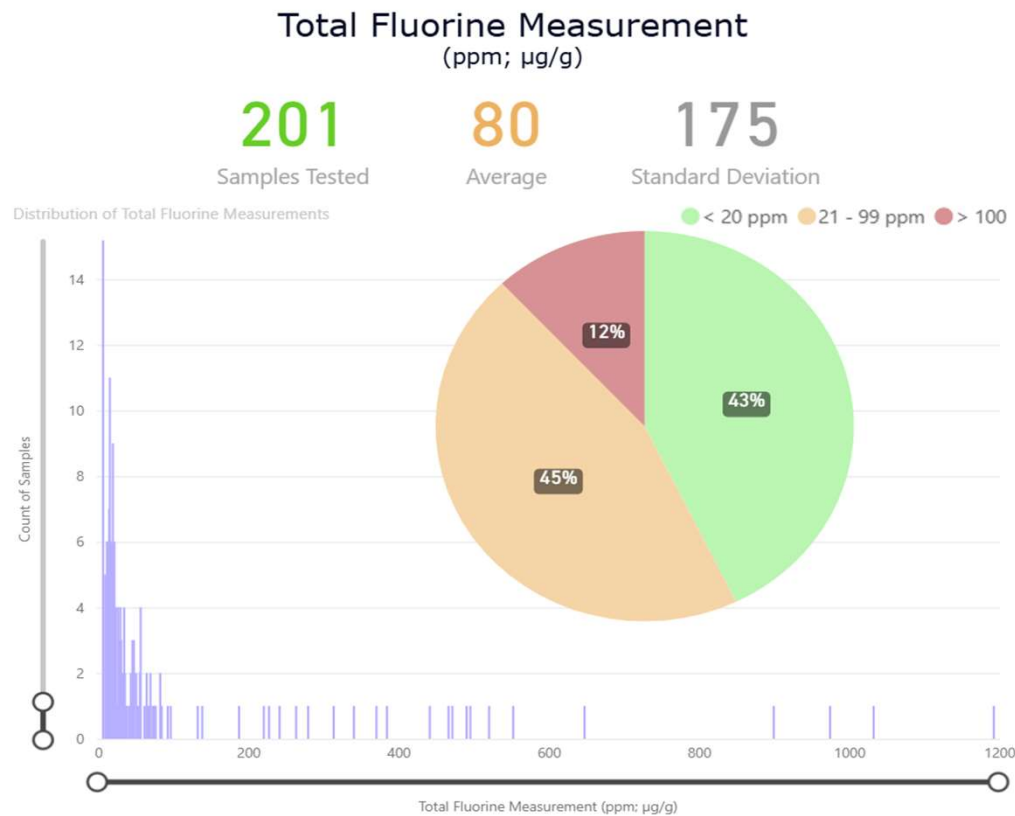


Liquid Ink Evaluation

- Liquid ink samples provided by converter and combusted via oxidative pyrohydrolytic combustion with ion chromatography
- Three samples were measured below the limit of detection (5 ppm)

Sample	Total Fluorine Measurement (PPM; mg/kg)
Sample 1	< LOD
Sample 2	< LOD
Sample 3	< LOD
LOD	5

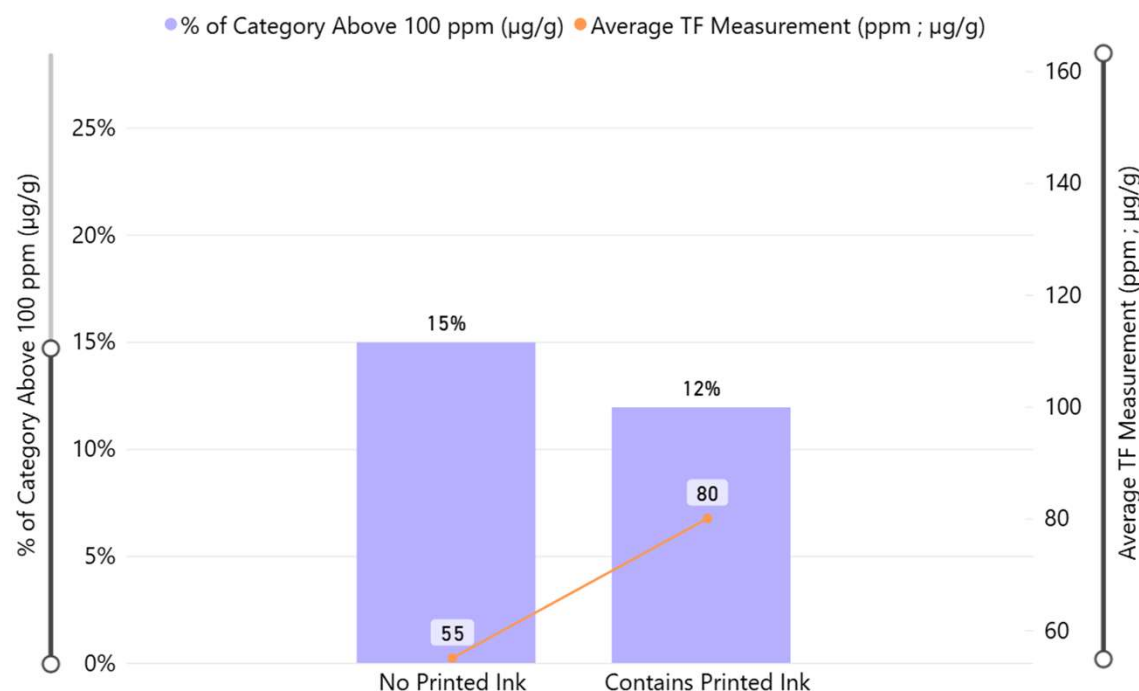
Packaging Containing Printed Ink/Decoration



- Legacy data with traditional testing methods

Packaging Containing Printed Ink/Decoration

- Packaging with printed decoration had an average total fluorine value of 80 ppm, with 12% of the samples tested measuring above 100 ppm*
- Packaging that did not contain printed decoration had an average total fluorine value of 55 ppm, with 15% of the samples tested measuring above 100 ppm*



**100 parts per million (ppm, or mg/kg) is the most common total organic fluorine threshold in the United States*

Packaging Containing Printed Decoration

- Additional sample details of printed decoration legacy samples tested

Country of origin	Number of Samples
Abu Dhabi	4
Australia	1
China	10
Greece	1
Kuwait	5
Mexico	4
Unknown	147
USA	29

Material Type	Number of Samples
Uncoated paper	2
Rigid	6
Molded fiber	1
Flexible	105
Coated paper	87

Food Contact	Number of Samples
FCM	159
NFCM	36
Unknown	6

Polymer Type	Number of Samples
2- HDPE	15
4- LDPE	9
5- PP	7
7- Other	2
Multilayer	43
N/A	88
PE	16
Unknown	21

Adhesive Presence	Number of Samples
Adhesive	85
No adhesive	45
Unknown	71

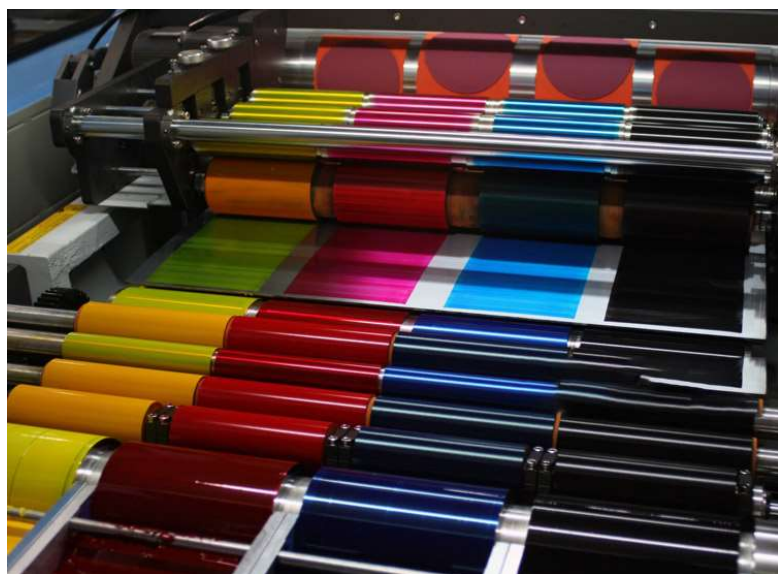
Year Tested	Number of Samples
2024	18
2023	44
2022	41

Printed Ink Presence	Number of Samples
Printed ink	201

Pigment Presence	Number of Samples
No pigment	58
Pigment	53
Unknown	5

Paper Lightness	Number of Samples
Bleached	36
Unbleached	51
Unknown	3

PCR Presence	Number of Samples
No	23
Unknown	162
Yes	16



Total fluorine measurements are low for the liquid ink samples tested using current testing methods

Legacy data (2021-2025 using traditional testing methods) show printed or decorated materials have a slightly higher average total fluorine value, but most samples remain under the typical US threshold of 100 ppm.

What companies need to know

1 What is changing?

How AOAC performance requirements are evolving for broader PFAS coverage.

2 What does it mean?

How method validation, reporting, and confidence affect business decisions.

3 What should industry do?

Questions to ask laboratories, suppliers, and internal quality teams.

Focus: comparability • defensible data • regulatory readiness

Targeted vs non-targeted PFAS

Two complementary approaches: different strengths, different outputs

TARGETED

- ✓ Known PFAS list
- ✓ Reference standards
- ✓ Quantitative concentration
- ✓ Best for compliance decisions

NON-TARGETED / SUSPECT

- ✓ Broader chemical space
- ✓ Evidence-based identification
- ✓ Qualitative / semi-quantitative
- ✓ Best for discovery and risk screening

What is next in Ink Research

Evaluate Printing Colorants and Components that Impact Safety and Quality of Recycled Resins for Food Contact Applications

Project Goal: Investigate and establish the relationships among printing-ink class, ink-component fate during mechanical recycling, and the chemical safety and quality of PCR produced from direct-printed PP food packaging.



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What is next in Ink Research

Evaluate Printing Colorants and Components that Impact Safety and Quality of Recycled Resins for Food Contact Applications

Objective 1: Identify packaging inks and pigments that degrade into hazardous or restricted substances during recycling

Objective 2: Evaluate technologies to effectively remove chemicals of concern

Objective 3: Propose a framework for assessing inks for compatibility with sustainable recycling



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Take-Home Messages

- 1 **Start with the decision, not the instrument.**
- 2 Targeted and non-targeted analyses answer different questions for all CoC
- 3 Matrix validation and contamination control is critical for all CoC
- 4 Non-targeted findings must be reported with transparent confidence (*what is the lab doing and methods must be available*).

Questions & discussion

Thank you and be a part of the Polymer and Food
Protection Consortium!!!

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