Fluorinated Compounds in U.S. Fast Food Packaging

Simona Balan, PhD
Senior Environmental Scientist
Safer Consumer Products Program, DTSC
Simona.Balan@dtsc.ca.gov
Fluorinated Compounds in U.S. Fast Food Packaging

Laurel A. Schaider,*† Simona A. Balan,‡ Arlene Blum,§‖ David Q. Andrews,¶ Mark J. Strynar,#* Margaret E. Dickinson, V David M. Lunderberg, V Johnsie R. Lang,○ and Graham F. Peaslee@

†Silent Spring Institute, Newton, Massachusetts 02460, United States
‡California Department of Toxic Substances Control, Sacramento, California 95814, United States
§Green Science Policy Institute, Berkeley, California 94709, United States
‖Department of Chemistry, University of California at Berkeley, Berkeley, California 94720, United States
¶Environmental Working Group, Washington, D.C. 20009, United States
#National Exposure Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, United States
VChemistry Department, Hope College, Holland, Michigan 49423, United States
○Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee 37831, United States
@Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, United States
Outline

1. Intro to PFASs

2. Fluorine in Food Packaging via PIGE
Polyfluoroalkyl and Perfluoroalkyl Substances (PFASs)

- Man-made chemicals
- Used since the 50’s, e.g. to make products non-stick, waterproof, soil/stain/oil-resistant, and in firefighting foam
- At least one carbon fully fluorinated (i.e. no more C-H bonds)

\[ \delta^+ \text{C} \quad \text{---} \quad \text{F}^\delta^- \]

One of the strongest bonds in chemistry, leads to environmental persistence
There are over 3000 PFASs
Different kinds of PFASs

PFASs

- perfluoroalkyl acids (PFAAs)
  \( \text{C}_n\text{F}_{2n+1}\text{R} \)
- perfluoroalkane sulfonic acids (PFSA)
  \( \text{C}_n\text{F}_{2n+1}\text{SO}_3\text{H} \)
- perfluoroalkyl phosphonic acids (PFPA)
  \( \text{C}_n\text{F}_{2n+1}\text{PO}_3\text{H}_2 \)
- perfluoroalkyl phosphoric acids (PFPA)
  \( (\text{C}_n\text{F}_{2n+1})(\text{C}_m\text{F}_{2m+1})\text{PO}_2\text{H} \)

- perfluoroalkane sulfonyl fluoride (PASF)
  \( \text{C}_n\text{F}_{2n+1}\text{SO}_2\text{F} \)

- perfluoroalkyl iodides (PFIs)
  \( \text{C}_n\text{F}_{2n+1}\text{I} \)

- per- and polyfluoroalkyl ether-based substances
- per- and polyfluoroether carboxylic acids (PFECAs)
  e.g., \( \text{C}_2\text{F}_5\text{OC}_2\text{F}_4\text{OCF}_2\text{COOH} \)
- per- and polyfluoroether sulfonic acids (PFESA)
  e.g., \( \text{C}_6\text{F}_{13}\text{OCF}_2\text{CF}_2\text{SO}_3\text{H} \)

- fluoropolymers (FPs)
  - polytetrafluoroethylene (PTFE)
  - polyvinylidene fluoride (PVDF)
  - fluorinated ethylene propylene (FEP)
  - perfluorooalkoxy polymer (PFA)
  - polyvinyl fluoride (PVF)

- side-chain fluorinated polymers
  - fluorinated (meth)acrylate polymers*
  - fluorinated urethane polymers*
  - fluorinated oxetane polymers

- perfluoropolyethers (PFPEs)
  - e.g., \( \text{HOCH}_2\text{O-}[\text{C}_m\text{F}_{2m}\text{O-}]_n\text{CH}_2\text{OH} \)

* These polymers are based on monomers derived from PASFs or fluorotelomer-based raw materials.

Intro to PFASs
Fluorine in food packaging via PIGE

OECD (2016); [http://www.oecd.org/test-pfc/pfass/]
Exposure concerns

- Ubiquity in the environment
- Environmental persistence
- Bioaccumulation
- Long or non-negligible elimination half-lives
- Presence in nearly all humans tested
PFASs are widespread in environmental and biological samples

<table>
<thead>
<tr>
<th>Media</th>
<th>Chemicals</th>
<th>Concentrations</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Clara River watershed, CA</td>
<td>PFOA and PFOS</td>
<td>&lt;1 – 5.9 ng/L</td>
<td>SCCWRP 2015</td>
</tr>
<tr>
<td>WWTP effluent</td>
<td>PFOA and PFOS</td>
<td>3.0 – 1050 ng/L</td>
<td>ATSDR 2015</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>PFAAs (C3-C14)</td>
<td>126 – 809 µg/kg</td>
<td>Yan et al. 2012</td>
</tr>
<tr>
<td>Soil (U.S.)</td>
<td>PFAAs</td>
<td>0.035 – 6.10 ng/kg</td>
<td>Rankin et al. 2016</td>
</tr>
<tr>
<td>Outdoor air</td>
<td>FTOHs</td>
<td>0.06 – 0.19 ng/m³</td>
<td>Muller et al. 2012</td>
</tr>
<tr>
<td>Indoor air (homes &amp; schools)</td>
<td>FTOHs</td>
<td>12.5 ng/m³ (mean)</td>
<td>Fromme et al. 2015</td>
</tr>
<tr>
<td>Indoor air (offices)</td>
<td>FTOHs</td>
<td>0.24 – 94.2 ng/m³</td>
<td>Fraser et al. 2012</td>
</tr>
<tr>
<td>Daycare center dust</td>
<td>PFOA / PFOS</td>
<td>41 / 31 µg/kg</td>
<td>Bjorklund et al. 2009</td>
</tr>
<tr>
<td>House dust</td>
<td>PFCAs (C6 to C14)</td>
<td>&lt;1.0 – 37.4 µg/kg</td>
<td>Liu et al. 2011</td>
</tr>
<tr>
<td>Breast milk</td>
<td>11 PFASs</td>
<td>0.03 – 0.07 ng/ml (mean)</td>
<td>Kang et al. 2016</td>
</tr>
<tr>
<td>Cord blood</td>
<td>PFOA</td>
<td>1.6 – 3.7 ng/ml</td>
<td>ATSDR 2015</td>
</tr>
<tr>
<td>Adult human blood</td>
<td>PFOA / PFOS</td>
<td>2.1-9.6/14.7-55.8 ng/ml</td>
<td>ATSDR 2015</td>
</tr>
</tbody>
</table>
PFASs may have potential adverse impacts

- Aquatic toxicity and terrestrial ecotoxicity
- Endocrine disruption
- Immunotoxicity
- Neurotoxicity
- Developmental toxicity
- Cancer (testicular and kidney)
- Organ toxicity

C8 Science Panel
The PFAS market is changing

- Reduced emissions of PFOA, its precursors, and related longer-chain PFASs
  - U.S. EPA’s 2010/2015 Stewardship Program
  - U.S. EPA significant new use rule (SNUR)
- Shift from longer-chain PFASs to shorter-chains, fluorinated ethers, branched and cyclic compounds (“novel” PFASs)
- Some PFAS-free products available
Newer PFASs – safer?

- Shorter half-lives in humans
- Faster elimination rates
- Less toxic than legacy PFASs
- Lack of evidence for ecotoxicity
Newer PFASs – safety concerns?

- Non-negligible half-lives in humans
- Environmental persistence
- Mobility in the environment
- Accumulation in plants
- Lack of safety data
The thinking about PFASs is changing too

The Madrid Statement on Poly- and Perfluoroalkyl Substances (PFASs)

Arlene Blum,1,2 Simona A. Balan,2 Martin Scheringer,3,4 Xenia Trier,5 Greta Goldenman,6 Ian T. Cousins,7 Miriam Diamond,8 Tony Fletcher,9 Christopher Higgins,10 Avery E. Lindeman,2 Graham Peaslee,11 Pim de Voogt,12 Zhanyun Wang,4 and Roland Weber13

Intro to PFASs

Fluorine in food packaging via PIGE
These Chemicals in Pizza Boxes and Carpeting Last Forever

More than 200 scientists around the world document the threats of perfluorinated compounds and call for more government control.

By Lindsey Konkel, National Geographic

PUBLISHED MAY 1, 2015

Scientists at Environment Canada went public in a rare interview to confirm that they largely agree with a statement signed by more than 200 scientists worldwide that warns about health risks from a family of 150 or more fluorinated chemicals known as perfluoroalkyl and polyfluoroalkyl substances (PFASs), which are widely used as stain and water repellents. PFASs came to international attention after being detected in the blood of residents near a DuPont facility in West Virginia, where the company had been processing PFAS chemicals for years. The scientists say that the compounds persist in the environment and are capable of entering the human body through drinking water, food, and even air. The PFASs have been linked to developmental and endocrine effects, liver damage, immune system effects, and cancer in animal studies. Although there is limited evidence of PFASs causing cancer in humans, the scientists say more research is needed.

Nicholas Kristof

What do a pizza box, a polar bear and you have in common?

All carry a kind of industrial toxicant called poly- and perfluoroalkyl substances, or PFASs, that do two things: They make life convenient, and they also appear to increase the risk of cancer.
The entire class was added to Biomonitoring CA’s Priority Chemicals list.
All PFASs are Candidate Chemicals for the Safer Consumer Products (SCP) program
Safer Consumer Products framework

1. Candidate Chemical List
   - As designated by 23 authoritative bodies

2. Priority Products
   - Product-Chemical combinations that may cause harm

3. Alternatives Analysis
   - Manufacturer evaluation of alternatives

4. Regulatory Response
   - DTSC considers range of possible responses

Intro to PFASs
Fluorine in food packaging via PIGE
2015 – 2017 Priority Product Work Plan

- Identifies five policy priorities:
  - Clear exposure pathways to Candidate Chemicals
  - Chemicals detected in biomonitoring studies
  - Chemicals observed in indoor air and dust
  - May impact children or workers
  - May adversely impact aquatic resources, or observed through water quality monitoring

- Identifies seven product categories
- Lists example chemicals
PFASs are in all the 2015-2017 Work Plan product categories

- Building Products
- Beauty, Personal Care, and Hygiene Products
- Household/Office Furniture & Furnishings
- Cleaning Products
- Office Machinery (Consumable Products)
- Cleaning Products
- Fishing and Angling Equipment
- Clothing

Intro to PFASs
Fluorine in food packaging via PIGE
Scope of SCP’s current work

- Carpets and rugs
- Indoor upholstered furniture (residential, business and institutional)
- Carpet and upholstery care and treatment products
SCP’s Work on PFASs

- Public background document (Nov. 15, 2016)
- Webinar (Nov. 15, 2016)
- Public workshop (Jan. 31, 2017)

https://dtsc.ca.gov/SCP/Workshops.cfm

Follow updates in our E-list:

Multiple routes for PFAS exposure

- Human
- Biota
- Air & Dust
- Wastewater
- Landfill Waste
- Soil
- Sludge
- Surface Water & Groundwater

Intro to PFASs
Fluorine in food packaging via PIGE
Main routes of PFAS exposure for most adults: diet and drinking water

Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants

Xindi C. Hu, David Q. Andrews, Andrew B. Lindstrom, Thomas A. Bruton, Laurel A. Schaider, Philippe Grandjean, Rainer Lohmann, Courtney C. Carignan, Arlene Blum, Simona A. Balan, Christopher P. Higgins, and Elsie M. Sunderland
Fluorinated Compounds in U.S. Fast Food Packaging

Laurel A. Schaider,*† Simona A. Balan,‡ Arlene Blum,§‖ David Q. Andrews,¶ Mark J. Strynar,*# Margaret E. Dickinson,⊥ David M. Lunderberg,⊥ Johnsie R. Lang,⊥ and Graham F. Peaslee,@

†Silent Spring Institute, Newton, Massachusetts 02460, United States
‡California Department of Toxic Substances Control, Sacramento, California 95814, United States
§Green Science Policy Institute, Berkeley, California 94709, United States
‖Department of Chemistry, University of California at Berkeley, Berkeley, California 94720, United States
⊥Environmental Working Group, Washington, D.C. 20009, United States
#National Exposure Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, United States
⊥Chemistry Department, Hope College, Holland, Michigan 49423, United States
©Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee 37831, United States
@Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, United States
Most comprehensive study to date

  - 395 from 27 large U.S. fast food chains
  - 12 from individual restaurants
- Particle Induced γ-ray Emission (PIGE)
- LC/MS & LC/TOF MS on 20 samples
Sample type

- Food contact paper
  - Sandwiches, burgers and fried food
  - Tex-Mex food
  - Deserts and breads
- Non-contact paper
- Food contact paperboard
- Paper cups (hot & cold)
- Other beverage containers
- Miscellaneous (e.g. lids and applesauce containers)
Spectroscopy

Excitation Source - Sample - Detector

Intro to PFASs
Fluorine in food packaging via PIGE
e.g. XRF portable detector

http://www.nitonuk.co.uk/
Fluorine is more problematic...

- X-ray energy is too low
- No UV-Vis transitions
- FTIR C-F ambiguous
- FT-NMR insensitive

www.edax.com

Intro to PFASs

Fluorine in food packaging via PIGE
Hope College Ion Beam Analysis Lab

Ex Vacuo Analysis

1.7 MV tandem Van de Graaff Accelerator

Intro to PFASs

Fluorine in food packaging via PIGE
### Particle Induced γ-ray Emission (PIGE)

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid</td>
<td>Complicated instrumentation</td>
</tr>
<tr>
<td>High sensitivity</td>
<td>Not compound-specific</td>
</tr>
<tr>
<td>Total F measurement</td>
<td>Surface measurement (100-200 µm)</td>
</tr>
<tr>
<td>Minimal sample prep</td>
<td></td>
</tr>
<tr>
<td>No interferents</td>
<td></td>
</tr>
<tr>
<td>No matrix effects</td>
<td></td>
</tr>
<tr>
<td>Non-destructive</td>
<td></td>
</tr>
</tbody>
</table>

**10 nA of 3.4 MeV protons for 180 s**

**Intro to PFASs**

Fluorine in food packaging via PIGE
Typical PIGE spectra

![Graph showing PIGE spectra for PFAS-treated and non-treated paper]

- **19F at 110 keV**
- **19F at 197 keV**
33% of samples had detectable F (16-800 nmol/cm$^2$)

**Percent with fluorine**

- **Dessert & bread wrappers**: 56%
- **Sandwich & burger wrappers**: 38%
- **Paperboard**: 20%
- **Paper cups**: 0%
## Results by packaging type

<table>
<thead>
<tr>
<th>Package Type</th>
<th>No. of Samples Tested</th>
<th>No. of Brands Tested</th>
<th>No. of States Tested</th>
<th>% with F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food contact paper (by category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandwich/burger</td>
<td>138</td>
<td>20</td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>Dessert/bread</td>
<td>68</td>
<td>9</td>
<td>5</td>
<td>56</td>
</tr>
<tr>
<td>Tex-Mex</td>
<td>42</td>
<td>3</td>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td>Food contact paper (all)</td>
<td>248</td>
<td>27</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Food contact paperboard</td>
<td>80</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Noncontact paper</td>
<td>15</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Paper cups</td>
<td>30</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Other beverage containers</td>
<td>25</td>
<td>10</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>9</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>407</td>
<td>29</td>
<td>5</td>
<td>33</td>
</tr>
</tbody>
</table>
## Results by packaging type

<table>
<thead>
<tr>
<th>Packaging Type (by category)</th>
<th>No. of samples tested</th>
<th>No. of brands tested</th>
<th>No. of states tested</th>
<th>% with F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food contact paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandwich/burger</td>
<td>138</td>
<td>20</td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>Dessert/bread</td>
<td>68</td>
<td>9</td>
<td>5</td>
<td>56</td>
</tr>
<tr>
<td>Tex-Mex</td>
<td>42</td>
<td>3</td>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td><strong>Food contact paper (all)</strong></td>
<td><strong>248</strong></td>
<td><strong>27</strong></td>
<td><strong>5</strong></td>
<td><strong>46</strong></td>
</tr>
<tr>
<td>Food contact paperboard</td>
<td>80</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Non-contact paper</td>
<td>15</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Paper cups</td>
<td>30</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Other beverage containers</td>
<td>25</td>
<td>10</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>9</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>407</strong></td>
<td><strong>29</strong></td>
<td><strong>5</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>
## Results by packaging type

<table>
<thead>
<tr>
<th>Packaging Type</th>
<th>no. of samples tested</th>
<th>no. of brands tested</th>
<th>no. of states tested</th>
<th>% with F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food contact paper (by category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandwich/burger</td>
<td>138</td>
<td>20</td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>Dessert/bread</td>
<td>68</td>
<td>9</td>
<td>5</td>
<td>56</td>
</tr>
<tr>
<td>Tex-Mex</td>
<td>42</td>
<td>3</td>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td>Food contact paper (all)</td>
<td>248</td>
<td>27</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Food contact paperboard</td>
<td>80</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Noncontact paper</td>
<td>15</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Paper cups</td>
<td>30</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Other beverage containers</td>
<td>25</td>
<td>10</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>9</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>407</td>
<td>29</td>
<td>5</td>
<td>33</td>
</tr>
</tbody>
</table>
## Results by packaging type

<table>
<thead>
<tr>
<th></th>
<th>no. of samples tested</th>
<th>no. of brands tested</th>
<th>no. of states tested</th>
<th>% with F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>food contact paper</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(by category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sandwich/burger</td>
<td>138</td>
<td>20</td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>dessert/bread</td>
<td>68</td>
<td>9</td>
<td>5</td>
<td>56</td>
</tr>
<tr>
<td>Tex-Mex</td>
<td>42</td>
<td>3</td>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td><strong>food contact paper</strong></td>
<td>248</td>
<td>27</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>(all)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>food contact paperboard</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>noncontact paper</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>paper cups</strong></td>
<td>30</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>other beverage containers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>miscellaneous</strong></td>
<td>25</td>
<td>10</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td>407</td>
<td>29</td>
<td>5</td>
<td>33</td>
</tr>
</tbody>
</table>
## Results by packaging type

<table>
<thead>
<tr>
<th></th>
<th>no. of samples tested</th>
<th>no. of brands tested</th>
<th>no. of states tested</th>
<th>% with F</th>
</tr>
</thead>
<tbody>
<tr>
<td>food contact paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(by category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sandwich/burger</td>
<td>138</td>
<td>20</td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>dessert/bread</td>
<td>68</td>
<td>9</td>
<td>5</td>
<td>56</td>
</tr>
<tr>
<td>Tex-Mex</td>
<td>42</td>
<td>3</td>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td>food contact paper</td>
<td>248</td>
<td>27</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>(all)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>food contact</td>
<td>80</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>paperboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>noncontact paper</td>
<td>15</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>paper cups</td>
<td>30</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>other beverage</td>
<td>25</td>
<td>10</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>miscellaneous</td>
<td>9</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>407</td>
<td>29</td>
<td>5</td>
<td>33</td>
</tr>
</tbody>
</table>
**No significant differences by region**

<table>
<thead>
<tr>
<th>State</th>
<th>Food contact paper</th>
<th>Food contact paperboard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>detection frequency</td>
</tr>
<tr>
<td>California</td>
<td>38</td>
<td>55%</td>
</tr>
<tr>
<td>DC Metro</td>
<td>41</td>
<td>54%</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>59</td>
<td>46%</td>
</tr>
<tr>
<td>Michigan</td>
<td>79</td>
<td>41%</td>
</tr>
<tr>
<td>Washington State</td>
<td>26</td>
<td>38%</td>
</tr>
</tbody>
</table>

Intro to PFASs

Fluorine in food packaging via PIGE
## Where did PIGE detect F?

<table>
<thead>
<tr>
<th>Restaurant</th>
<th>Arby’s</th>
<th>Burger King</th>
<th>Carl’s Jr.</th>
<th>Checkers</th>
<th>Chick-Fil-A</th>
<th>Chipotle</th>
<th>Church’s Chicken</th>
<th>Culver’s</th>
<th>Dairy Queen</th>
<th>Domino Pizza</th>
<th>Dunkin’ Donuts</th>
<th>Five Guys</th>
<th>Jack in the Box</th>
<th>Jimmy John’s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>KFC</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krispy Kreme</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McDonald’s</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panera</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pizza Hut</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiznos</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round Table Pizza</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starbucks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steak’n’Shake</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taco Bell</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taco Time</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wendy’s</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
89 known PFASs in 20 samples by LC/MS

- Total F < 16 nmol F/cm$^2$
- Total F > 200 nmol F/cm$^2$

Approx. LOD for PIGE

Fluorine in food packaging via PIGE
PFOA in 6 samples, despite 2011 phaseout

**Approx. LOD for PIGE**

**Total F < 16 nmol F/cm²**

**Total F > 200 nmol F/cm²**

- PFCAs
- PFSAs
- FTSs
- diPAPs
- PF ethers
- Other

**Peak area (Thousands)**
Unknown PFASs by LC/TOF MS

Peak area (Thousands)

Total F < 16 nmol F/cm²
Total F > 200 nmol F/cm²

Approx. LOD for PIGE

Intro to PFASs
Fluorine in food packaging via PIGE
PIGE method great for rapid screening

... but likely not sensitive enough to detect all intentionally added PFASs

- According to the Danish Ministry of Environment and Food:
  - ~0.6 – 60 µg F/g paper associated with surface coatings
  - 0.35 µg F/dm² guideline (includes impurities)

- PIGE LOD 16 nmol F/cm² (LOQ 50 nmol F/cm²), equivalent to:
  - ~60 µg/g F in wrappers, ~14 µg/g F in paperboard
  - 30 µg F/dm²
Implications

- At least 33% of U.S. fast food packaging contains intentionally-added PFASs
- Alternatives likely already in use
- Fast food companies may be unaware
Implications

- At least 33% of U.S. fast food packaging contains intentionally-added PFASs
- Alternatives likely already in use
- Fast food companies may be unaware
C8 and C6 have similar biological activity \textit{in vitro}

Fluorinated Compounds in U.S. Fast Food Packaging

Laurel A. Schaider, Simona A. Balan, Arlene Blum, David Q. Andrews, Mark J. Strynar, Margaret E. Dickinson, David M. Lunderberg, Johnsie R. Lang, and Graham F. Peaslee

Researchers found fluorinated chemicals in one-third of the fast food packaging they tested, according to a report cnn.it/2jWU6Rw

Researchers find "another reason" to avoid fast food: Chemicals in the packaging

Substances with links to health problems have been found in wrappers and containers, where they can leach into food.

washingtonpost.com

The Nasty Ingredient in Fast-Food Wrappers
mojo.ly/2jCPzA4

Fluorine in food packaging via PIGE
Researchers have found that one-third of fast food packaging such as burger wrappers contains fluorinated chemicals, grease-repelling compounds that can harm the immune system and are even linked to cancer. What do you think?

“Anything that touches a Guacamole Bacon Thickburger for long enough is bound to get some chemicals on it.”

Neil Fitch • LECTURE BOOKER

“Just to be safe, I’ll go behind the counter and eat straight off the griddle from now on.”

Paula Werther • TRUANCY INVESTIGATOR

“This is the wake-up call I needed to stop eating burger wrappers.”

Dan Walters • JUICE BOTTLER
Thank you!

- Laurel Schaider, Silent Spring
- Arlene Blum, Green Science Policy Institute
- David Andrews, EWG
- Mark Strynar, US EPA
- Margaret Dickinson, Hope College
- David Lunderberg, Hope College
- Johnsie Lang, Oak Ridge Institute
- Graham Peaslee, University of Notre Dame
- The SCP Team