

Greener Solutions Case Study: PFAS and Molded Fiber Packaging

What was the Challenge:

PFASs (poly- and per-fluoroalkyl substances) are often added to food packaging to improve oil and water barrier properties of paper materials (1,2). The challenge was to identify safe and degradable alternatives to PFASs in this context. This research was conducted by a team of undergraduate and graduate students at UC Berkeley, and supported by Berkeley Center for Green Chemistry and household product manufacturer, Method. The team identified molded fiber products as the food packaging industry sector with the largest dependence on PFASs, and therefore an urgent need for alternatives (3).

Alternatives were chosen by the team on the basis of comparable technical performance to polylactic acid (PLA), and order-of-magnitude reduction in hazard in terms of its environmental, health, and safety performance compared to PFASs (Figure 1.1). This is because PFASs are known to overperform in terms of its barrier properties, so the team chose to compare their alternatives to PLA, the most common compostable plastic, as a more realistic technical performance benchmark for acceptable performance for consumers.

Simplified EHS:		Carcinogenicity/ Mutagenicity	Developmental/ Reproductive Toxicity	Acute Toxicity	Systemic Toxicity	Skin/Eye Sensitisation and Irritation	Aquatic Toxicity	Persistence
Existing Chemicals	6:2 Fluorotelomer methacrylate	H	H	M	H	H	V	V
	6:2 Fluorotelomer alcohol	H	H	M	H	H	V	V
	2-(N,N-Diethylamino)ethyl methacrylate	M	V	H	V	V	V	L
Key		Hazard:	Low(L)	Medium (M)	High (H)	Very High (V)	Data Gap (DG)	
		Confidence:	Low	High				
Simplified Technical:		Water Contact Angle	Porosity (Oxygen Permeability)	Thermal Resistance	Temperature Dependence	Tensile Strength	Degradability	
Relevant Property	Grease Resistance (kit value)							
PLA	12+	75-85°	38-42	335°C	52.4-150°C	27-35 MPa	>150 days	
Key		Best Performance	Medium	Worst	Data Gap (DG)			

Figure 1.1: Baseline environmental and technical performance for PLA and PFAS.¹

The alternatives were compared to PLA on multiple key parameters: water contact angle, kit value for grease resistance, water vapor permeability, porosity, thermal resistance, thermal dependence, dispersibility, tensile strength, and degradability. These factors spanned properties important for consumer experience as well as manufacturing requirements. For example, consumers expect a certain level of grease and water repellency from their food packaging

¹ References for EHS and Technical Performance tables can be found in the original report, available at: <https://bcgc.berkeley.edu/greener-solutions-2020/>

products, as measured by water contact angle and kit value, respectively. On the other hand, the alternatives should also be able to withstand high temperatures required in the production steps of the food packaging material. Finally, degradability was an important property to ensure a competitive advantage over plastics and PLA.

The alternatives were further compared to PFASs for environmental, health, and safety performance on Group I, Group II, and Environmental Hazard and Fate endpoints as defined by GreenScreen for Safer Chemicals (4). Examples of relevant endpoints include carcinogenicity, reproductive toxicity, endocrine toxicity, acute mammalian toxicity, skin irritation, and persistence.

Four alternatives that showed order-of-magnitude reduction in hazard compared to PFASs, and were comparable to PLA in technical performance were found. Of the four, the team recommended in their final written report that lignin, a rigid and omniphobic plant fiber (5), was the most promising alternative material for molded fiber products. Lignin's strengths include a grease resistance rating that matches that of PLA and a water contact angle that exceeds PLA (6,7). Its sustainability profile is also remarkable, as it can be sourced from a waste product of the paper milling industry and degrades faster than both PLA and PFASs (8,9).

Why this Project was Important:

PFASs are an entire class of chemicals containing fluorocarbon chains, whose defining characteristic is the ability to strongly repel both water and oil (10). Teflon and Scotchgard are two common consumer products that contain PFASs, in addition to food packaging materials. The negative health effects of long-chain PFASs such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are well known, and these substances continue to persist in the environment despite their widespread phaseout between 2000 and 2015 (1, 11). Health hazards of concern to the entire class of PFASs include kidney and testicular cancer, elevated cholesterol, liver disease, decreased fertility, thyroid problems, hormone dysregulations, immunosuppression, and adverse developmental effects.

The food packaging industry as a whole is under pressure to find alternatives to PFASs that are compostable, non-toxic, and still perform up to consumers' expectations. Common compostable bioplastics are often turned away from composting facilities due to their long degradation time (over 150 days) in comparison to most food waste (8). Additionally, compost generated from compostable plastics cannot be certified as organic, and generate less profit for composting facilities by volume. Paper packaging, in contrast, has the potential to be sustainably produced from a renewable feedstock, and is generally considered a compostable material. The global market for molded fiber materials in food packaging was valued at USD 1,687 million in 2018, and paper-based packaging waste made up 41% of all packaging waste, the largest share of any

material type (12). Consumers demand paper packaging for its natural look and feel, and better sustainability profile over plastic.

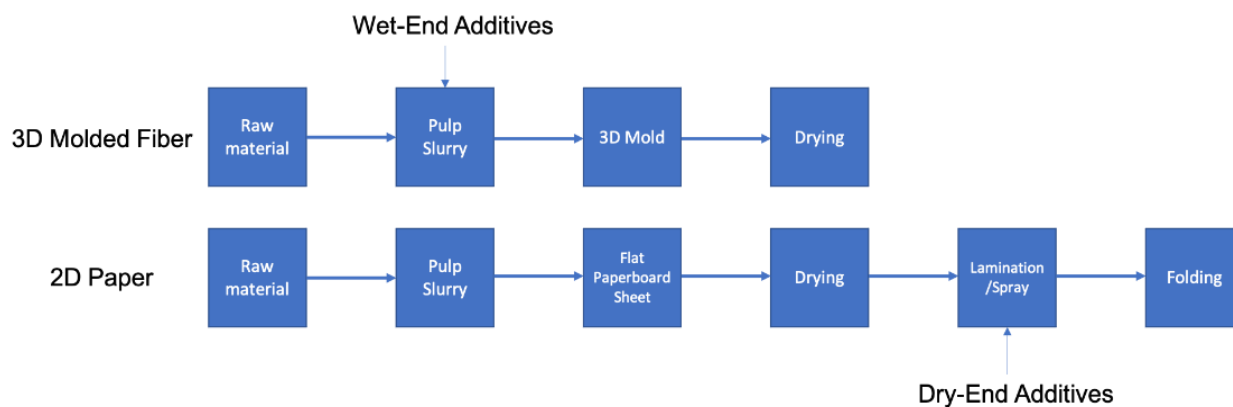


Figure 2.1: Wet end vs. dry end manufacturing, comparison of molded fiber with 2-D paper products.

Within the paper food packaging industry, molded fiber is the sector with both the highest reliance on PFAS additives, and the greatest opportunity area for unique and innovative solutions to PFAS alternatives. Two-dimensional folded paper products are produced from flat sheets of paper which are then cut and folded into boxes, bowls, and cups. Because these products proceed through an intermediate phase as a flat sheet, they are able to be laminated or coated with water and oil-repellent sprays or films. In contrast, molded fiber products are formed into a 3-dimensional shape directly from the slurry phase, which makes lamination impossible, and spray coating prohibitively costly. Therefore, molded fiber products have a strong reliance on “wet end” additives, such as PFASs, that are added directly to the slurry phase (Figure 2.1). The addition of PFASs to provide oil and water barriers to paper packaging however, poses a hidden risk to human and environmental health and complicates both recycling and composting (13). The problem of PFASs in food packaging is especially urgent due to the multiple pathways for contamination into the food system: from direct transfer by contacting food, or improper disposal leading to water and crop contamination (10). This research project outlined the search for suitable alternatives and offered the industry a guide to the current landscape of technology available for sustainable oil and water-barriers and a framework for how to integrate them into existing processes.

Who was Involved:

This project was initiated by Berkeley Center for Green Chemistry as part of Greener Solutions, a project-based graduate level class on green chemistry solutions to problems posed by industry, offered through the School of Public Health at UC Berkeley. The team dedicated to researching

PFAS-free solutions to food packaging was mentored by household product manufacturer Method and food packaging industry experts from World Centric, and guided by foundational reports written by the Department of Toxic Substances Control and Safer Chemicals Healthy Families (2,3). The student team consisted of: Minerva Teli, a first year Environmental Science PhD student, Aaron Maruzzo, MPH student at the Environmental Health Science program at UC Berkeley School of Public Health, Anna Kurianowicz, a fourth year undergraduate Biochemistry & Molecular Biology student at UC Berkeley, and Kelly Chou, a fourth year undergraduate Chemistry student at UC Berkeley.

What was the Solution:

Molded fiber production is deeply interconnected with the greater paper-making system. At the start of the system, trees are harvested and transported to pulp and paper mills (14). The raw plant material is then processed to strip and separate cellulose fiber from waste products (lignin, pigments, etc.). Cellulose fiber has been used by the paper industry for specific characteristics: white in color, foldable, lightweight, absorbent, writable, and printable. In print paper making, flexibility and hydrophilicity are the primary desired functional characteristics. For food packaging, however, the technical needs of the material are very different. Structural rigidity and water/oil repellency are the primary desired qualities characteristics. To achieve this new functionality, additives such as PFASs or plastic coatings are most commonly used. Moreover, once the paper has been produced and used, the fibers can be recycled and turned back into paper pulp to produce new paper, cardboard, or molded fiber products (Figure 3.1).

The team studied the paper-making system in depth and identified two primary strategies with which to intervene. The first was to introduce new functional additives to the system in a way that did not require additional processing by the molded fiber manufacturer. Solutions under this strategy can reduce initial costs of incorporating new materials into the process and may offer a familiar add-in procedure for imparting barrier properties. These “externally sourced solutions” included rhamnolipids and pectin. The second strategy was to repurpose or reprocess existing materials within the paper production cycle. These solutions have potential to reduce costs in the long term by creating new value from waste products in the paper production system, while simultaneously improving the sustainability profile of the product as a whole. An added benefit from this solution is that common chemicals and processes from the industry can be reused, rather than new solvents and processing materials which would require new protocols and treatment. These “internally sourced solutions” consisted of cellulose nanocrystals (CNC’s) and lignin.

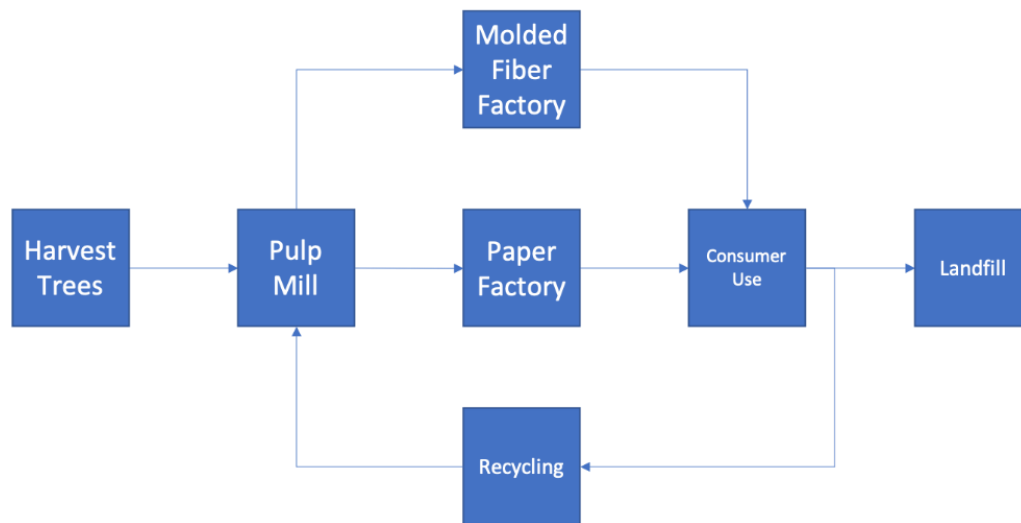


Figure 3.1: Paper system map.

Strategy 1: Externally Sourced Solutions

The team first researched opportunities to impart barrier properties with materials from outside the paper-making system. Solutions of this type are potential drop-in replacements for PFASs and work similarly in terms of procurement and incorporation into the molded fiber product. Direct additives have lower startup costs and don't require investment into additional processing steps, but do incur new material costs for the product. Rhamnolipids and pectin are two proposed solutions from this strategy.

Rhamnolipids

Rhamnolipids are a microbial bio-surfactant produced by *Pseudomonas aeruginosa* bacteria (15). The team chose this solution to imitate a PFAS surfactant-type mechanism using a natural product. Additionally, rhamnolipids and related biosurfactants have great potential by nature of their sustainable production, degradability, and biological tunability based on the microbe and substrate. While surfactants generally refer to compounds with a polar head group and nonpolar tail group, and are most commonly used to bind oil and water together, the original long-chain PFAS compounds, PFOS and PFOA, were also considered surfactants (16). These compounds bind to cellulose on the surface of paper by a polar head group, and their fluorinated tails point away from the paper surface to form a water and oil repellent layer. Rhamnolipids feature a rhamnose head group that is structurally very similar to cellulose, and long hydrocarbon tails that can repel water (Figure 3.2). The team proposed that the rhamnose head group could be bound to the surface of cellulose via dehydration synthesis using a strong acid. Meanwhile, the hydrocarbon tail groups could be further functionalized or layered to incorporate added functionality, such as oleophobicity in the future. While applications of biosurfactants in industrial processes are rapidly expanding, their use as food packaging additives is largely unknown. Because little research had been done on rhamnolipids in this context, a structurally

similar, and well-documented palmitic acid and mineral system was chosen as a proxy to illustrate the proposed technical performance of rhamnolipids (17), but ultimately was not appropriate as an alternative, due to its effects on human health, and its unsustainable sourcing.

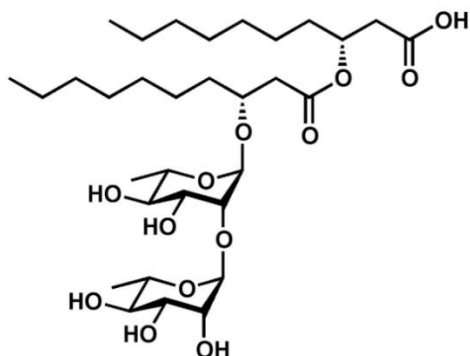


Figure 3.2: Rhamnolipids structure.

Rhamnolipids and related biosurfactants are a potentially highly sustainable alternative to PFASs which work by the same mechanism as older long-chain fluorinated compounds such as PFOA and PFOS. The strategy is currently limited by the lack of research on its use in this context, but can also approach greater feasibility with future investigation into its incorporation into cellulose fibers, perhaps by adopting features of the palmitic acid system, such as the addition of minerals to aid attachment to the paper surface.

Pectin

The second solution, in contrast to a surfactant mechanism, involved using pectin to fill pores within the molded fiber matrix to achieve a water and oil barrier (Figure 3.3). The team arrived upon this solution by studying how polymers and plastic films repel oil and water. Paper materials are extremely porous, allowing extremely fast and total wetting. Reducing these pores can slow or completely prevent water or oil penetration. Pectin is a rigid biopolymer found in ripening fruits and is a primary component of jams and jellies (18). The degree to which pectin forms a hard gel can be controlled by the concentration of calcium ions and pH, leading to differing degrees of crosslinking in the polymer network, resulting in its application in a wide variety of flexible films that function as water, oil, and aroma barriers (19). Its incorporation into a fiber matrix rather than applied as a film may therefore be more challenging, but its tunable nature might allow for pectin's hardening capability to be adapted to work within a molded fiber matrix. The team proposed direct addition of pectin into the slurry phase of the molded fiber manufacturing process to allow for uniform incorporation with the cellulose fibers, though more research is necessary to understand potential challenges with working with this material, such as clumping and control of the degree of gel hardening.

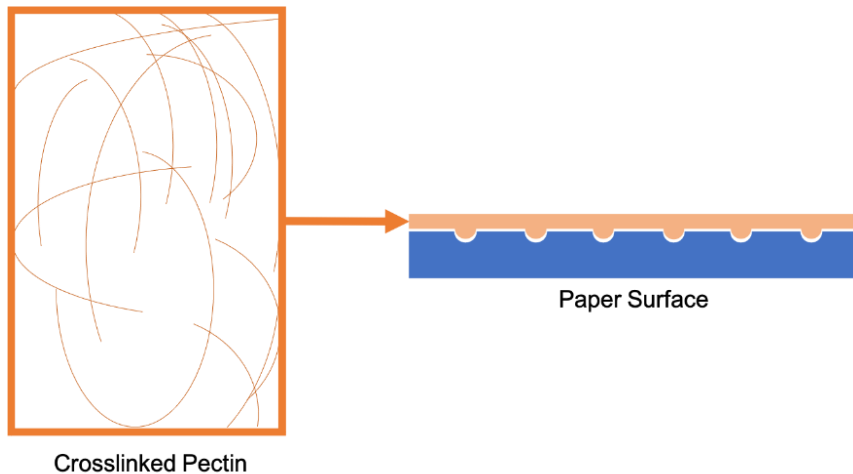


Figure 3.3: Pectin crosslinking diagram.

Strategy 1 Technical Performance

Both rhamnolipids and pectin showed technical promise based on a preliminary literature search using a proxy and film application, respectively. For rhamnolipids, a large improvement in water contact angle was observed for its palmitic acid proxy, and similar behavior may be expected from rhamnolipids. Its degradability (8-12 days) is also far better than the PLA baseline (over 150 days). For pectin, its water barrier properties are comparable to PLA, and its degradability is also greatly improved (4 days). Its strength and thermal resistance are much less compared to PLA. Nonetheless, both solutions were still early-stage proposals and required more research to understand how these solutions could be incorporated into a molded fiber process.

Relevant Property	Grease Resistance (kit value)	Water Contact Angle	Porosity (Oxygen Permeability)	Thermal Resistance	Temperature Dependence	Tensile Strength	Degradability
PLA	12+	75-85°	38-42	335°C	52.4-150°C	27-35 MPa	>150 days
Rhamnolipid	DG	120-140°	DG	240°C	90-120°C	DG	8-12 days
Pectin	DG	47-87°	DG	174-180°C	5-35°C	7.1 MPa	4 days
Key	Best Performance	Medium Performance	Worst Performance	Data Gap (DG)			

Figure 3.4: Technical Performance Table for Rhamnolipids and Pectin.

Strategy 1 Environmental, Health and Safety Performance

Both rhamnolipids and pectin solutions showed significant improvements in health hazards compared to PFASs overall. Rhamnolipids were reported to have reduced hazard on several orders of magnitude for carcinogenicity, mutagenicity, acute mammalian toxicity, and skin sensitization. They were, however, shown to cause severe eye tissue damage at certain concentrations. This hazard arises from exposure to aqueous solutions of rhamnolipids, and can be minimized by adjusting concentration and implementing proper workplace safety measures to protect worker populations that may be exposed. Pectin also displayed several orders of

magnitude differences in safety compared to PFASs in all hazard endpoints, with the exception of skin and respiratory sensitization. These hazards likely arise from its powder form and are not a concern once the pectin is bound in a gel. Calcium carbonate and ethylene glycol are necessary additives to the production of pectin films. While some health concerns for these materials exist, the overall tradeoffs are minimal when compared to the safety gains from replacing PFASs.

		Carcinogenicity/ Mutagenicity	Developmental/ Reproductive Toxicity	Acute Toxicity	Systemic Toxicity	Skin/Eye Sensitisation and Irritation	Aquatic Toxicity	Persistence
Existing Chemicals	6:2 Fluorotelomer methacrylate	H	H	M	H	H	V	V
Externally Sourced Solutions	Rhamnolipid	M	DG	L	DG	H	L	L
	Pectin	M	M	L	L	M	L	L
	Calcium Carbonate	L	M	L	L	M	L	V
	Ethylene Glycol	L	V	M	M	M	L	L
	Key	Hazard:	Low(L)	Medium (M)	High (H)	Very High (V)	Data Gap (DG)	
		Confidence:	Low	High				

Figure 3.5: EHS Performance Table for Rhamnolipids and Pectin.

Strategy 2: Internally Sourced Solutions

The team identified opportunities to improve molded fiber functionality without adding new materials to the paper-making production system. By reusing waste materials like lignin and cellulose and finding new functions for familiar processes, the overall molded fiber production process would become more circular and hazards from introducing new compounds and protocols could be greatly reduced. For example, sulfuric acid is a highly corrosive, strong acid that is the industry-standard stripping agent for isolating cellulose. Although safer alternatives to this process chemical have been found, the team believed that identifying a replacement for a fundamental chemical in the papermaking industry would be outside the scope of this research. Instead, the focus was placed on the end product's safety compared to the PFAS baseline and its overall compatibility with the existing papermaking system.

Cellulose Nanocrystals (CNC)

Native cellulose fiber, the primary component of paper and molded fiber products, is a ubiquitous biopolymer made up of crystalline and amorphous regions (20). Cellulose nanocrystals (CNC) are produced by isolating crystalline segments from native cellulose fiber, typically by acid digestion. Films were shown to become more rigid and hydrophobic following the incorporation of CNC's (21), leading the team to investigate its potential for use in molded fiber. The team further proposed that a particular strength of this method is its sustainable and easy sourcing. CNC's are versatile and can be produced from a multitude of cellulose sources, including recycled paper (20). This means molded fiber manufacturers may be able to produce CNC's in-house, or from the same pulp feedstock as their molded fiber materials. This adds greater control over specific properties of their product, and greatly reduces the impact of materials transportation compared to purchasing additives from an external source. CNC's have

an added benefit of adding structural stability to products made from recycled paper as well. Recycled fibers tend to be shorter and weaker compared to virgin fibers, so CNC's offer a valuable opportunity to transform shortened fibers into strengthening agents for use in the same final product. This method of modifying an existing material (cellulose) in the system to serve as a new and useful additive within that same system represents an important step toward closing the recycling loop in the molded fiber production process.

Lignin

Lignin is a naturally occurring, rigid, and hydrophobic biopolymer found in the cell walls of plants (5). It is a necessary component of plant structure, alongside cellulose. In contrast to naturally hydrophilic cellulose, lignin's hydrophobicity is crucial to allow plants to control water uptake. Lignin is usually extracted as a waste product in paper production (5). Its properties, while generally undesirable for traditional paper products, are well suited for use as a barrier additive for molded fiber. There is also great potential for use of "light-delignified cellulose" as a new virgin feedstock for molded fiber materials specialized for food packaging (22). This refers to cellulose fibers that are processed to partially remove lignin. This ensures that the natural bonds between cellulose and lignin are preserved, which leads to a stronger product. Light-delignified cellulose use in molded fiber has been successfully achieved, and reported with promising technical performance (22). As with CNC's, rethinking the role of a waste product, and identifying its potential for re-incorporation as a valuable additive to its original system could greatly improve the overall sustainability of the molded fiber process.

Strategy 2 Technical Performance

CNC's technical performance assessment was based on film applications due to availability of data in the literature. CNC's showed comparable performance for grease resistance and water contact angle, and markedly improved degradability (2 days) compared to the baseline of PLA (over 150 days). CNC's thermal performance and tensile strength are lower compared to PLA, but still within acceptable ranges. It has high water vapor permeability, however, indicating that performance may be negatively impacted by humid environments. Lignin was the most currently feasible option for use in molded fiber, and was the team's final recommendation for the industry. It has been implemented in molded fiber, with performance equal to and better than PLA in grease resistance, water contact angle, porosity, thermal properties, and tensile strength. It also shows improved degradability (23 days) compared to PLA.

Relevant Property	Grease Resistance (kit value)	Water Contact Angle	Porosity (Oxygen Permeability)	Thermal Resistance	Temperature Dependence	Tensile Strength	Degradability
PLA	12+	75-85°	38-42	335°C	52.4-150°C	27-35 MPa	>150 days
Cellulose Nanocrystals	11	65°	DG	250°C	30-60°C	15.6 MPa	2 days
Lignin	12	89°	26	260-290°C	85°C	20.3 MPa	23 days

Figure 4.1: Technical Performance Table for CNC's and Lignin.

Strategy 2 Environmental, Health and Safety Performance

Both CNC's and lignin have a far better overall hazard profile compared to PFASs. While some health concerns arise from CNCs' categorization as a nanomaterial, a 1-2 order of magnitude reduction in hazard is observed for nearly all hazard endpoints. The tradeoff of using this compound is an increased score for skin sensitization. This hazard is currently not believed to pose a risk to users, and may be mitigated for worker populations with safety controls, but more research on the nature of this hazard is needed. Lignin is widely considered a completely benign substance. Its hazards, therefore, are minimized compared to the PFAS baseline. A tradeoff present for both CNC's and lignin, however, is the use of sulfuric acid in their required processing steps. Sulfuric acid is well established as a strong and highly dangerous compound. While safer alternatives to sulfuric acid have been reported, the team cited widespread use of the strong acid as justification for inclusion in their comparison to baseline hazards. They reasoned that if companies were to implement either solution immediately, they would likely use sulfuric acid due to its ubiquity in papermaking processes, and therefore the team did not wish to misrepresent the likely hazards that would arise from using sulfuric acid. The team suggested further research into replacing sulfuric acid on a large scale throughout the fiber material and papermaking industry as a next step.

		Carcinogenicity/ Mutagenicity	Developmental/ Reproductive Toxicity	Acute Toxicity	Systemic Toxicity	Skin/Eye Sensitisation and Irritation	Aquatic Toxicity	Persistence
Existing Chemicals	6:2 Fluorotelomer methacrylate	H	H	M	H	H	V	V
Internally Sourced Solutions	Cellulose Nanocrystals	M	M	L	M	M	M	L
	Lignin*	L	L	L	L	L	L	L
	Sulfuric Acid	M	M	V	V	V	H	V
	Key	Hazard:	Low(L)	Medium (M)	High (H)	Very High (V)	Data Gap (DG)	
		Confidence:	Low	High				

Figure 4.2: EHS Performance Table for CNC's and Lignin.

What was Innovative about the Solution:

PFASs and other fluorinated compounds have long been used as cheap, convenient, and one-size-fits-all additives for water and oil barrier properties. However, industry's heavy reliance on PFASs, even in cases where it overperforms for its intended function, has led to a lack of diverse, sustainable, and tailored solutions for specific product sectors. Phase-outs of PFASs have led to an urgent need for alternatives in the food packaging industry, but this simultaneously offers an opportunity for innovation in safe, high-performing barrier materials designed for food applications. The team's work in researching PFAS alternatives led to insights which may result in more precise solutions that reduce the waste generated from overperforming materials, and provide a level of barrier performance more appropriate for selective food packaging

applications.

The internally sourced solutions outlined by the report were particularly innovative because they reimagined the function of existing components of the papermaking system. These solutions offered a balance between human and environmental safety, technical performance, and economic feasibility. The use of CNC is innovative for its direct modification of cellulose, the primary component of all paper and molded fiber materials. Cellulose is generally considered to be a highly hydrophilic material, but when processed into its nanocrystalline form, its inherently rigid and hydrophobic properties can be fully employed. By stretching the material properties of the base material to their full potential, there is potential to save both cost and hazard by altogether eliminating the need for an external material such as a PFASs. The lignin solution innovates even further by turning a waste product of paper production into a valuable functional component for molded fiber. Lignin is typically removed to isolate pure bulk cellulose fibers, specifically because its rigid and hydrophobic properties are undesirable for general paper production. By matching those needs with that of food packaging, however, the proposed solution offers a potential new value stream for paper producers, and cost savings for molded fiber manufacturers.

Both strategies, by nature of their careful connection with the existing paper system, are also inherently compatible with the existing processes and manufacturing norms of molded fiber. Because the solutions draw from the existing pool of materials familiar to the industry, the alternatives are able to easily adjust as the industry shifts toward more sustainable chemicals and processes. In this way, the solutions proposed by the team represent innovative ways of approaching the problem of water and oil barriers and filling the need left by the replacement of PFASs.

What was the Impact:

The Greener Solutions team report and presentation to industry has begun a critical conversation on how eliminating use of PFASs in food packaging could be achieved. The team targeted molded fiber materials due to their high rate of PFAS use and their unaddressed processing needs. While a number of sustainable PFAS alternatives for food packaging already exist, such as biopolymers and waxes, they are generally applied as sprays and film coatings. Molded fiber products are directly formed into three-dimensional shapes, so film and spray applications are often difficult and prohibitively costly to implement. Therefore, the industry will benefit from early research and investment into alternatives to better prepare for future costs required by new formulations and processing equipment. By targeting a sector that relies so heavily on fluorinated compounds, the team offered solutions for an industry locked out of many established PFAS alternatives, which opens possibilities for large cost and material savings.

In 2018, molded fiber packaging materials were valued at USD 4.02 billion in 2018, with an expected CAGR (Compound Annual Growth Rate) of 4.9% from 2019 to 2025. Food packaging applications of molded fiber materials make up over 50% of the total market share of molded fiber (USD 2.01 Billion) (23). Pricing an average 0.5 oz. molded fiber clamshell box at 16 cents, this would result in the total number of clamshell box sales in 2018 to be 12.5 Billion boxes (24). Estimating that PFASs are added at a concentration of 0.2% by mass, would result in a savings of over 40 metric tons of PFAS material per year. Preventing PFASs from eventually entering the environment by replacing non-essential applications is far more effective and less resource intensive than removing it. Substitution of PFASs in even a small percentage of the molded fiber industry has the potential for great environmental impact due to the large market size of this product sector.

Method, the industry partner for this project, was keen to support this research for its potential to replace plastics as well. While these proposed solutions were created with PFAS substitution in mind, plastics are also related by the shared challenge of materials that can provide degradable water and oil properties. “At Method, we want to make products benign by design, from the formulation to the packaging... materials that can impart barrier properties with a sustainable end of life are definitely of interest to us,” said Kaj Johnson, Green Chef at Method. As such, the impact of finding PFAS alternatives reaches beyond current PFAS-containing products and to sectors beyond food packaging. The project is positioned to guide industry in the search for greater sustainable packaging and materials, by offering solutions that address the specific technical performance and consumer needs essential to the product while designing out chemicals of concern.

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