Advancing sustainability in fibre based food packaging with PFAS and plastic free chemical concepts

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INTRODUCTION:

In the realm of food packaging, the quest for sustainability has become paramount as we seek alternatives to traditional materials that are both environmentally friendly and functional. Brands need to find ways to align their packaging solutions with their sustainability commitments. Fibre based food packaging, derived primarily from renewable resources, has gained prominence for its eco-friendly attributes. The versatility of paper makes it adequate for different kinds of applications such as fast foods, frozen food and liquid products. However, a critical consideration in the realm of food packaging is its ability to resist different liquids, fats, water vapour and oxygen, a property traditionally associated with less sustainable materials. This plays a vital role in whether the packaging meets the criteria for each application or not.

Chemical solutions for oil and grease resistant fibre based packaging

Fibre based packaging lacks inherent resistance to oil and grease, necessitating the incorporation of additional components to provide them grease resistance. Oil and grease resistance, OGR, is the ability to inhibit the penetration of grease, oils, and fats. This is important to protect against the accidental transfer of oil, grease, and fats from the product or package to the user, and to stop the aesthetic spoiling of the packaging caused by oils, grease, and fats penetrating the substrate. Without a proper protection, oils and liquids can soak into the package and cause the paper fibres to degrade, compromising the package's structure and creating stains and blotches.

The key to expanding the use of fibre based packaging for new and more demanding end-uses is chemistry. Chemistry enables renewable fibre based packaging that not only meet high standards of functionality, durability, and safety but also maintain complete recyclability.

Moving beyond PFAS and plastic dependency

Historically, the most common commercial method for imparting oil and grease resistant properties to fibre based food packaging involves the use of plastic or harmful compounds such as per- and polyfluoroalkyl substances, PFAS.

Plastic is the predominant raw material in packaging applications, primarily owing to its cost-effectiveness and protective

attributes. Plastic films are typically applied to fibre based packaging by extrusion or lamination technology. However, plastic films can cause issues with repulpability and compostability of the final product. The non-recyclable and non-biodegradable characteristics of plastic raise significant concerns about environmental impact, contributing to pollution in both landfills and aquatic ecosystems. The degradation process of plastic is a lengthy one, ranging from tens to hundreds of years, influenced by environmental variables such as sunlight, heat, and pH conditions. Compounding this issue, the effects of global warming and acid rain, resulting from climate change, further slow down the degradation of plastic. Consequently, plastic pollution in the oceans inflicts harm on organisms, and sea life. EU rules on single-use plastic products (SUPD) aim to prevent and reduce the impact of certain plastic products on the environment, in particular the marine environment, and on human health.

PFAS are a diverse group of synthetic chemicals with strong carbon-fluorine bonds that are chemically inert and resistant to high temperatures. PFAS based chemicals are commonly applied in the wet end or as a surface sizing together with starch. However, they are often referred to as “forever chemicals” due to their bio persistence, leading to irreversible environmental exposure and accumulation. Furthermore, exposure to PFAS has been linked to carcinogenic effects and potential disruption of the human endocrine and reproductive systems. This has led to a number of proposed bans and restrictions in several countries, including a restriction proposed by five EU-countries and submitted to ECHA on January 13, 2023.

To enhance sustainability and diminish the environmental impact of plastics and PFAS, it is imperative to seek alternative chemistries for fibre based packaging.

PFAS and plastic free chemistry adapted to end-use requirements

There are various application methods employed to impart PFAS and plastic free oil and grease resistance to fibre based packaging. The choice of application method depends on various factors, including the properties of the additives, the desired level of resistance, the type of packaging being produced, and the specific requirements of the end-use applications. Each method offers a unique approach to achieving effective oil and grease resistance. Manufacturers may choose the method that best suits their production processes and the characteristics they want to impart to the final paper product.

At BIM Kemi, we have developed different chemical concepts adapted to specific customer requirements; wet end additives, barrier coatings and combination systems for high demand barrier properties.

Wet-end additives

The oil and grease resistant additives can be added directly to the pulp slurry at different stages of pulp preparation. This allows for uniform distribution of the additives among the paper fibres. By incorporating these additives into the wet end of the papermaking process, it enables paper manufacturers to produce grease resistant paper or board, such as food wrapping paper, pizza cartoons etc, without the need for barrier surface applications on- or offline while maintaining high speed production. It also enables the production of grease resistant 3D moulded fibre products for fast food/food on the go applications, without the use of a plastic lamination on the surface or PFAS in the wet end.

BIM Kemi has developed a novel wet end additive that provides grease and oil resistance, BIM Oilguard™ (European patent pending). The additive is based on cationic micro dispersions with excellent attraction to the cellulose fibre enabling a good distribution in the pulp suspension and adsorption to the cellulose fibre before forming the paper, board or moulded fibre product. Studies have shown that no retention aids are needed and oil uptake can be reduced by 80 % on bleached kraft virgin pulp sheets and by 75 % on recycled kraft paperboard, see image below.

300 gsm sheets	Untreated	Treated with BIM Oilguard™
Backside after hot oil test		
Hot oil 5 min (g/m²)	110	28
Cobb60 (g/m²)	318	18
Oil drop test	7 min	6 hours

Oil and grease hold out comparing untreated paper with paper treated with BIM Oilguard™

The additive also gives water resistance but is favourably combined with a traditional sizing agent for optimal water sizing. Performance testing of sheets made from different pulp source treated with the wet end additive show that different pulp types have different optimum dosage levels and give rise to different OGR properties. It is well established that unbleached pulp demonstrate better inherent water sizing ability and in general, requires lower amount of sizing additive. This is also observed when finding the optimum dosage level for BIM Oilguard™. Fine tuning combinations of pulp types and level of refining in combination with BIM Oilguard™, excellent oil and grease resistant properties can be achieved. Additionally, high density and good formation are other important parameters when producing oil and grease resistant fibre based food packages using a PFAS free wet end additive.

Barrier coatings

Barrier coatings are made from water based dispersions that are laid on the surface of paper- or board to provide a protective layer against water, moist, oils/fat (OGR) and oxygen. Barrier formulations typically consist of aqueous polymer dispersions (Latex) that forms a non-porous film after evaporation of water. Latex is a stable aqueous dispersion of organic polymer particles. Typically used polymers are modified ordinary styrene-butadienes, different acrylates and methacrylates, polyolefins, vinylene acetates, copolymers of these or natural biopolymers. Chemical composition of barriers chemistry can be tailor made depending on the demand placed on the barrier and expected packaging life term requirements.

Different additives, such as waxes and pigments, can be added to improve functional properties including oil, grease, water- and moist resistance. Choice of additive is dependent on desired property of the end product. Waxes are typically added to boost hydrophobicity and oil/grease resistance. Pigment (fillers) may be added to increase properties such as runnability and

The BIM Barrier Standard helps us identify which properties are required. To meet the requirements up to three different barriers can then be applied in up to three layers.

cost-effectiveness. Barrier coatings that are made of a blend of polymeric latexes and pigments have high surface energy (lower hydrophobicity) and are widely used as a primary layer to even out paper surfaces and facilitate deposition of a second overlaying coating layer.

Barrier coatings based on thermoplastic polymers are often heat sealable with technologies such hot-bar welding, impulse welding and ultrasonic. Effective sealing can be achieved at approx. 100-150 °C depending on contact pressure and dwell time. Heat sealing are typically used in food packaging applications including flexible pouches and bags, as well as tray and bowl sealing for food packaging.

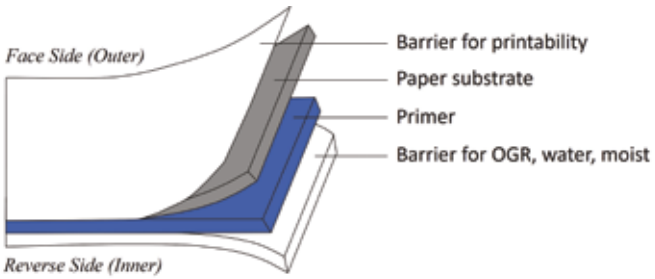
The increased focus on recycling and sustainable packaging has driven the trend to replace fossil raw materials in water based coatings with renewable analogues. Alternative biopolymers, like polysaccharides and lignins, along with bio based waxes can be used for fully or partially biobased coatings. Today, the higher cost, more difficult processing and lower performance in comparison to fossil based, hinders exploitation in many industrial applications. For applications with high sustainability demands, biobased barrier coatings are still interesting alternatives to consider. Introducing viable fully or partly bio based barriers is a focus area in the industry.

Application of barrier coatings on paper surfaces can be achieved with conventional coating methods in-line or off-line such as Bar or Blade, Roll, Air-knife, Flexographic and Spraying. Drying can be achieved with Infrared, Contact drying or hot air ovens. These method provides a controlled and precise application of the additives to the paper surface. The deposited of respective layer have a large effect on barrier resistance depending on paper substrate and demand and typically varies between 2-15 g/m2 (dry).

Barrier coatings represent a complex technology with thousands different types of waxes, polymers, and pigments. Formulating modern, highly efficient, and sustainable products demands specific scientific skills and expertise. BIM Kemi has developed an extensive barrier coating program that is intended for fibre based packaging, BIM Barrier™. Functional barrier concepts has been a focus area in the company for over 40 years.

BIM Barrier™ is applied on the surface of paper or board in order to add functions like oil and grease resistance, moist and water resistance. Depending on the end-use and desired properties of the packaging materials, different types of barrier coatings, or even a combination of barriers, can be necessary. Therefore, we at BIM Kemi have defined the BIM Barrier Standards. This is a tool to help eliminate over-packaging and achieve optimal use of resources by identifying the requirements for each product.

The Barrier Standards required for a packaging material are defined by the demand placed on the barrier and the expected packaging life term. Depending on requirements we can tailor a solution with one layer, two layer or combination of two layers or even three layer to create the perfect mix of properties. A typical multilayer concept intended for food packaging is shown in image 4 and consist of a pigment based pre-coating with one or two over layers to provide oxygen and OGR/water/moist resistance.



Example multilayer concept for food packaging that consists of primer layer and WOGR barrier deposited on paper substrate towards the inside and a printable (pigment based) outer layer.

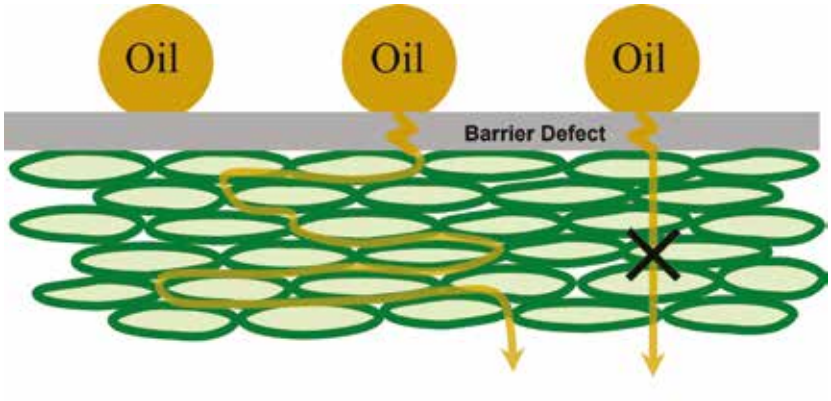
Combination system

Combining wet end additives and surface coatings in paper and board manufacturing can offer enhanced oil and grease resistance to the final product. The combination allows for a comprehensive approach to enhance resistance throughout the entire paper structure. Combining wet end additives and surface coatings allows for customization without compromising other essential characteristics of the paper and is advantageous for high demand barriers.

Barrier coatings can only provide OGR to the surface of the substrate and offer no internal protection, i.e., protection from the migration or “wicking” of oils and fats through contact with any cut edges inside the packaging. Here, an internal treatment to the pulp is necessary to give wicking protection. Additionally, adding a wet end additive to the pulp, can enable low grammage weight surface barrier coatings while achieving desired OGR properties. For high demand barriers, a combination of wet-end additive and surface coating is advantageous.

BIM Kemi has developed a new technological innovation significantly improving oil and grease resistance of fibre based paper and board packaging products by combining wet-end treatment, BIM Oilguard™ with barrier coatings, BIM Barrier™.

BIM Dual Barrier is especially advantageous for packaging types where it is hard to achieve an even coating, such as 3D-shaped products and low-weight surfaces but can be used for all types of fibre based packaging with higher demands.

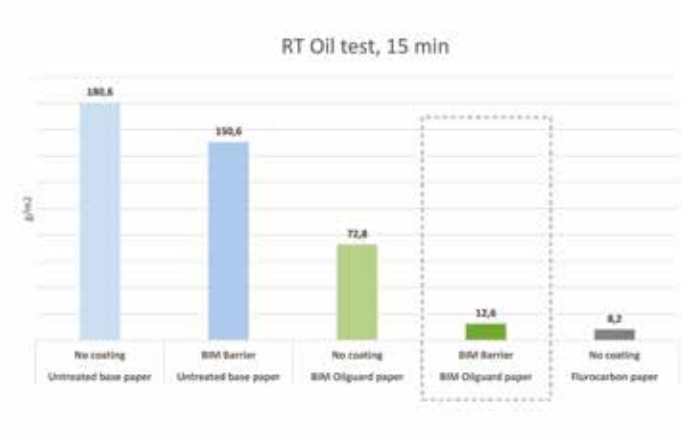


Mode of Action: The proposed oil barrier mechanism of the BIM Dual Barrier Concept shows a cross section of fibre product with BIM Oilguard™ in the fibre matrix and BIM Barrier™ coated on the surface.

Customer values of BIM Dual Barrier

- Superior oil- and grease resistance
- Protects against oil penetration through film/surface coating defects and edge wicking
- Enables low-weight barrier coatings
- Additional barrier properties, e.g. moist (WVTR), water and oxygen (OTR) resistance.
- Re-pulpable and recyclable
- Food contact approved BfR XXXVI, FDA 176.170
- Compostability can be achieved

With BIM Dual Barrier Concept, similar OGR resistance as PFAS treated fibre based packaging can be achieved with a substantially higher sustainability profile.



Case study of BIM Dual Barrier concept. Test of BIM Barrier™ coating on BIM Oilguard™ treated paper, 190 gsm compared to PFAS treated paper.

OGR test methods

The industry standard of via 3M KIT method is widely used for testing OGR on flat and folded surfaces. 3 M KIT method was developed mainly for measuring treatment of fluorochemicals. In recent years alternative methods such ASTM F- 119 and Cobb-Unger oil absorbency tester have been widely used. In contrast to 3 M KIT method the latter methods use more realistic test oils and are more adequate for estimating oil penetration and evaluating efficiency of barriers and wet end additives.

Collaborative action for a sustainable future

In conclusion, fostering collaboration between producers and chemical suppliers is crucial for advancing sustainable and functional fibre based food packaging solutions. Producers should be able to expect comprehensive support and consultancy from their chemical partners, particularly regarding application setup and optimization. It is important for chemical suppliers to provide cost- and time efficient tools to assess the function of the different solutions for grease and oil resistance before committing to a full scale test.

BIM Kemi offers a full service and support package including

- Oil and grease evaluation methods
- Pre-study lab evaluation
- BIM Repulpability & Recyclability test
- BIM Compostability test
- Application support

As a supplier of speciality chemicals, we recognise the potential we and our chemistry hold in enabling the transition to PFAS and plastic free fibre based food packaging, thereby contributing to a more environmentally sustainable future.

BIM Kemi is a family-owned entrepreneurial company that has been developing and producing specialty chemicals for the global pulp and paper industry with a focus on sustainable solutions since 1973. Over the years, BIM Kemi has been listed four times among Europe's top 500 rapidly growing entrepreneurial companies and received several awards for its dedication and contributions to the business world and the industry. With a global workforce of approximately 220 dedicated professionals, BIM Kemi operates across the world, with production units located in Sweden, Norway, Finland, England, and South Africa, and local operations in Germany, Poland, Belgium, the Czech Republic, Portugal, and France and agents and distributors in most other countries with pulp and paper manufacturing. The headquarters are located in Stenkullen, outside Gothenburg, Sweden, and house the central research and development department, customer service lab, and one of five production facilities. We are members of the UN Global Compact and have a gold rating by Ecovadis. BIM Kemi is your dedicated partner in innovative and sustainable chemistry solutions for the pulp and paper industry.