Barrier coatings and their role in the paperization of packaging

Oliver Waddington, Head of Business Development - WB Barrier Coatings at Siegwerk

INTRODUCTION:

A growing environmental consumer awareness and rising regulatory requirements for the design of packaging continue to drive the demand for more sustainable packaging alternatives designed for circularity. As a result, brand owners and packaging designers are increasingly looking for ways to "paperize" their packaging by using renewable and recyclable fiber-based materials instead of plastic.

Mega trend "Paperization"

The primary purpose of packaging is to protect, preserve, and promote the packed goods - a job plastic packaging does very well in many application areas. But plastic packaging also comes with major challenges as it's often not recycled, or even worse, ends up in the environment and the oceans. The reason for this is the outdated economic "take-make-use-dispose" principle, which is responsible for roughly 90 percent of plastic packaging being thrown away after a single use. We are currently in a transformation phase moving towards a circular economic model that enables circularity of packaging by using recyclable and renewable materials so that resources can be used as long as possible and packaging "waste" has an economic value and does not end up in nature. Regulatory requirements for the recyclability of packaging are becoming increasingly strict worldwide, making it more urgent than ever to rethink the future design of packaging now.

In this context, the switch from plastic-based to fiber-based materials - generally called paperization - is one of the biggest trends we see in the market today. Afterall, paper already has a very well-established recycling stream in many places around the world. So, wherever the required packaging functionality can be achieved by switching from plastic to paper or paperboard packaging, we can already leverage a proven material recovery stream. However, to unlock the full recycling potential, "paperized" packaging solutions need to support the recycling process with repulpability and properties ensuring compliance to existing recycling streams - otherwise paperization misses its target. Examples of successful transition from plastic to fiber-based packaging alternatives are appearing the market, and in the media, what feels like everyday. From pouches for dry food like cereal and pasta, to sugar confectionary and chocolate; to containers for foodservice and food-to-go; trays for fresh fruits and vegetables; to non-food applications like tissue and hygiene paper packaging.

Barrier and functional coatings as enabler

As most paper and paperboard grades are inherently porous and hydrophilic, they often have little to no barrier properties compared to multi- or mono-layered plastic-based packaging, which clearly limits their performance potential and thereby the suitable application range for packaging. To achieve the required functional properties, such as barrier, for suitable pack performance such as shelf-life; metallized substrates, polyethylene (PE) or other polyolefinic co-extruded or laminated barrier layers have been commonly used to coat paper and fiber-based materials - often with negative consequences for the recyclability of the final packaging

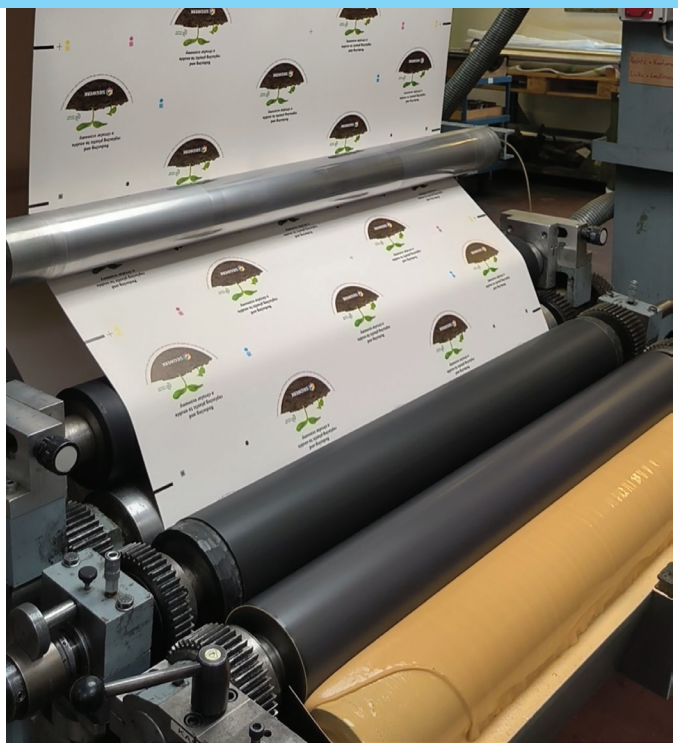

Figure 1: Siegwerk's innovative barrier coatings enable the transition from plastic-based to fiber-based packaging.

structure. A safe and sustainable way to get around the performance limitations of paper and fiber-based materials is to use water-based functional coatings as they can create the required barriers between the filling good and the packaging whilst also ensuring recyclability.

In other words, barrier coatings can equip renewable and fiber-based materials like paper and board with functional properties to achieve suitable shelf-life and packaging performance to replace or reduce the use of plastic. Therefore, barrier coatings play an essential role in widening the packaging paperization scope, enabling the use of paper and paperboard for a wider range of packaging applications and thus support the development of recyclable and circular packaging solutions in a well-established and proven recycling stream.

When talking about barrier performances for paper packaging it is not only about protection against the outside, but also protection against the inside. Protecting the filling good from the outside includes, for example; barriers against water and water vapor, oxygen and other gases, as well as aroma, oil, grease, and UV light. In turn, for the protection of the packaging material from

the filling good inside include, for example; barriers against water, oil and grease, as well as against acids, bases, or alcohol, depending on the packed product. So, the requirements for functional coatings always depend on the intended use of the packaging, whether it comes into direct contact with sensitive filling goods, such as food, the environmental conditions it is exposed to along the supply chain and, of course, the shelf life of the packaged goods. Just look at a paper cup that needs to be impervious to liquids, a cheeseburger wrapper that needs to be resistant to grease, a pouch of coffee that needs to maintain aroma, a tray of fruit that needs to be resistant to water and a cement sack that needs to withstand moisture vapour.

In some cases, a single barrier type is sufficient, but in most packaging applications a combination of several properties is required. This also includes the extension of the barrier performance of a coating with sealability – a very important attribute for many packaging converting processes – or adding another coating, for example; with slip or a anti-slip function to facilitate downstream converting on a filling line, or supply chain demands such as palletization.

Effective paper barriers with full recyclability

As one of the world's leading manufacturers of printing inks and coatings for packaging applications and labels, we at Siegwerk know exactly what it takes to utilise functional coatings in packaging and we work closely with industry partners to ensure our coating solutions are designed to be compatible with material recovery systems, especially paper recycling.

Our portfolio of water-based barrier coatings already includes solutions for the protection of cartonboard and corrugated board as well as flexible paper packaging materials against liquids, oil and grease, water vapor, and oxygen. Whether used for paper cups, fast food wrappers, corrugated boxes, sachets, pouches, or flow packs, they all meet the functional needs of the application, such as; barrier performance, flexibility, and sealability, without compromising recyclability, and where it makes sense, also compostability.

Take for example the resistance to liquids - one of the most important requirements for barrier coatings when it comes to fiber-based packaging due to the hydrophilic nature of most papers and boards. Whether it's a hot or cold, acidic, or oily liquid, the packaging needs to keep fluids in, or out effectively. However, water is also a key part of the fiber recovery process, so we need to find the right balance between using coatings to enable packaging performance without preventing repulpability. At Siegwerk, we have a dedicated team of experts constantly developing and optimizing our coating solutions and looking for the best ways to ensure we support circularity in the fiber-based packaging value chain.

	Considerations for barrier performance	
Common Topics	**Target**	**Consider**
Base paper / board	High quality, smooth & dense paper / board	Paper porosity, smoothness, homogeneous structure, internal sizing, surface sizing, & surface coating ("clay coated")
Coating layers	Homogenous coverage without defects and fully closed film surface	More layers = less defects. Pre-coating ("primer") or double coating. Different coating systems have pros & cons. Specialist coating (e.g., curtain, air knife, blade, rod/bar) will usually provide higher coatweight and better coverage than other methods
Coating laydown ("coatweight")	Full coverage and acceptable barrier performance	Higher coatweight usually means better barrier performance but can also increase the risk of blocking
Foam / Air	No air in the coating mix when applied to avoid defects	Use of additional defoamers may affect barrier performance, so adjustment of equipment and use of deaeration systems is preferred
Drying	Defect-free, dry surface and balanced internal paper/board moisture	Type of drying (hot air, IR, etc) and drying conditions have a significant impact on the coating performance. Temperature range is important
Blocking at rewinder	Zero blocking, as this can damage the barrier	Lower web temp and minimum coatweight reduce risk of blocking

Figure 3: Considerations for achieving good barrier performance.

Figure 2: Examples of successful transition from plastic to fiber-based packaging alternatives are appearing the market, and in the media, what feels like everyday.

Critical factors for using barrier coatings

As discussed, there are many factors that needs to be taken into consideration when developing and using functional coatings for fiber-based packaging, let's look a bit deeper into some of these for achieving barrier performance.

For example, the selected base paper or board is very important, more precisely its technical characteristics such as porosity, smoothness, homogeneous fiber structure, internal sizing, surface sizing, and surface coating, are all parameters to be considered. Another critical factor is choosing the right coat weight; a higher coating laydown usually means a better barrier effect but requires more drying capacity and can increase the risk of blocking which can negatively impact downstream converting, or even damage the barrier. In general, a lower web temperature and minimum coat weight can reduce the risk of blocking. Sufficient drying is also crucial for good barrier performance as the drying method (e.g. hot air, IR, etc.) and the drying conditions have a significant impact on the coating performance. Here, temperature range and final moisture content are key to ensure a dry surface and a balanced internal paper/board moisture. Other critical factors include the use of pre-coating, primer, or multi-layer application, as well as the selection of the right coating application system to achieve a homogenous coverage without defects and a fully closed film surface.

In summary, it is always important that the barrier coating is aligned with the paper or board substrate to be coated, as well as the planned end-use application, and also the coating, printing, and converting equipment to be used. Therefore, at Siegwerk when we start working on a barrier coating project with a customer, we always examine the substrate in detail first, check the existing machinery options, verify the possibility for customizing the coating, and the opportunity to add additional products to further benefit the converting process.

Important Topics	**Considerations for converting performance**
Base paper / board	Packaging papers and boards are often specialised and there can be significant differences between different grades, even from the same supplier. It's important we conduct any testing on the same grade as our customer
Barrier requirements	Try to find out all the **actual** requirements, as well as what is currently being used. Is a combination of different barriers required? This is often not easy. e.g., LDPE is used for commercial reasons but is actually 'over specified' for many applications. Consider some, moderate, good, excellent if specific values are not available
Sealing	Find out as much as possible about the process. e.g., temperature range, dwell time, hot tack, pressure, heat type, coating-to-coating or coating-to-fibre, "lap" or "fin" seal
Further converting	It's important to consider what other functionality might be needed for the coating in the supply chain. e.g., flexibility for folding/bending, stability at high/low temperatures, anti-static, blocking/release, CoF Also, is there a need for printing/gluing on the barrier coating
Applying the coating	Different coating methods have pros and cons. It's important to understand what method is being used and what requirements/limitations that brings. e.g., min/max coatweight, single/multiple layers, drying conditions

Figure 4: Considerations for achieving good converting performance.

Developing functional coatings

Today, we already offer a broad range of single and multi-functional coatings for all kinds of requirements that address the performance gap of paper and board and facilitate the transition to circular fiber-based packaging solutions - from flexible packaging through to folding cartons and corrugated boxes. Even though innovative barrier coatings already enable the switch from overengineered plastic to fiber-based packaging in some application areas, packaging paperization still requires extensive R&D efforts to develop barrier solutions for all performance levels, also meeting the highest packaging functionality demands. Since several years, we at Siegwerk have been focusing our attention on the development of functional and barrier coatings.

When formulating functional coatings for paper and board applications the work begins with an extremely accurate selection of raw materials, which are then modified and integrated with additives with similar functionalities to traditional silicones, waxes, substrate wetters, tension modifiers etc. to enable the creation of the required effects, such as barrier performance, but without impacting the recyclability of the coated paper or board. In addition, it is important to further enhance equipment compatibility to support invested infrastructure and always keeping in line with the newest recycling requirements for effective fiber recovery.

Another challenge is packaging safety, especially for sensitive filling goods such as food. At Siegwerk we benefit from a highly skilled team of product safety experts as well as specialized, independently audited, labs which are capable of conducting, for example; migration tests. Whether it's staying away from fluorinated materials, such as PFAS or PTFE, or using new and innovative materials which need extra attention to be fully tested and understood, our team keep us one step ahead of legislation and ensure our coatings are always developed using safe raw materials.

Depending on the end use application and performance required, our water-based barrier solutions are based on natural, renewable, or synthetic raw materials, and are also suitable for food contact. They can all be supplied ready-to-use which enables customers to use their existing application equipment such as coating, printing, and converting machines.

Sustainable innovations

Something which has always been important to us is the use of renewable and natural raw materials in our coatings. This is an exciting area with many new and innovative materials available coming into the market, but it also often represents a significant technical challenge to achieve sufficient functional performance, especially for barrier coatings, and also commercial challenges such as security of supply and cost. With our UniNATURE Water-Oil Barrier Coating we have launched last year our first barrier solution with certified natural content for single-use paper plates. It has proven to effectively reduce the absorption of water, oil and grease

Figure 5: The switch from plastic-based to fiber-based materials - generally called paperization - is one of the biggest trends we see in the market today.

on platestock boards and is suitable for direct food contact while maintaining its recyclability through the paper recovery system. Therefore, our barrier coating offers a sustainable alternative to replace restricted coatings on single-use paper plates according to Single Use Plastics Directive (EU 2019/904) and other relevant legislations.

It is already clear today that it will not be possible to "paperize" every type of plastic packaging and replace it by fiber-based alternatives approved for the paper recycling stream in the short term. And where plastic films cannot be replaced, our focus is on enabling mono-plastic structures. Just last year, for example, we co-developed a water-based oxygen barrier for film, together with our partner Henkel, that will enable the development of more recyclable flexible film for food packaging. This is just one example of the innovations we are continuously working on together with our partners and customers, whether to further optimize barrier properties, enable mono-material structures, or find other ways to enable sustainable packaging circularity.

Enabling circularity in packaging is one of our key drivers at Siegwerk. Not only because of plastic reduction, improvement of reusability, and ease of recycling are clear demands from the market, but also because we believe we have a responsibility to future generations to make every effort to handle all resources with care. We are enabling this trend not only through the development of new barrier coatings, but also through extending our portfolio of sustainable solutions for circular packaging in all areas and continuously increasing the renewable content in all our products, wherever possible.

For further information, we have prepared a helpsheet which can downloaded at **www.siegwerk.com/en/inks-coatings/coatings.html.**

About Siegwerk

Siegwerk is an international, market-leading manufacturer of printing inks and coatings for all kinds of packaging. As a family-owned company in its sixth generation, Siegwerk relies on almost 200 years of expertise and knowledge in printing today. The company knows what it takes to develop and print successful and responsible packaging solutions: From highly functional and eye-catching to sustainable and safe designs - it provides printers, converters, and brand owners worldwide with high-quality ink and coating solutions customized to their individual needs.

About the author: Oliver is commercial and strategic lead for water-based coatings at Siegwerk. With over 15 years' experience in the fiber-based packaging industry working with functional papers and boards, he has dealt with many types of coatings and for a wide range of packaging applications.

Oliver Waddington, Siegwerk