Barrier coatings as green chemicals for a sustainable future in the paper industry

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INTRODUCTION:

The rising awareness of environmental issues puts new demands on the paper and pulp industry. But the switch to more sustainable solutions is often impeded by an exaggerated perception of its complexity. Today, all necessary technology is in place, and with standardized models, the path forward becomes both clear and approachable.

Our oceans are drowning in plastics. It comes from rubbish that we throw away on the street, from fishnets that are discarded, from washing synthetic clothing, and from plastic packaging of all kinds.

The estimated size of the plastic waste in the oceans ranges from 700,000 (the size of Poland) to 15,000,000 square kilometres (the size of Russia), and an important part of the waste is directly derived from the paper and pulp industry.

Over time, plastic falls apart into small fragments, transforming the water into a big soup of microplastics. When plankton and other small animals mistake them for food, the particles enter the food chain. This pollution affects the world's largest ecosystems, and in the end, us humans.

The oceans constitute 72 percent of the earth's surface and are our primary oxygen suppliers. The oceans are also the main source of food for more than half the world's population.

To protect the oceans, the European Commission wants to reduce single-use plastics and make manufacturers responsible for the waste phase of their products.

The negative impact of plastics

Chemical suppliers have an important part in helping the pulp and paper industry develop new and long-term sustainable products with high quality and minimal impact on people and the environment. One way is to reduce the use of plastics as a barrier in paper and board. This would benefit the environment in many regards and is not just limited to the oceans.

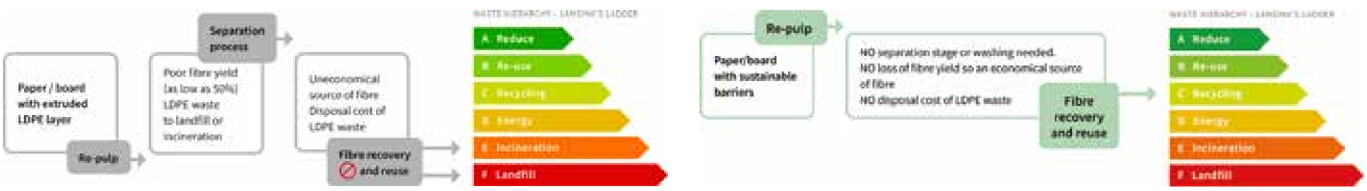
As a non-renewable and fossil-based product, plastics also contributes to climate change, and even if paper and boards extruded with plastic are technically recyclable today, the separation process is complex, can deliver poor yields of recycled fibre and there is still plastic to dispose of in the end at a cost. Not surprisingly, it has been estimated globally that only a minor part of these materials is recycled annually, leading most to enter landfills where it can persist in the environment for more than 500 years.

A solution for today

To create a sustainable future, we need to reduce our dependency on polluting and non-renewable materials. By substituting plastics with more sustainable alternatives, the pulp and paper industry can make a real difference. And with recent years' big advancements there is no excuse for delaying the switch. Today all types of packaging, from food to cosmetics, can be made without plastics.

The advantages are many and the consumers increasingly expect the end products to be sustainable. When switching from plastics to barrier coatings the products become repulpable and recyclable like ordinary paper. In many cases, even compostability can be achieved. The end product can be treated as a mono-material and therefore be directly re-pulped and all fibre reclaimed with no special separation or cleaning stage (and therefore no consequential loss of fibre yield when recycling, or plastic film to dispose of to landfill).

Figure 2 & 3: Circularity is created by making the fibre more economical to recover through existing recycling streams.



At the same time, we can achieve all the advantages of plastic materials. High water, oil- and grease resistance, low temperate and tropical MVTR, low OTR, and rapid sealing properties. We can even add other specialty chemicals to add further function. For example, combining with other chemical treatments to the pulp to give internal protection from oils and fats.

When switching to more sustainable alternatives it is important to make sure that one environmental issue is not replaced by another. You should therefore make sure that the barrier coatings you use are water-based dispersions and contain no VOC, solvents or "forever" chemicals like PFAS.

Figure 4: Another way to visualize the benefits of sustainable barriers compared to plastic based barriers.

One barrier coating doesn't fit all

The transition from plastics to more sustainable materials is not a straightforward task for packaging producers. It requires a deep understanding of both the requirement for each product's end-use as well as the needed barrier properties. 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 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.

To make this simple, we have divided the packaging demands into five key properties: hydrophobicity, oil- and grease resistance, water vapor transmission, oxygen transmission, and heat sealing.

Let's examine these five properties in simple language.

Hydrophobicity

Hydrophobicity is the physical property of a barrier coating to repel a mass of water. This is important to protect a product from water, hold liquid and moist/wet products, and to keep the paper or board substrate dry, and preserve its structural integrity and strength.

Strictly speaking, there is no repulsive force involved, it is an absence of attraction. Hydrophobic barrier coatings tend to be formulated with nonpolar components and therefore have a low surface free energy. Water droplets on these surfaces will exhibit a high contact angle (form a bead) as water is a polar molecule with high surface tension.

Hydrophobic is often used interchangeably with lipophilic, (fat-loving), however, the two terms are not synonymous. While more hydrophobic barrier coatings are usually more lipophilic (a trade-off of OGR performance), both properties can be combined.

Naturally, the more hydrophobic a barrier coating is, the more difficult it is to glue with water-based adhesives or print over with water-based inks.

Hydrophobicity is typically measured via an extended Cobb test (900s/1800s/3600s) and variations thereof. It can also be measured with the contact angle.

Oil- and grease resistance

Oil and grease resistance, OGR, is the ability to inhibit the penetration of grease, oils, and fats through the barrier coating layer and into the substrate. 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.

Figure 5: 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.

The Barrier Standards required for a packaging material are defined by the demand placed on the barrier and the expected packaging life term. Once the requirements are defined, we can tailor a solution with one layer, a combination of two layers, or even up to three layers, to create the perfect mix of properties.

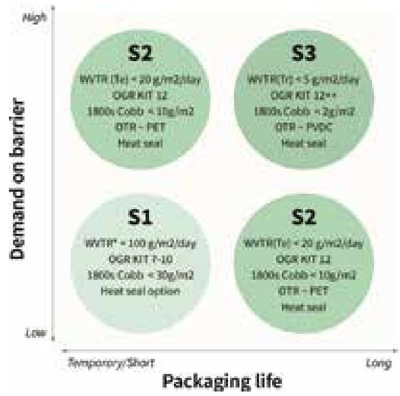


Figure 6: The perfect mix of properties.

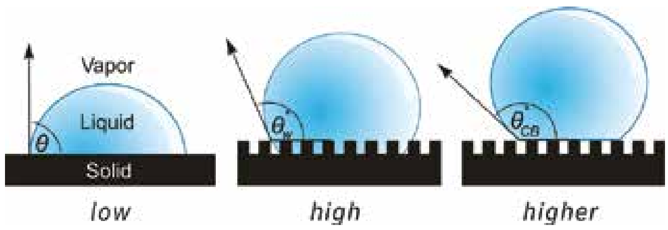


Figure 7: The contact angle is the angle conventionally measured through the liquid, where a liquid-vapor interface meets a solid surface. It quantifies the wettability of a solid surface by a liquid. A high contact angle = low wetting, a low contact angle = high wetting

OGR is the most common attribute for a barrier coating in food packaging as most food will contain some level of grease, oil, or fat. Barrier coatings work by placing an impermeable lipophobic (fat-hating) barrier membrane between the substrate and the packaged product.

Historically the traditional method to impart OGR properties to paper and board was with the use of fluorochemicals which work by reducing the surface energy of the substrate to lower than that of the surface tension of the grease, so the grease cannot penetrate. But these are non-degradable "forever" chemicals and are being banned for use across the globe.

The ability of a barrier coating to maintain good OGR properties on a crease or fold is also an important attribute.

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.

The industry standard of testing OGR is via 3m Kit method: 12 solutions with varying surface tensions (1 highest – 12 lowest; higher the value the greater the OGR). This method is used on the flat surface of the coated paper (Kit value) and on creased and folded areas (Kit on crease value). The 3M Kit method was developed for measuring treatment with fluorochemicals and some manufacturers have developed internal methods of measuring the OGR of barrier coatings.

Water vapour transmission

There are many applications where moisture control is critical. For instance, to keep moist stuffs moist (permeability to the environment) and dry stuffs dry (permeability from the environment). It also applies to moisture-sensitive foods and pharmaceuticals that are put in packaging with controlled MVTR to achieve the required quality, safety, and shelf life.

Water vapor transmission rate, WVTR, also known as Moisture vapor transmission rate, MVTR, is a measure of the passage of water vapor through a barrier coating. WVTR generally decreases with increasing thickness or coat weight of the barrier coating and two layers of barrier coating (primer plus topcoat) are generally more effective and efficient as micro defects or "pinholes" in the coating layers can cause significant failure. MVTR increases with increasing temperature and relative humidity (% RH).

The most common standard conditions for measurement are Temperate (23 oC / 70% RH) and Tropical or "Jungle" (37 oC / 90% RH) although others may be specified.

Oxygen transmission

Controlling the oxygen transmission is important to preserve the quality, safety, and shelf life of sensitive foodstuffs and pharmaceuticals by inhibiting dangerous bacterial growth and spoiling.

Oxygen transmission rate (OTR) is the measurement of the amount of oxygen gas that can permeate through a barrier coating over a given period. The mode of transport is a diffusion of oxygen from the environment to the inside of a package. Many foodstuffs sensitive to spoiling, i.e., dairy or meats, or products with long shelf-life expectations require a low OTR value and in some cases, the package will have been "purged" of oxygen with an inert gas, typically CO2 or nitrogen, before the final sealing.

OTR generally decreases with increasing thickness or coat weight of the barrier coating and two layers of barrier coating (OTR coating plus topcoat) or even three layers (primer plus OTR coating plus topcoat) may be necessary to achieve very low values.

Standard test methods are available for measuring the oxygen transmission rate of packaging materials. Completed packages, however, involve heat seals, creases, joints, and closures which often reduce the effective barrier of the package.

Heat sealing

Heat sealing is a method where two materials are sealed together by heating them while applying pressure on them for some certain time. In addition to barrier properties, heat sealability is one of the most important properties of packaging materials. Sealability affects the ability of the material to form hermetic seals, which is a necessity in different packages. Tight and strong seals contribute to the preservation of the product and, on the other hand, prevent any premature leakages.

There are different methods in heat sealing and these are for example hot-bar sealing, impulse heating, hot air blast heating, and ultrasonic heating. Heat sealing can be represented by a triangle model representing the necessary ingredients to create a seal. If one ingredient is reduced then the other ingredients must be increased to compensate and likewise, if one ingredient is increased then the other ingredients could be reduced.

Several different methods can be used for heat sealing. The suitable method depends on the material, application, packaging process, etc.

Seal strength can be measured by tensile strength testing instrument or by visually evaluating the fibre tear after manual sample tear.

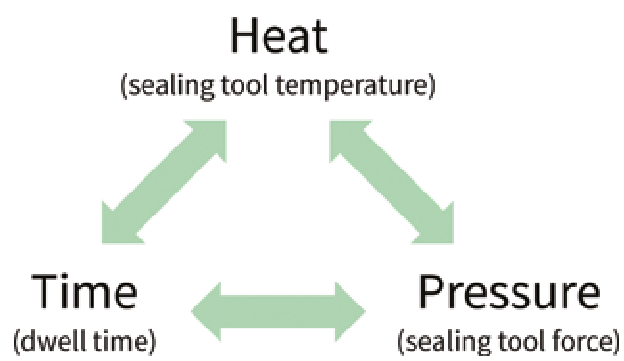


Figure 8: Simple triangle model of heat-sealing.

It's time to make the switch

We all have a responsibility to commit to a positive and greener future and the paper and pulp industry has an opportunity to make a real impact. The technology is already in place, and by applying a model like the BIM Barrier Standard the transition to sustainable products becomes clear and approachable.

In switching from fossil-based to sustainable barriers, you should be able to expect close support and consultancy from application specialists at your chemical partner. This support should range from identifying the barriers needed to machine setup and optimization.

A growing demand is also put on packaging producers to prove the green credentials of their products. This is often both a time-consuming and expensive task, especially when conducted early in a development project and applied to complex issues, like compostability.

An important function for chemical suppliers in the coming years is to provide cost- and time-efficient tools to assess the environmental properties of different solutions before committing to the full cost of a test at a certified laboratory. By doing so we can provide the full support that the packaging industry needs for a greener future.

Figure 9: The transition from plastics to more sustainable barriers is not only an important action for the oceans and the climate. With new regulations and an increasing demand for sustainable products, it's also a necessary change from a strict business perspective.

About BIM

BIM is a family-owned, entrepreneurial chemical company supplying the pulp- and paper industry since 1973. With a customer-focused research and product development, we develop innovative specialty chemical concepts designed to improve products and processes in a cost-effective and sustainable way. We focus on creating more value from fewer resources to use the world's limited resources more efficiently.

BIM provide services and concepts all over the world through a global network of experts, production units and R&D facilities. Our local operations include Sweden, Norway, Finland, England, Germany, Poland, Belgium, Czech Republic, Portugal, Spain, France, South Africa and dedicated agents and distributors in most other pulp and papermaking countries.

BIM in brief
Pulp and paper focus
Founded in 1973 by Peter Wållberg
Approx. 220 employees worldwide
Certified according to ISO 9001 and ISO 14001
Member of the UN Global Compact
Gold rated by Ecovadis
Associated with the Responsible Care Program