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The need for barrier coatings

Creating sustainable barrier papers
for next generation packaging

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The Art of Papermaking

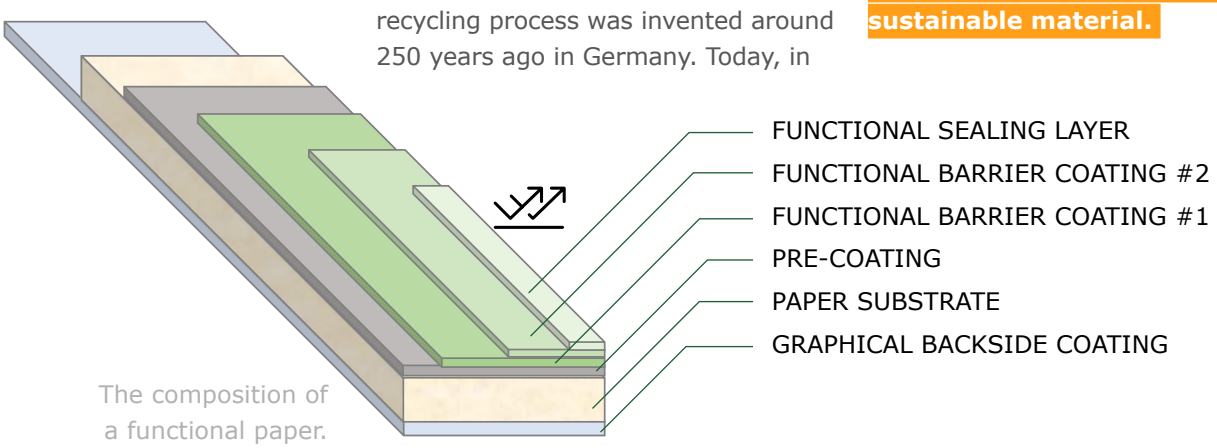
Paper is one of the oldest materials
to be invented by man

The art of papermaking is closely connected to the history of civilization and art. Since its invention in China more than 2000 years ago, paper has evolved into a global commodity after an unprecedented success story. Initially, paper served mankind's urgent need to communicate information in written form. Its invention allowed the ancient scribes to replace papyrus, parchment and other writing materials with an alternative that was both easier and less expensive to make. In the centuries that followed paper was used to create valuable prints and books. A new chapter in papermaking history began during the industrial revolution in the early 19th century, when the first paper machines were constructed. They enabled the mass manufacture of paper at far lower cost, transforming it into a product that is today part of our everyday lives and a widely-used packaging material.

Paper took a big step towards becoming a sustainable material when the recycling process was invented around 250 years ago in Germany. Today, in addition to being made from renewable resources, paper is the most recycled material in the world – with many countries achieving recycling rates of over 70%.

Untreated paper can only be used as a packaging material for products that are dry and non-greasy due to the porous structure of the paper web. It also has the major disadvantage of not providing a barrier against water vapor and oxygen. Paper and polymer film composites were developed to address these issues, and they are widely used as packaging material. However, they are also associated with the disadvantage that they are not recyclable unless they can be mechanically separated.

This marks the beginning of DELSCI's mission with the following clear objective: **To modify paper so that it has the necessary chemical and mechanical properties to preserve food or other substances while retaining its properties as a sustainable material.**



The composition of
a functional paper.

What types of barriers are needed for packaging solutions?

One of the most important functions of a packaging material is to protect the content from external influences that can cause degradation or spoilage.

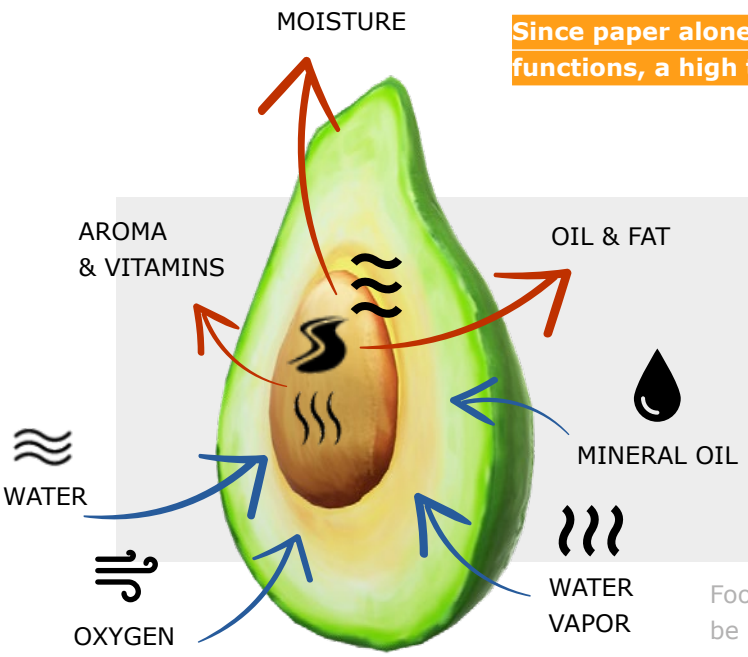
In the food industry packaging is a particularly sensitive issue because many food products degrade over time and stringent food safety requirements apply. Barrier papers have to deliver on all these counts because unnecessary food waste is obviously a definite 'no-go' for all stakeholders.

Barriers keep moisture, aromas and vitamins in and protect from external influence.

But what types of barriers are needed? Many food products have a specific moisture content that has to be kept constant during storage. It is also necessary to seal in specific aroma components and vitamins, and to ensure that oily and fatty components do not interact with or leach out from the packaging material.

Vice-versa, the barrier has to prevent external water vapor or water from penetrating the packaging and allowing the content to become moist, which will trigger the degradation process. Oxygen permeation can induce oxidation processes involving fats and other sensitive components, which can shorten the product's shelf life. The barrier also has to prevent mineral oil hydrocarbons (MOSH/MOAH), which can be found in small quantities in the recycled paper and board that is widely used as secondary packaging, from contaminating the food product.

Since paper alone cannot provide the necessary barrier functions, a high tech barrier coating is necessary.



Loss from the food to the environment through the package

Penetration from the environment to the food through the package

Food contains ingedients which have to be protected to guarantee food safety

What types of coatings provide suitable barriers?

The main function that any coating has to fulfill is to cover the porous base paper so that it provides an adequate barrier against the substances described above.

Film-forming agents play an important role in this context, which explains the market domination of film-forming polymers in the advanced food packaging segment. Polymer film has the advantage of providing a functional surface that is very thin and homogenous. Another benefit of polymer film is that it can be formed in any shape with heat.

Film-forming polymers, or a combination of different materials with film-forming properties, are suitable as barrier coatings because they can be applied to the paper surface.

But that's just one side of the coin. Simply applying a polymer film to paper won't help us to achieve our objective of creating a sustainable paper packaging.

The two most important properties of paper, from a sustainability perspective, are its renewable resource origin and its ability to naturally degrade into water and carbon dioxide. On the other hand, very few film-forming polymers are biodegradable. Most of the commonly known plastic materials with effective barrier properties are non-biodegradable and contribute to the pollution of oceans and beaches because they can take hundreds of years to break down.

Our first-choices for barrier coatings are polymers or mixtures containing polymers which originate from renewable resources and are readily biodegradable

Bearing that in mind, our first-choices for barrier coatings are polymers or mixtures containing polymers which originate from renewable resources and are readily biodegradable.

Many types of modified cellulose polymers can perform this function, as can cellulose itself, particularly a microfibrillated form of cellulose that can prevent permeability. Next to cellulose derivatives which are characterized by ß-(1→4)-linked D-Glucose molecules, all types of derivate of D-glucose molecules which are linked over α-(1→4)-bonds are also suitable.

This polymer is known as amylose, a polysaccharide made of α-D-glucose units and one of the two main components of starch. The other component is amylopectin which contains α-(1→4)-linked glucose residues that are connected by α-(1→6) branch linkages, making the molecules more soluble. Starch plays a very important role in paper coating since it is also film-forming and can be applied in an aqueous solution, which is compatible with the paper making process.

Being readily available from multiple sources such as potatoes, corn, rice and wheat, **starch is the prototype for a perfectly sustainable coating material** that is ideal for paper.

There is, however, one major drawback. As a water-soluble and hydrophilic biopolymer, starch is unable to provide an effective barrier against water and water vapor. On the other hand, it is effective against oil, grease and nonpolar gases such as oxygen.

Other types of biodegradable and renewable biopolymers are also interesting prospects for future barrier applications. One is **polymers that are biodegradable but also derived from fossil resources. They offer both effective barrier properties and a good sustainability profile.** Generally water-soluble like starch, these polymers and have excellent film-forming and barrier properties against nonpolar gases such as oxygen. Prominent examples are polyvinyl alcohols (PVAs) and ethyl vinyl alcohol copolymers (EVOH). Neither of these polymers have an adverse effect on the degradation properties of paper because they are fully biodegradable. Although the raw materials do not have entirely renewable origins (a pure cellulose/starch combination is 100% renewably sourced) the barrier paper will still be made of more than 95% renewably sourced raw materials, which is a very good figure.

The last category includes polymers that are both non-biodegradable and from fossil origin, which makes them the least preferred choice. Nevertheless, in special applications requiring a high-performance barrier against water and water vapor, these polymers are still needed. DELSCI is trying to minimize the use of these polymers in current solutions and already working on renewable alternatives for the future.

The sustainability journey is a gradual transition and we cannot achieve a 100% to 0% change in one single

step, which is why we still permit the use of polymers that are neither renewable nor biodegradable to a small extent in our formulations. Every effort is made to minimize these components and we will continue to phase them out. We are already well on the way to enabling a first generation of more sustainable products and we believe that the first step reduction from 100 % fossil to 1-10% fossil components is a major achievement!

When it comes to the property of recyclability there can be no compromise. Only fully recyclable paper offers a real advantage over composite materials which can only be thermally processed for energy recovery. The good news is that even **papers with a coating containing part non-biodegradable material can be fully recyclable.** This means that we can achieve our ambitious target in the first new generation of barrier papers.

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