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MANUFACTURING OF BIOBASED PACKAGING MATERIALS FOR THE FOOD INDUSTRY

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Abstract. Engineering of a biobased package or packaging material requires knowledge of the processing and material properties of the polymers. If the properties of the native biopolymer are not identical to the required one, or if the polymer by nature is not thermoplastic, a certain modification of the polymer must take place. For very specific requirements (very low gas permeability or high water resistance) it is unlikely that one polymer will be able to provide all required properties even after modifications. Hence, it is necessary to use multiple materials in a composite, a laminate or co-extruded material.

Key words: biobased materials, food packaging, polymers, food

INTRODUCTION

Foods are dynamic systems with limited shelf-life and specific packaging requirements. While the issues of food quality and safety are first and foremost in the mind of food producers and retailers, a range of other issues surrounding the development of any food package must be addressed before a particular packaging system becomes a reality. Biobased food packaging materials must meet the criteria of the specific foods and comply with the food and packaging legislation. Furthermore, interactions between the food and packaging material should not compromise food quality or safety. This research is based on currently available literature and information about biobased food packaging. Apart from the widely used cellulose-derived materials (paper, board, cellophane, etc.), the focus of biobased food packaging materials is on potential food applications rather than on actual commercial applications. As pointed out in this research the biobased materials can, notably, be used for packaging of a number of different foods and the performance of biobased materials is constantly being improved. Hence, more biobased food applications will emerge in the near future.

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POSSIBLE PRODUCTS PRODUCED OF BIOBASED MATERIALS

The fundamental repeating chemical units of the biobased materials described so far are identical to those of a significant body of the conventional plastics. Thus, in the broadest sense, polysaccharides possessing repeating acetal functionality can be regarded as the naturally occurring analogues of the synthetic polyacetals; proteins (repeating peptide functionality) can be compared to the synthetic polyamides while polylactic acid is merely an example of the diverse group of polyesters. Clearly, however, the gross physical and chemical properties of native biobased materials and their synthetic counterparts are quite different and this is a feature of additional chemical functionality inherent in biobased materials. It should be expected that following requisite processing and product development of biobased materials resulting properties should equal or better those of the conventional alternatives.

However, such processing and product development is not always trivial and is unlikely to be cost effective in all cases.

It is not surprising, therefore, that the current applications of biobased materials seek not to emulate the properties of conventional plastics, but to capitalise on inherent biodegradability and on other unique properties of these polymers. Biobased plastic applications are currently targeted towards single-use, disposable, short-life packaging materials, service ware items, disposable non-wovens and coatings for paper and paperboard applications. However, the possible products made from biobased resources covers a broader range, and some of the potential products and applications are summarized in Table 1 [Chandra and Rustgi 1998].

Table 1. The major processing routes to potential biobased products [Chandra and Rustgi 1998]
Tabela 1. Podstawy metod produkcji biomateriałów [Chandra i Rustgi 1998]

Processing route Sposób produkcji	Product examples Przykład wyrobu
(Co-)Extruded film	Packaging film
Cast film	Packaging film
Thermoformed sheets	Trays, cups
Blown films	Packaging film
Injection (blow-)moulding	Salad pots, cutlery, drinking beakers, cups, plates, drinks bottles, trays
Fibres and non-wovens	Agricultural products, diapers, feminine hygiene products, certain medical plastics, clothing
Extrusion coating	Laminated paper or films

In general, the same shapes and types of food packaging can be made from synthetic and biobased resources. The question is whether the same performance can be achieved by using the biobased materials as with the synthetic ones.

BLOWN (BARRIER) FILMS

Blown films comprise one of the first product categories to be developed based on mineral oil derived biodegradable polyesters. They have successfully been applied as garbage bags and related applications. Film blowing grades of renewable polymers have been developed based on PLA. Blown films based on these biopolyesters exhibit excellent transparency and cellophane-like mechanical properties. The sealability depends on the degree of crystallinity and good printability can also be achieved. The possibilities of film blowing PHB/V materials are at this time limited due to their slow crystallization and low melt strength. In many food packaging applications, a water vapour barrier, as well as gas barriers are required. No single biobased polymer can fulfil both of these demands. In this case, the use of co-extrusion can lead to laminates which meet the objectives. Paragon materials which are based on thermoplastic starch can be film blown in a co-extrusion set-up with polymers like PLA and PHB/V as coating materials, resulting in a barrier coating which, for example, proved to be successful in the packaging of cheese [Tuil et al. 2000].

The use of Paragon tie-layers provides the adhesion between the coating and the base layer. In this way, starch-based materials could provide cheap alternatives to presently available gas barrier materials like EVOH and PA6 [Rindlav-Westling et al. 1998].

The properties (mechanical strength, gas and water vapour properties) of blown films can be improved by coating of a glass-like ultra thin layer of SiOx or by producing nano-composites. Addition of nano-particles during processing of the film produces composites with improved water and gas barrier properties and ongoing developments at TNO industry (NL) aims at producing hydrophobic starches based on these composites. A similar approach is to use a glass-like ultra-thin coating of SiOx improving the barriers of the material immensely [Fischer et al. 2000, Johansson 1997, Johansson 2000].

THERMOFORMED CONTAINERS

A next class of products is thermoformed containers for food packaging. In order to be able to thermoform a polymer it should be possible to process this material from the melt (extrusion) into sheets and consequently thermoforming these sheets just above the Tg or Tm of the material. Thermoformed products can be found based on PLA and PHB/V. Again, it is possible to produce thermoformed articles from laminates based on Paragon, as well as other thermoplastically processable biopolymers.

FOAMED PRODUCTS

Starch-based foams for loose fill applications have been commercially introduced with success some years ago and the market for these products is still growing. Foamed products like trays and clamshells based on starch for food packaging have not yet been introduced commercially. Products based on a molding technique from a slurry phase

are close to market introduction. These products are produced form starch base slurries with inorganic and agrofiber based fillers. Other proposed techniques include loose-fill molding and extrusion transfer molding and expandable bead moulding [Tuil et al. 2000].

Foamed products based totally on PLA are still in a developmental phase. In order to be able to use these starch-foamed products in food contact applications coatings should be applied on the starch- based foams. Adhesion between the foam and the coating is of importance. Paraffin and other oligomer based coatings are proposed next to PLA and PHB/V based coatings. Protein and medium chain length PHA based coatings are close to market introduction [ATO 2000].

COATED PAPER

It is expected that paper will remain an important biobased packaging material. Paper and board materials have excellent mechanical properties, however, the gas permeabilities are too high for many food applications. The hydrophilic nature of the paper-based materials is a major challenge of these materials when packaging moist foods. To date, the paper-based materials have been coated with a thin layer of synthetic plastic which has provided the materials with the required gas property and water resistance. Alternatively, biobased materials might be used as coating materials thus paving the way for a 100% biobased packaging material. Paper based materials coated with PE are readily repulpable as the hydrophobic PE is easily removed in the pulping process. Hence, paper-based materials coated with biobased, hydrophobic polymeric materials are, likewise, going to be repulpable [ATO 2000].

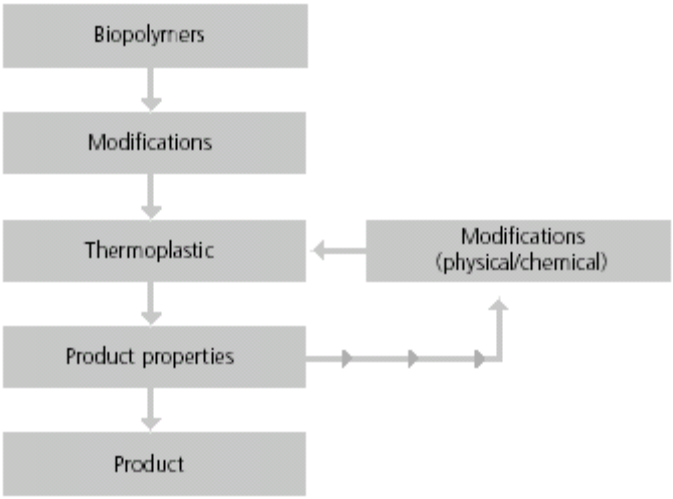

Fig. 1 Designing and manufacturing of biobased packages [ATO 2000] and packaging materials require a multistep approach
Rys. 1. Etapy projektowania i produkcji bioopakowań [ATO 2000]

CONCLUSION

Today, biobased polymers have an increasing importance. The main reason is they are produced from renewable resources and also they can be recycled. Biobased polymers have different categories according to different production methods and different applications in food industry. The research concerning applications of biobased polymers shows that not only they have suitable properties for applications in food industry but also they have a low cost. If we compare them with petroleum products; having recycle option, products of renewable resources, having low cost and having suitable properties for packaging applications are going to make them the most preferable material in the near future.

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PRODUKCJA BIOOPAKOWAŃ NA POTRZEBY PRZEMYSŁU SPOŻYWCZEGO

Streszczenie. Produkcja bioopakowań i materiałów służących do ich wyrobu wymaga znajomości technologii i właściwości polimerów. Jeżeli właściwości naturalnych polimerów są niezgodne z wymaganiami lub nie są one termoplastyczne, muszą być poddane niezbędnym modyfikacjom. Jeden materiał nie spełnia z reguły wszystkich wymagań (np. odporność na działania wody lub mała przepuszczalność gazów), a więc do stworzenia odpowiednich laminatów jest niezbędne użycie kilku surowców.

Słowa kluczowe: bioopakowania, pakowanie, polimery, żywność

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