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Karl F. Tiefenbacher[a]
[a] Biopac Biologische Verpackungssysteme Gesellschaft mbH, Leobendorf, Haasstrasse, Austria

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STARCH-BASED FOAMED MATERIALS—USE AND DEGRADATION PROPERTIES

KARL F. TIEFENBACHER

Biopac Biologische Verpackungssysteme Gesellschaft mbH
Haasstrasse, A-2100 Leobendorf, Austria

ABSTRACT

Many discussions on packaging lead to undue expectations regarding the usability of degradable materials. There is also considerable misuse of the term "biodegradable." The manufacture of a new foamed material based on native starch is discussed. The structure forms by water evaporation and gelatinization of starch during a molding and heating step. Typical applications are shown. Composting tests confirm degradation within a few weeks without the accumulation of residues.

INTRODUCTION

Technical utilization of natural polymers such as cellulose and starch is common. On the other hand, many products first made from natural materials have been replaced by synthetics which are durable, tailor-made, cheap, and better at meeting various other requirements.

Are studies using starch in the development of new materials likely to alter this trend?

PACKAGING DISCUSSIONS

Any serious discussion about packaging includes some justified requests:

Less waste generation
No long-time stable, "overqualified" materials for short time use
Closed cycles
Sustainable economy

On the other hand, there are unjustified expectations:

Renewable raw materials solve all problems
Degradable materials can directly substitute for conventional glass, plastic, and metal packaging systems
"Edible" packaging is an ideal solution

Current discussions on packaging and waste generation are justified and necessary. It is worthwhile to find ecologically optimized systems, but there will be no easy, general problem solution.

RAW MATERIAL STARCH

Starch is built up by various fast-growing plants in remarkably high concentrations, often more than 80% of dry substance—an impressive figure if you compare it with 40–50% cellulose in wood [1].

The differences between starch sources (wheat, potato, corn, tapioca, . . .), and even between breedings of the same plant type, offer a selection for product optimization. Generally, one has to deal with quality fluctuations due to climate, storage, or isolation procedures of these biological raw materials.

Starch properties, such as amylose/amylopectin ratio, molecular weight, swelling, and gelatinization, are important for the formation of stable products. Degradability under aerobic and anaerobic conditions is essential for closing the natural product cycle.

STARCH-BASED FOAMED TRAYS

A process for the production of foamed starch trays has been developed [2]. A mixture of native starch, plant fibers, food additives, and water is injected into heated molds which are somewhat similar to injection molding tools. Raw material parameters (swelling, gel point, water-holding capacity), physical parameters (temperature, pressure, time), and the formula have to be properly adjusted. Foaming is done only by steam evaporation. After the primary structure formed, and with an ongoing reduction of water, the glass temperature rises. After demolding and humidity equilibration, a stable and flexible material is obtained.

A porous central part is enclosed between continuous surfaces of gelatinized starch (Fig. 1). The density can be varied between 0.1 and 0.3 kg/dm^3. The basic colors are white or a light cream color, depending on the ingredients.

PROPERTIES, USES, LIMITATIONS

Because the trays have a pure polysaccharide structure, they are neutral in odor and taste and stable against light and oxygen. They also have good heat

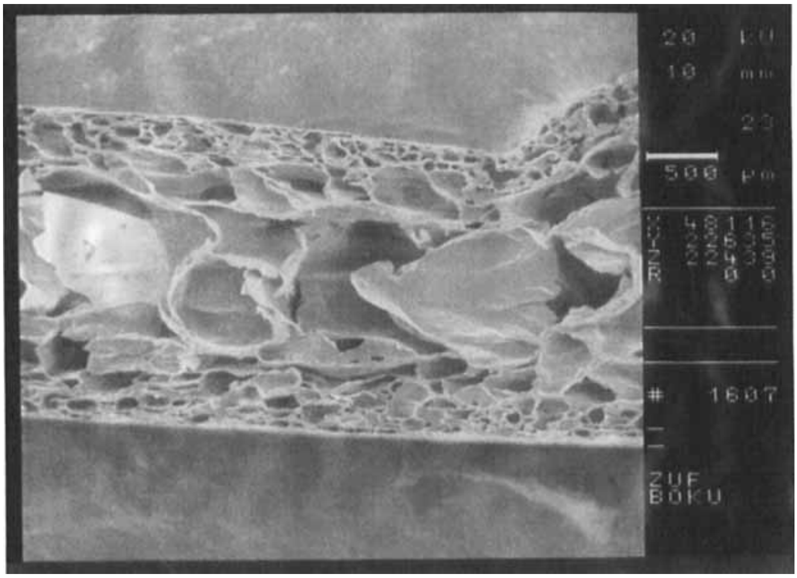

FIG. 1. Cross section of the foamed material. (Scanning electron microscopy by Zentrum fur Ultrastrukturforschung, Vienna.)

isolation and printability properties. Typical applications are (Fig. 2) for fast food trays and as blisters for cookies, sweets, and technical articles. Approvals for these food uses currently exist for Austria, Germany, and the European Community.

The main limitation regarding degradability is its instability against prolonged contact with aqueous liquids. For these applications a coating is necessary.

DEGRADATION

The sorption isotherm [3], which is rather similar to starch isotherms, shows that with high water activity there is a point where the porous structure collapses after equilibration. The free volume increases with water adsorption, and the glass temperature further decreases. This moisture uptake accompanied by structural collapse is the only essential factor necessary to start degradation.

Degradation has been studied twice:

1. An extended study by A. Pfeil, Fraunhofer Institut für Chemische Technologie, shows 100% mineralization by a standardized drum procedure [4].
2. Practical tests have been made in the municipal waste composting plant Stockerau, Austria [6].

THE FRAUNHOFER INSTITUTE STUDY

The samples were subjected to a composting climate intensified by a drum procedure [5] during two cycles of 7 days each, without exposure to mechanical

FIG. 2. Some examples of foamed starch-based trays.

strain. Humidity, pH, and aeration were controlled. The starting composition was 20% starter compost and 80% mixed bio waste with a C/N ratio of ~25:1. The maximum temperature in the composting cycle was between 65 and 70°C.

The degradation capacity was documented by gravimetric, spectroscopic, and micromorphological analyses. Jute yarn was used as a reference. The loss of tear strength of jute yarn was 49% for the first cycle and 74% after two cycles. This jute degradation corresponds to an earth degradation of about 6 weeks exposure.

As a result of composting, the starch-based trays were practically decomposed:

After 14 days of composting, the trays had decomposed into crumbs. The loss of mass amounted to 80%.

Cross sections showed an inflation of hollow spaces, which facilitated biological action.

Infrared spectroscopic analysis of the residues indicated no accumulation of nondegradable organic degradation products. Complete mineralization can be expected when composting is continued.

These extended degradation studies were done to substantiate the use of such terms as "compostable" and "biodegradable" for this new type of foamed product.

Nowadays, "biodegradability" is often overstressed, and this leads to a lot of scepticism. Here are some reasons for it:

Disposal problems become well known to the consumer.

There was and is severe misuse of "biodegradable" announcements for green marketing.

Cleavage or solubility of materials is often used synonymously with biodegradability.

CONCLUSIONS

A clear definition of "biodegradable" and its control are necessary. It should be applicable only to products which degrade in a reasonable time, under standard conditions, and without the accumulation of nondegradable parts.

The new starch-based 100% degradable material can be substituted for some longtime stable packaging products. It uses quickly renewable plants, it is prepared by a well-known low risk procedure, and the cycle is completed by fast mineralization in composting.

REFERENCES

[1] K. Winnacker and L. Küchler, *Chemische Technologie*, Vol. 5, 4th ed., pp. 589 ff and 657 ff.
[2] Patent Application WO 9112186.
[3] Ch. Gigl, "Untersuchung der mechanischen Eigenschaften eines biologisch abbaubaren, aus Stärke hergestellten Packstoffs," Diplomarbeit, TU München-Weihenstephan, Germany, 1991.
[4] A. Pfeil, Fraunhofer-Institut für Chemische Technologie; Abbauverhalten von BIOPAC-Ampullentrays, FhG-Projektstudie #102 458, Pfinztal, Germany, 1991.
[5] K. Schmidt, *KA Abwasser, 5*, 456 (1988).
[6] G. Walter, Biotonne und Kompostierung in der Praxis am Beispiel der Stadtgemeinde Stockerau; Lecture Seminar "Bioabbaubare Verpackungen" Mannheim, Germany, 1992.