



SULAPAC® STRAW KEY FEATURE: OCEAN SAFE

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Background

It is even more difficult to clean the ocean from microplastics than visible litter. Fully biodegradable materials do not yield microplastics, as these will be assimilated by naturally occurring microorganisms.

Biodegradation is a chemical process in which materials are metabolised into water, carbon dioxide, and biomass by naturally occurring microorganisms, such as bacteria, fungi, and algae. In other words, the material is eaten up by the organisms leaving no trace of the original material behind. The process of biodegradation depends on the environmental conditions, which influence it (e.g. temperature, inoculum, humidity, etc.) and on the material or application itself. To claim a product's biodegradability, the ambient conditions have to be specified and a timeframe for biodegradation must be set in order to make claims measurable and comparable. [1] Industrial compost is considered as the most aggressive environment for biodegradation, while open sea water is considered as the least aggressive environment. [2]

Plastic is a new substrate in the natural environment. For most fossil plastics there are no naturally occurring organisms which could metabolize them. Thus, if traditional plastic ends up in nature, either in the form of microplastics or visible litter, it's very persistent and stays there for hundreds of years. In the course of time this means accumulation.

Biodegradable materials do not contribute to plastics accumulation in nature as they are fully assimilated in a specific time frame leaving behind no traces. [3, 4] It should be highlighted that biodegradability is an inherent product characteristic not an end-of-life option.

The mechanism of biodegradation is complex and according to Kjeldsen, A. et al [5] consists of three phases

- 1) Abiotic-deterioration, which is defined to be degradation due to physical forces, light and temperature and exposure to atmospheric oxygen and pollutants which can lead to a breakdown of a material.
- 2) Biofragmentation, during which the availability of the material increases as it is both physically and chemically more accessible to the action of microorganisms and the enzymes secreted by them.
- 3) Microbial assimilation and mineralisation, which can be characterized as the microorganism "eating" and "digesting" the polymers for their own growth and energy needs. The final stage of biodegradation is the assimilation of the monomers into a microorganism to generate cellular biomass and carbon dioxide (or methane depending on availability of oxygen, effectively air). Aside from oxygen, other environmental factors will affect both fragmentation and microbial degradation rate, such as pH, temperature, moisture content etc. A variable blend of active microorganisms is more likely to facilitate rapid biodegradation of polymers compared with a single type of microorganism.

It is important that the degradation process does not stop at fragmentation (stage 2) as this is the case with non-biodegradable polymers resulting in accumulation of microplastics. It should be noted that in stage 3, 100% of the carbon in the polymer is never converted to CO₂ as the products of the mechanism described above are CO₂, H₂O and biomass. The carbon converted to biomass carbon always decreases the CO₂ evolution from 100% level.

Key feature: ocean safe

The Sulapac® Straw is ocean safe as it biodegrades fully into CO₂, water and biomass in marine environment within a similar time frame as tree leaves in nature. Various tree leaves have shown to disintegrate and biodegrade in the nature in 0.5-4 years depending on the tree species and environment [6,7,8]. To summarize, as the Sulapac straw and biological materials fully biodegrade in nature, they do not accumulate and thus are not capable to collect harmful chemicals or pathogens than can enrich along the food chain [9,10].

Criteria

Several test methods for biodegradation of materials in marine environments exist. As open sea water (without sediment) is regarded as the most difficult environment for biodegradation, we have chosen ASTM D6691 “Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium or Natural Sea Water Inoculum” as the test method for the biodegradation of the Sulapac Straw. In this test the sample is in powdered form in natural sea water and the CO₂ production during biodegradation is measured as a function of time. It thus indicates the molecular level degradation of the material into CO₂, H₂O and biomass [11]. In addition to ASTM D6691, we have performed field tests in open sea water. In the field tests the mass loss and visual changes of the material are measured.

Validation

Marine biodegradability tests of the first generation Sulapac straws showed 3% biodegradation in a time frame of 3.5 months in open environment conditions in the Baltic Sea, which suggests a similar biodegradation speed as that of tree leaves in nature assuming that the biodegradation of the Sulapac Straw occurs with an constant rate [Third party study performed by Finnish Environment Institute in Oct/2019]. In the ASTM D6691 testing, both O₂ consumption and CO₂ generation were measured for 112 days [Third party study performed by OWS in Oct/2019]. Combined data from the Baltic Sea and ASTM tests suggested a full biodegradation of the straw ranging from 2 to 5 years. Also, it should be noted that according to EN 13432 tests, the straw is industrially compostable and that the degradation products are not ecotoxic, and do not exceed the threshold values for heavy metals [12].

Currently, there is no international standard providing clear pass/fail criteria for the degradation of thermoplastic materials in sea water. To the best of our knowledge, the comparison of the biodegradation of Sulapac Straw to that of naturally occurring biological materials provides scientifically sound criteria to claim that Sulapac Straw is ocean safe. ISO TC61/SC14/WG2 is in progress of developing a standard that will specify test methods for the determination of the degree of disintegration of biodegradable plastic materials exposed to marine habitats under real field conditions.

References

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