BIODEGRADABLE MATERIALS - SOME UNTOLD TALES OF FICTION AND CONSUMER HIGH EXPECTATIONS!

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THE UNDERLYING INDUSTRIAL NEED

Sustainability and green chemistry for some, eco-friendliness for others, are the modern Industry principal drivers at a global scale for new products generation, created with the incorporation from their conception of a «cradle-to-cradle» life cycle approach - as «grave» and «burial» can no longer be considered a viable or rational approach to waste management.

Moreover, in the packaging/package waste directive (94/62/EG), requirements for recyclable packages are set; biological recycling is one of the acceptable methods. By using biological treatment techniques according to EN 13432, the respective goals in the European Parliament and the Council's directive 94/62/EG can be fulfilled.

A clear and undisputable witness of the emerging industrial need as above is the growth of the eco-certification market, as well as the bundle of a plethora of internal eco-benchmarking tools that indeed aim at incorporating metric estimates of the environmental impact of products and process; the most recent probably the most reliable tool coming from the Outdoor Industries' Associations in USA is the Eco-Index [1].

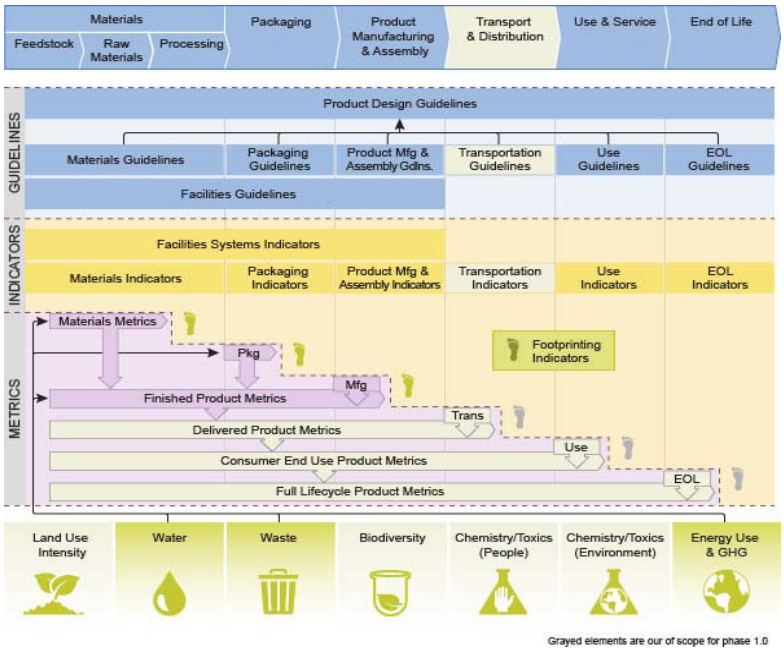

Figure 1. Eco-Index structural elements – β-version [1]

However - inevitably some might say - there has been confusion in the definition, but also extensive misuse of the term biodegradable as a marketing edge.

Such unfounded claims for oxo-fragmentable plastics (100% biodegradable eco- or green bags) recently ended up in court [3] presented to the consumer as 100% biodegradable, when the attributed fast fragmentation during testing obtained through additives – often metal

catalysts of plastic fragmentation induced by heat or ultraviolet irradiation – was not followed by mineralisation and biodegradation.

Along these lines there is a continuing attempt aiming at promoting what is allegedly resourced from natural or/and renewable – indifferently fast or slow – organic materials as biodegradable and often 100% biodegradable. A good example of this misleading campaign is the promotion of vegetable tannins and vegetable tanned leathers as easier biodegradable and ecological products.

The following list of indicative biodegradation rates should be considered only critically before accepting any claims: cotton rags, 1-5 months; paper, 2-5 months; rope, 3-14 months; orange peels, 6 months; wool socks, 1 to 5 years; cigarette filters, 1 to 12 years; tetrapaks, (plastics composite) milk cartons, 5 years; leather shoes, 25 to 40 years; nylon fabric, 30 to 40 years; plastic bags, 10-20 years; plastic 6-pack holder rings, 450 years; styrofoam cup, 1-100 years; banana peel, 2-10 days.

Is Biodegradability a Product Lifecycle Metric?

Most recently the Bioplastic Council on their position paper for oxo-biodegradables [2] dismissed the use of both terms as unfounded or misleading, as there is no such unique and standardised specification and testing method to prove them. Indeed, there is a long list of National and International standards and testing methods that can merely support claims for biodegradability under specific end-of-life conditions.

Not all materials biodegrade under all biodegradation testing conditions applied!

EN, ASTM and DIN relevant standards exist primarily for plastics and polymers and it is evident that labeling although linked to biodegradability under specific testing conditions shall certify compostable not biodegradable products. As of 2008, accepted industry standard specifications are: ASTM D6400, ASTM D6868, ASTM D7081, ISO 17088, EN13432 or EN1995. Most standards exist primarily for plastics and polymers and labeling although linked to biodegradability under specific testing conditions certifies compostable not biodegradable products.

A clear witness of this is that EN 14995 is addressing all four of the following characteristics for the plastic materials tested: (1) biodegradability; (2) disintegration during biological treatment; (3) effect on the biological treatment process and (4) effect on the quality of the resulting compost.

Standard testing according to EN 13432 comprises:

- Characterization of the material. Components potentially dangerous to the environment or important for the biological treatment identified, e.g. heavy metals, carbon / hydrogen / nitrogen contents and identification of polymers and additives.
- Aerobic Biodegradability Testing, during optimal conditions according to one of the following methods in which the amount of carbon dioxide produced is measured: (i) aerobic (with oxygen) aquatic biodegradation according to ISO 14852, or (ii) aerobic small scale composting according to ISO 14855-1. Biodegradability tests can be completed with the determination of biomass and carbon balance.
- Disintegration test. To prove that the material/product is disintegrated into small fragments not possible to sieve through a 2 mm sieve. Industrially compostable waste is tested according to ISO 20200 or ISO 16929. Small scale (home) compostable waste is tested according to SP method 4148.
- Eco-toxicological impact on mature compost. The compost derived from the disintegration test is composted to maturity. After that, its effect on water- or soil-living organisms is eco-toxicologically tested. The tests can be performed on higher plants according to OECD guideline 208 + annex E in EN 13432.

The Standard (EN 13432) is very similar to the ASTM D6002, except that it has pass/fail specifications built into it. The key specification is the requirement of >90% biodegradability for blends, copolymers etc., as measured by ISO14855 (controlled composting) test method.

In a nutshell, EN 13432 tests assess the rate of disintegration and aerobic biodegradation during a model composting process, the value and utility of the resulting humus with eco-toxicological means and the absence of high content of restricted metals. It is not the appropriate protocol for assessing anaerobic biodegradability (e.g. valorisation of waste for biogas generation), whereas the eco-toxicity assessment remains an issue.

Is a Natural also a Biodegradable Material? Biobased Materials' Content

On the other hand, recently and in order to impede growing false communication to the consumer of biodegradability, as well as restrain the ever increasing smearing campaign of truly natural materials, EPA and ASTM have stipulated a definition for biobased materials, often applied as raw materials for the manufacture of natural and synthetic products / compositions, namely: "Biobased is an organic material in which carbon is derived from a renewable resource via biological processes. Biobased materials include all plant and animal mass derived from CO_2 recently fixed via photosynthesis, per definition a renewable source".

The biobased content of modern products can be objectively measured by ASTMD6866 Standard method using radiocarbon and isotope ratio mass spectrometric analysis. In hybrid products that contain both natural resourced and synthetic materials USDA is setting a quota % limit value as a threshold for a product to be labeled «biobased».

Maybe some – reiterate, some! – allegedly natural products (e.g. tannins, enzymes, colourants etc.) can then be rationally and objectively categorised as biobased; this, in turn, does not equal to these molecules been proven biodegradable, or compostable. Compostability depends very much upon their structural and microtoxicity properties and quite often the lability of components poorly fixed in the product under examination. Testing by applying EN 14995, EN 13432, ASTM, D6400 or ASTM D6868 may verify product labeling as compostable under specific conditions.

Are Biodegradable Products Serviceable and Durable?

Durability and serviceability are key attributes required by the consumer to avoid waste and littering of the environment, as well as for economic as well as prestige related reasons. Service and use indicators have been included in the Eco-index tool, as well as durability related parameters incorporated in ECOLABEL, whereas other certification schemes foresee increasingly stringent limits regarding bio-availability of metals and fastness of other chemicals (dyes) upon contact and use.

«Easy care» as an added value has boosted Green Chemistry development of polymers, resins and reactive dyes, used in anti-soiling and hydrophobisation systems of various consumer products.

Moreover, often biopolymers show poor mechanical strength and resistance to microbiological or city micropollutants attack, and, therefore, their stabilisation and structural or /and surface modification is necessary. Good examples are collagenic based biomaterials, leather and paper.

Durable and easy-care consumer goods and materials, products of sustainable manufacture, are usually robust and persistent in the environment under normal composting conditions. A measurable life expectation in city polluted microenvironments of 75-100 years is not unreasonable.

The trade-off in this case can only be avoided with advanced waste treatment and recovery technologies, e.g. fungal biomass bio-leaching, bio-adsorption and bio-conversion.

Misleading or False Communication of Biodegradability – Consumer Protection

Two tribunal cases, notably won by Antitrust authorities in Australia and in Italy, have already sanctioned the distribution of 100% degradable shopping bags (Coop in Italy: PE with pro-oxidant additives [3]).

In the mean time the U.S. Federal Trade Commission (FTC) [4] has advised companies "that unqualified biodegradable claims are acceptable only if they have scientific evidence

that their product will completely decompose within a reasonably short period of time under customary methods of disposal."

Additionally, the U.S. National Advertising Division (NAD) of the Council of Better Business Bureaus recommends that advertisers discontinue claims such as "100% oxo-biodegradable" because such statements incorrectly suggest that a plastic will quickly or completely biodegrade with the help of these additives [5]. NAD and FTC have taken action against companies using the additive technology for "oxo-biodegradables" and using the word "biodegradable" for marketing purposes that have made false and unsubstantiated claims [6].

However, false or unqualified communications of biodegradability or unsubstantiated comparative advertising continues harming the Industry and the consumer.

Inevitably gatekeepers the only real gatekeepers are consumers' organizations and Trade's Associations.

Examples of false or misleading communication:

1. «New Coop bags, 100% degradable. To be useful also to nature» (Italy).

Tribunal case conclude in 2005 [3] with the company been sanctioned on the grounds misleading and comparative advertisement (Coop shopping PE + Additives bags).

A similar case also concluded in a similar manner in Australia.

2. Biodegradable Shoes: www.ecotoe.com

«Our Bella shoe, Sherpa boot and Heather sandal are both biodegradable (apart from the metal buckle on the Heather sandal which you have to cut off if you are putting them in the compost). It costs a lot (15,000 Euros) to test biodegradability to the European standard; we know the materials we have used are biodegradable and natural but over the next year we are going to put a worn shoe into a controlled compost "situation", take photos over a period of time and make an animated film of it once it has finished. We have the bits and pieces to put this test together but so far we have been a little too busy making the shoes to get this project "out of the garage". Although it is quite likely to stay in the garage once it's under way anyhow (this is taking a bit longer than planned to set up).

Our Iona textile shoe is not fully biodegradable, it is an animal free product and we have done all we can to make it environmentally friendly. The upper and lining textiles are from a great eco-ethical textile supplier and are biodegradable and made in an environmentally friendly way. We are working on the soles which are not biodegradable and use a non bio degradable adhesive… but we have a lead and are hoping to solve this. Our aim is an animal free shoe that is biodegradable.»

Unsubstantiated statements and a cinematographic methodology for monitoring biodegradation of whole shoes is mentioned with an incredible assumption that leather free shoe is animal free (that is a new Indicator) and biodegradable. Moreover, what also remains unclear for all those testing consumer goods as footwear is whether how the shoe has aged prior to testing, through normal or field wear+tear, as a lot of the chemicals in them change (see detanning, oxidation of phenols to quinones, hydrolysis of almost everything, dyestuff oxidation, migration of fatliquors and other chemical components, denaturation through wet heat impact).

3. Ferragamo Ecobag!

«The collection, entitled Eco Ferragamo, feature five day bags in the Italian label's signature style - think chic, soft leather in classic shapes. The difference? These bags have undergone a tanning process that uses natural products instead of the usual, environmental unfriendly metal elements, making the leather biodegradable and water-resistant. The dyes used contain tannins made from tree bark and the linings are made from sustainable hand-woven hemp, a much greener choice than cotton.

Reassuringly the whole process has also been certified by German institute SG-Mark who ensure that no environmentally harmful substances are used.

So you can invest in the must-have accessory of the season with a clear conscience.»

- Leathers probably sourced from quality tannery in Tuscany and are full vegetable tanned calf skins. Hydrolysable tanning applied most probably is Sumac.

- All leather articles are biodegradable! What differs is the rate and extent of biodegradation, depending on the conditions applied during testing, whereas it is not communicated what testing method was applied and the results of the assays.

- Vegetable tanning, as most known organic tannages, do not render leather water-resistant. Instead vegetable tanned leathers are extremely hydrophilic, if a semi-metal tanning process, hydrophobic fatliquoring or/and hydrophobisation finishing had not been applied. There is nothing natural about water-repellent leather!

- SG certification does not qualify the environmental friendliness of the process (namely waste, energy/water consumption and degree of abatement) as do Ecolabel, Eco.L, EcoSure labels, but only compliance to a specific RSL. SG-label guarantees that a leather product does not pose any health risk to human health – in simple words compliance to a RSL is certified, nothing else! Moreover, if SG certification has been granted to the product leather that does not include any limit for extractable with artificial sweat Cr, whereas the soluble tanning metals content is regulated (total <200 mg/kg), a condition, however, that does not guarantee a metal free leather or process.

- The application of natural dyes (from tree bark) highlighting another medium-high polluting technology – oligophenols - characterized by low exhaustion, high COD and isochrome value of generated wastewater, low anaerobic biodegradability of waste, poor light and dry- and wet-rub fastness of colour. This is probably also the reason the leathers were hydrophobised in dry finishing.

CONCLUSIONS

The use of the term biodegradable is de facto redundant and often misleading and ought to be substituted by product lifecycle metrics of:

- Biobased content;

- «Cradle-to-cradle» Life-Cycle-impact for the product and its specific uses, that is only possible if the primary product is fully retraceable;

- Durability and serviceability, as per Eco-index internal benchmarking tool guidelines.

Biobased raw materials sourced from fast renewable agricultural and biomass feedstocks are the foundations of sustainable eco-friendly recyclable products manufacture, which can compete and capture markets currently dominated by products of the petrochemical industry.

On the other hand, misleading and comparative anedafic promotion, as for example myths still propagated by entrepreneurs for the various types of stabilisation chemistries applicable in leather and shoe components' manufacture - particularly when complete LCA studies' results have become available to the truly measurable product impact - ought to stop or be penalised.

Finally, a campaign for educating the public about the seemingly clean and natural, in conjunction to its service-use and end-of-life is well due, as marketing campaigns based on inconclusive scientific data at best and in most cases on (un)-reasonable assumptions have already handicapped enough the chemical industry and consumer goods' producers.

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