

1 Introduction

2 Biobased, renewable materials offer a
3 wide range of advantages over
4 synthetic, fossil-based materials, given
5 that their performance matches the
6 requirements. Several impact
7 categories are commonly used to grade
8 the environmental impact of materials
9 but also in terms of health impacts for
10 both, humans and animals, and, on a
11 wider base, effects on eco-systems in
12 general. Impacts such as carbon dioxide
13 footprint, energy consumption, land
14 use, etc. are to be considered. In this
15 regard, it is important to emphasize
16 that the totality of impacts is taken into
17 account to allow for fair and
18 appropriate comparison. This includes
19 end-of-life scenarios and the fate of
20 materials if involuntarily or even
21 deliberately introduced into the
22 environment. Even though materials
23 must not be designed in a way that they
24 are supposed to be disposed of in
25 nature, having the possibility in mind
26 that this eventually could take place is
27 contributing to responsible
28 engineering.



30 To start with: What is Vernovo?

31 Vernovo materials are based on two
32 main components that are both
33 sourced from nature: plant/cellulose
34 fibers and polymers derived from plant
35 constituents, extracts, or fermentation
36 products, respectively. In order to
37 generate the variability in material
38 properties from hard to soft and
39 biodegradable vs. non-degradable, the
40 ratios in which the base materials are
41 blended are varied and thus the
42 protocol for the manufacture of the
43 biopolymer component is adapted.

44 Vernovo belongs to the domain of so-
45 called natural fiber/wood-polymer
46 composites (NF/WPC), a class of
47 materials that offers various beneficial
48 features that let them outperform
49 conventional plastic materials. In this
50 regard, it is eminently important that
51 both components, the cellulose fibers,
52 i.e. the plant fiber/wood component,
53 and the polymer are of sustainable
54 origin. Contributing to deforestation
55 would not be a wise engagement in
56 terms of sustainability. Hence, the
57 cellulose fibers are to be sustainably
58 sourced and derived from material
59 streams that do not require the cutting
60 down of trees. Still, the material must
61 be safe and fulfill regulations for food-
62 grade materials.

63 In Vernovo, the cellulose is PEFC
64 sourced directly from the food industry
65 and certified renewable plant extracts.
66 Essentially, all carbon atoms in the
67 cellulose fraction of the material
68 originate from carbon dioxide that was

once photosynthetically converted into plant cell constituents.



Similar considerations are valid for the polymer component. Using a conventional petrol-based synthetic polymer would tremendously diminish the sustainability of the composite material. Thus, the polymer component should preferentially also be a biopolymer. Biopolymers can in principle be categorized based on their origin and their fate, i.e. being based on renewable resources and/or biodegradable. Thus, non-degradable polymers can be derived from renewable resources, but it is also possible to have degradable polymers being prepared synthetically. In particular, in applications in which durability and mechanical performance are key for a successful solution, degradability is detrimental to the material performance for degradability goes against durability. Hence, also for the polymer component, renewability is the major feature that provides sustainability for every carbon atom

also in the polymer phase should have once been carbon dioxide, converted into plant material by photosynthesis.

In contrast, conventional synthetic polymers such as PVC, polyolefins, or nylon are derived from crude oil or gas that need to be lifted and sophisticatedly refined. During exploitation huge fractions of methane are emitted into the atmosphere, a greenhouse gas (GHG) approximately 20 times worse than carbon dioxide, or exploitation is even executed through fracking processes that exhibit massive negative impacts on the environment. Furthermore, during refinement, vast amounts of energy are required that regularly are produced from non-renewable carriers of energy.

Essentially, as confirmed by a 3rd party life cycle analysis (LCA) Vernovo materials generate far less CO₂ and other greenhouse gas emissions and consume fewer fossil fuels during manufacture compared to virgin petroleum-based plastic products. There are no non-renewable material sources utilized in the manufacturing of Vernovo.

Vernovo is also superior to natural rubber, which is derived from latex and thus inherently carries the risk of allergenic reactions. Even more so, albeit derived from natural resources, latex from rubber trees is commonly

sourced in vast mono-cropped plantations for which typically rainforest was destroyed.

What else?

In conventional plastic materials, a wide range of processing aids, performance additives, and stabilizers are added in fractions of up to 10% to allow for shaping the materials and stabilize against heat and shear during processing as well as during application. Vernovo is manufactured via a process that does not require any of these substances. It is thus totally free of for instance phthalates, BPA, parabens, or substances of very high concern. Importantly, no PFAS are added during the manufacturing process. Thus Vernovo, produced with food-grade cellulose fibers and plant constituents, does not contain allergens and passed the strict REACH EU standards required for materials produced in the European Union. Furthermore, no dairy, nuts, meats, wheat, gluten, or fish are used in the manufacture of non-flavored bones. Moreover, no artificial colors, flavors, dyes, or harmful chemicals were added and thus are present in Vernovo including mutagenic or carcinogenic compounds.

What makes Vernovo unique?

The well-designed balance between the main constituents allows Vernovo to exhibit the right balance of strength, stiffness, and flexibility. In terms of

wear/abrasion resistance, it is safer in its generality over for instance Nylon or PVC. Whereas PVC by itself is a very brittle material that requires vast amounts of plasticizers (> 10 %) to attain flexibility suitable for the application, natural rubber lacks strength and stiffness and needs to be blended or modified in order to suit the required mechanical performance. Nylon provides a set of properties matching those required but unless suitably stabilised is prone to impact by UV irradiation and heat which can lead to deterioration of properties and even change the behaviour by induced post-crystallisation turning the material brittle. Opposed to Vernovo, Nylon is also quite sensitive to moisture and can undergo hydrolysis by being attacked by enzymes present in the saliva.

Benefits to the teeth and harmless in the digestive tract- PET FORMULATION

Vernovo PET formulation is designed to provide protection to your dog's teeth by allowing humans to select from various durability formulations from soft to hard depending on chew strength. All densities lend themselves to helping clean your dog's teeth exhibiting the right balance of stiffness, strength, flexibility, and hardness. This allows the dog to satiate their need to chew while the teeth-cleaning nubs and ridges clean above the gum line and prevent the build-up of tartar, helping to stop bad breath and tooth decay in its tracks. In this regard, Vernovo is designed in a way allowing for flaking but being splinter resistant, which

1 reduces the chance of cracked teeth
2 compared to nylon, rubber, and other
3 highly processed chew products.

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5 Being based on natural, food-grade
6 material it is perfectly safe to ingest
7 Vernovo in limited amounts in small
8 pieces smaller than the size of oatmeal
9 flakes or rice grains. They are to pass
10 through the dog's digestive tract. Due
11 to the material's composition, there are
12 no sharp edges that might cause cuts or
13 irritation. Whereas the cellulose
14 particles are food-grade non-soluble
15 fiber, the polymer component is inert to
16 the digestive system, so even when
17 ingested in small quantities it will pass
18 without harm. However, it is not meant
19 to be a meal substitute product.

20

21 Seamlessly meeting all applicable
22 standards, and by-far surpassing the
23 requirements regarding pet toys, also
24 qualifies Vernovo for the use in
25 children's toys for which of course the
26 strictest regulations and requirements
27 are present. In particular, the absence
28 of PFAS, etc and completely omitting
29 the addition of problematic additives
30 during manufacture shapes Vernovo
31 perfectly suitable for use in kids and
32 toddler toys.