

Customer Information Sheet

DSM Dyneema protects people and the environment

Increasing market demand for sustainable solutions

Sustainability is the fundamental business driver for DSM, and the company is consistently one of the leaders on the Dow Jones Sustainability Index. DSM Dyneema acknowledges and supports the increased focus that government procurement agencies are putting on sustainability. It views this as part of the growing trend towards a more responsible supply chain for ballistic materials. DSM Dyneema provides a leading innovative material for the production of lightweight, reliable, and durable life protection solutions. The low weight and extended life-time of these products mean that they start with an advantage

when it comes to reducing the ecological footprint of the entire value chain – less material, lasting longer.

1. Carbon footprints and LCAs can be decisive when choosing a product

According to one major aramid fiber supplier [1], the production of 1 kg of their fiber results in the emission of 19.7 kg of CO₂. Emissions of CO₂ associated with the production of 1 kg of Dyneema® fiber, on the other hand, are noticeably lower at 14.4 kg. DSM Dyneema has a long-running energy saving program that should lead to that figure falling in the medium-term to just 10.6 kg.





Furthermore, the amount of Dyneema® fiber required for the production of a typical body armor vest can be up to 20% less than a comparable vest made with aramid fiber. This should prove a decisive factor in favor of Dyneema® for fiber users who are serious about sustainability.

Life Cycle Analysis, or LCA, provides further clear information of the benefits in terms of overall environmental impact of using Dyneema® fiber. An LCA complements carbon footprint data by assessing environmental impacts associated with the various stages of a product's life, considering inputs of water, energy, and raw materials, and releases to air, land, and water. DSM Dyneema commissioned an independent consultancy firm to carry out an LCA on Dyneema® UD in accordance with internationally accredited measurement standards. While performing the LCA, the consultancy firm calculated the total carbon emissions for the entire value chain from the raw materials to the finished vest in use over a 10 year lifetime. The evaluation was based on a typical body armor vest [specification NIJ 01.01.04 level 3A] made using

Dyneema® UD, and compared it with results from vests made with alternative armor materials.

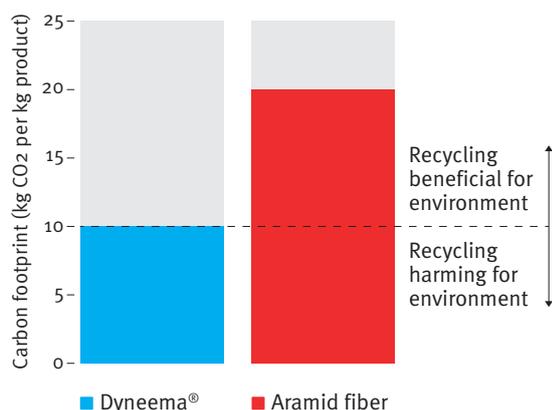
It concluded that, compared with aramids, the emissions over 10 years lifetime were approximately 30 % less when the vest was made using Dyneema® UD.

2. Energy recovery comes out top in end-of-life solutions

At some point, every product comes to the end of its useful life. This is when another challenge emerges: how best to second use the product. Plastics Europe [2], the trade association of European plastics manufacturers, has summarized the emerging technology portfolio for mechanical recycling. Because Plastics Europe's vision on waste management is firmly rooted in LCA methodology, we will continue to track its work, with a view to identifying best practices in value recovery.

We are assessing the economic, ecological and technical feasibility of two recovery options for Dyneema® material:

DSM Dyneema will focus on thermal energy recovery to minimize environmental impact



Due to the very low carbon footprint of Dyneema® compared to aramids, Dyneema® will focus on energy recovery instead of recycling to have the lowest integral carbon footprint.

A. Mechanical recycling of clean fiber

DSM Dyneema is currently working with industry partners on technologies for recycling polyethylene fiber and converting it into chopped material that can be used for applications such as staple fiber. The clean fiber production waste at the Netherlands production site is already being recycled in this way.

Just as with alternative products, the mechanical recycling of Dyneema® UD is considered unattractive on environmental grounds, since the carbon footprint of the process is higher than producing from virgin fiber.

B. Energy recovery: generating green energy, such as electricity, steam or process heat.

The combustion value of Dyneema® material amounts 40-45 MJ/kg. This is similar to oil and twice as high as that for coal. Incineration with energy recovery is a highly efficient and clean way of releasing the energy stored in polymers and is particularly suitable for polyolefins such as Dyneema®. When combusted in a high efficiency incineration plant, with so called R1-status, the energy generated is called 'green energy', and energy certificates can be provided meeting EU regulations.

In terms of carbon footprints, incineration with energy recovery of Dyneema® fiber and Dyneema® UD products makes much more sense than mechanical recycling. This is because the carbon footprint of the production process for

virgin Dyneema® fiber is relatively small—not much larger in fact than the footprint of the mechanical recycling process, especially when the transport step between the source of the waste and the recycling operation is taken into account. That difference will be almost eliminated once DSM Dyneema implements its energy saving program for producing virgin fiber. It may actually be counter-productive in environmental terms to transport fiber waste to mechanical recycling facilities, if R-1 incineration facilities are nearby.

Because the carbon footprint of the production of aramid fiber is significantly larger than the one for Dyneema®, there is a stronger driver to mechanically recycle them. However even for aramids the recycling of fibers embedded in resin is generating more carbon dioxide than producing virgin aramid fibers.

It is clear that, whatever the solution chosen, it has to be local to have the lowest possible impact on the environment. For the energy recovery solution, DSM Dyneema can provide customers with contact to a selected partner company that can provide certificates on energy regeneration. Please contact your account manager for details on this prototype program.

Taking steps to further reduce ecological footprint

Reduction and responsible handling of waste created during the production of Dyneema® fiber and composites, as well as during their fabrication into finished products, is of key importance to DSM Dyneema. A continuous optimization of our yield is resulting in an ongoing reduction of waste streams. Downstream from here, to help customers optimize the production efficiency of cutting lines used in the manufacturer of ballistic articles, DSM provides them with the option of ordering Dyneema® UD in widths other than the standard 1.60 m. Please consult your account manager for more details. As a further contribution towards reducing the environmental impact of its total supply chain, DSM Dyneema uses paper and carton transport packaging made with recycled paper. The packaging can be recycled again after use.

DSM Dyneema issues a Life Time Expectancy statement, as part of the product specification sheet (PSS) of a Dyneema® UD product. The statement provides information for users on how best to ensure the long-term performance of the material. The statement underlines the product's durability and notes that it has a longer replacement cycle than the industry average. For exact data, please refer to our Product Specification Sheets (PSS), developed for each individual product grade. This long life time expectancy was confirmed by a scientific article presented at PASS seminar 2012 [3].

Brighter Science, Brighter Lives

We are committed to continuously improving and providing the best solution possible, to reinforce our position as industry leader, to live to our businesses' purpose: to create brighter lives for people today and generations to come. Your account manager will keep you updated on any key developments and relevant solutions.

- 1 Information for 2011 emissions taken from Teijin web site [2012]. <http://www.teijinaramid.com/sustainability/eco-footprint/carbon-footprint/>
- 2 Plastics Europe <http://www.plasticseurope.org>
- 3 Effect of Real Aging on Ballistic Articles made of Dyneema® UD, by Padovani, Meulman and Louwers, proceedings PASS seminar 2012 Nurnberg, Germany.

Key points:

- DSM is very committed to sustainability
- LCA shows that the CO₂ emission of a Dyneema® based vest is 30% less compared to aramids
- Thermal recycling with energy recovery of Dyneema® UD cutting waste is an environmentally friendly way to reduce landfill.
- Due to the lower carbon footprint of Dyneema® compared to aramids, Dyneema® will focus on thermal energy recovery instead of fibre recycling to have the lowest carbon footprint.

Please contact your account manager if you want further explanation of DSM's recycling options.

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