Hydropol™ End-of-Life Overview

Hydropol™ is a specially engineered polymer that is used to create a range of products that can help to eliminate harmful plastic pollution at source.

This is possible thanks to the unique chemistry of Hydropol™ and means that multiple environmentally safe disposal options are possible when packaging or products containing Hydropol™ reach the end of their natural usage.

The following document provides an overview of some of the most common methods.

Recycling

Mechanical Recycling

Hydropol™ film has been certified as fully recyclable at up to 7wt% functional barrier in a multi-layer film according to Cyclos HTP method CHI-C8-PEF-1/4.1 with the use of PCR-based LDPE recyclate as a reference. This confirms that Hydropol™ can be recycled within the existing polyolefin based flexible packaging waste stream without contamination and if the total volume of Hydropol™ is to exceed 7%, creating a waste stream for polyvinyl alcohol only would then become a viable option.

It is worth noting that this percentage is a sizeable amount of material in tonnage and therefore a significant safety margin and reassurance that Hydropol™ will not cause any issues when recycled can be expected.

Based on CEFLEX's Designing for a Circular Economy Guidelines which gives practical support and advice on circular economy design principles, we can confirm that Hydropol™, being a PVOH compound and when providing barrier properties for polyethylene (PE) and polypropylene (PP), would be aligned with the CEFLEX guidelines, in that it can be used up to 5% in the total structure of the material and be deemed compatible with PE and PP mechanical recycling.

CEFLEX has undertaken preliminary testing of PVOH film and may test for full mechanical recycling recyclability in the next phase of the future testing programme to fully substantiate the thresholds in the guidelines and further advise the value chain.

Hydropol™ is a thermoplastic polymer, therefore can be mechanically recycled back into pellet. This works well in closed capture loops, such as retail, where Hydropol™ can be collected in bulk. Aquapak are pleased to confirm that we have plans to open an internal programme to incorporate recycled content to further the circular economy and support our customers with global plastic taxes.

Paper Re-pulp

There is no international standard test method for evaluating the recyclability of paper and board products. We use ISO 5263:1 (laboratory disintegration of chemical pulps) to model conditions in a standard recycling mill as closely as possible.

Hydropol™ has been designed to be compatible with paper recycling processes. Coated on to paper, it has independently been tested for repulpability, using process conditions and temperatures (40°C) which emulate those used in a standard recycling mill typically at a re-pulp temperature of 40°C. Aquapak are pleased to confirm that representative Hydropol™ coated paper conforms to the following standards for paper recyclability:

- Italian National Recyclability Standard: UNI 11743 and assessed according to Test Method MC 501:2017 (Level A+ rating achieved)
- CEPI Recyclability Laboratory Test Method Version 2

Extensive work carried out in conjunction with DS Smith and Axchem has shown that Hydropol™ has no detrimental effects on the paper recycling system. Further details can be found on our website:

https://www.aquapakpolymers.com/request-white-paper/

https://www.aquapakpolymers.com/request-white-paper-2/

Compliance with these test methods for the fibre-based packaging will ensure that the final product can be labelled as 'recyclable' according to national labelling schemes such as On Pack Recycling Labelling (OPRL) in the UK. Aquapak are happy to support customers through this process.

Aquapak are aware the CEPI test method is currently under review and are working with the industry alliance focus groups within the 4Evergreen initiative responsible for updating the method.

Furthermore, we can confirm that representative Hydropol™ coated paper conforms to the Standard Test Method for Repulpability Version 1 – Dec 2022 developed by the Australian Packaging Covenant Organisation (APCO) and would score 'Good recyclability-acceptable'.

Biodegradation

Biodegradation is defined as any physical or chemical change in a material caused by biological activity. Plastics are usually biodegraded aerobically in nature, including in marine environments, anaerobically in sediments and landfills and partly aerobically in compost and soil.

Hydropol™ will disintegrate and completely biodegrade over time in both aerobic and anaerobic conditions.

Industrial (Municipal) Composting

ISO 17088

Hydropol™ film[1] has been certified against ISO 17088-2012 (Specifications for Compostable Plastics) by India's CIPET laboratory. The analysis used test method ISO 14855-1 (Determination of the Ultimate Aerobic Biodegradability of Plastics). The film reached 90.07% of biodegradation within 101 days, well below the threshold time limit of 90% within 180 days.

EN13432

The harmonised European Standard for specifying industrial compostability of packaging is EN13432. There are 4 main parts to the test: 1) Disintegration/fragmentation; 2) Biodegradation; 3) Ecotoxicity; 4) Compost quality, all of which are measured against a cellulosic standard.

Hydropol™ films have higher strength and other improved mechanical properties over existing compostable materials. As a result of this improved strength, they do not fragment quickly enough under the EN13432 test criteria in comparison to the less robust traditional compostable materials.

Whilst all Hydropol™ film will biodegrade in composting conditions, the actual claim for compostability can only be met by adhering to EN13432 testing and therefore Hydropol™ film is much more gauge dependent than weaker products.

However, Aquapak has historical independent test data and ongoing tests on Hydropol™ which confirm by testing and extrapolation under EN13432 protocols that not only is biodegradation occurring but EN13432 can be achieved depending on the Hydropol™ version and the gauge of the film.

- Hydropol™ film[2] is expected to pass the requirements of EN13432 at a gauge of 20µm.
- Hydropol™ film[3] is expected to pass the requirements of EN13432 at a gauge of 15µm.

Based on this, we would expect for Hydropol™[4] to pass the requirements of EN13432 at the same gauges.

Hydropol™ coated onto paper[5] demonstrated 100% or full disintegration within 6 weeks of composting under industrial conditions and therefore fulfils the disintegration criterion in a pilot-scale composting test according to:

- EN13432 Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging (2000).
- Australian standard AS 4736 Biodegradable plastics – Biodegradable plastics suitable for composting and other microbial treatment (2006)
- American standard ASTM D6400 Standard Specification for Labelling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities (2023)
- American standard ASTM D8410 Standard Specification for Evaluation of Cellulosic-Fiber-Based Packaging Materials and Products for Compostability in Municipal or Industrial Aerobic Composting Facilities (2021)
- American standard ASTM D6868 Standard Specification for Labelling of End Items that Incorporate Plastics and Polymers as Coatings or Additives with Paper and Other Substrates Designed to be Aerobically Composted in Municipal or Industrial Facilities (2021)
- International standard ISO 18606 Packaging and the environment - Organic recycling (2013)

Home Composting

There is currently no international standard specifying the conditions for home composting of biodegradable plastics. However, there are several national standards such as the French NF T51-800 (2015) and Australian AS 5810.

Hydropol™ coated onto paper[5] demonstrated 100% or full disintegration after only 2 weeks of composting at ambient temperature.

The French standard specification NF T51-800 (2015) stipulates that, when a material has passed the 90% disintegration requirement after 180 days according to ISO 16929, a material has demonstrated sufficient disintegration for home composting based on ISO 20200 at ambient temperature (20°C – 30°C).

According to the Australian standard specification AS 5810 (2010) the criterion for evaluation of disintegration in the slide frame test is that 90% of the test material has disintegrated from the slide frame and any remaining residue shall not be distinguishable from the other material in the compost at 500 mm as observed by the naked eye.

We are therefore pleased to confirm that Hydropol™ coated onto paper[5] complies, for the requirement of disintegration, with NF T51-800 (2015) and AS 5810 (2010).

Biodegradability of Organic Matter in Industrial and Municipal Wastewater Effluent Systems

The ratio of BOD5 to COD (Biodegradability Index) provides insight into the nature of pollution and biodegradability of organic matter in wastewater.

Biochemical Oxygen Demand (BOD5) measures the amount of oxygen consumed by microorganisms over a 5 day test period while breaking down organic matter in water.

Chemical oxygen demand (COD) quantifies all organic material (both biodegradable and non-biodegradable) – in terms of oxygen demand.

The Biodegradability Index (BOD5:COD ratio) serves as an 'unofficial indicator' of the proportion of readily 'biologically' biodegradable organic matter to total organic matter.

BOD5:COD < 0.1 – indicates the presence of high organic matter that is difficult to biodegrade

BOD5:COD >0.4 – indicates readily biodegradable organic matter.

Based on independent tests carried out by AquaEnviro according to the 5 Day Biochemical Oxygen Demand (BOD5) Second Edition 1988 with Dissolved Oxygen in Waters, Amendments 1988 Method, we can confirm that Hydropol™ has a BOD5:COD between 0.1-0.4 which is higher than the value obtained for commercial PVOH grades and suggests that Hydropol™ biodegrades in industrial and municipal wastewater effluent treatment systems.

Additionally, it can be noted that using an adapted/acclimatized activated sludge would likely increase the rate and extent of biodegradation achieved over the 5-day BOD test.

Aerobic Freshwater Biodegradation

The certification requirement for biodegradation in fresh water for OK Biodegradable WATER certification by TUV, in accordance with the ISO 14851 test method, is 90% carbon to CO2 conversion to be reached within eight weeks.

Hydropol™ melt-blown fibers[6] have been tested by an independent lab according to this test method and after 8 weeks, as measured by O_2 consumption, the biodegradation of test material with an average absolute biodegradation level of over 90% was reached. We can therefore confirm that Hydropol™ melt-blown fibers[6] fulfil the requirement on biodegradation as defined by EN 14987 Plastics - Evaluation of disposability in waste water treatment plants 2006.

Furthermore, Hydropol™ pellets have been proven to biodegrade using the same test method, ISO 14851- Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium- by measuring the oxygen demand in a closed respirometer.

Representative grade[7] achieved a degradation plateau at day 95 as determined by a non-linear curve fit of the data for oxygen consumption. Consumption of O2 by the test system indicated that the test sample biodegraded to 34% ThOD after 95 days of testing.

Representative grade[8] achieved a degradation plateau at day 85 as determined by a non-linear curve fit of the data for oxygen consumption. Consumption of O2 by the test system indicated that the test sample biodegraded to 18% ThOD after 85 days of testing.

The full test report can be found on our website:

https://www.aquapakpolymers.com/wp-content/uploads/Aquapak-Report.pdf

Anaerobic Digestion

This method is used for converting food waste into biogas which can then be used for energy generation and produces bio-digestate, a valuable fertiliser. Unusually, as most plastics are not, Hydropol™ films are compatible in AD systems. Clearly the gauge of the film, hydrolysis of the product and the type of AD system are critical. Film in the range 20-35µm of both fully and partially hydrolysed film will breakdown in thermophilic units within the normal operating dwell time. The thicker gauges of fully hydrolysed film require a hydro-treatment or pre-conditioning tank prior to entering the AD tank to enhance speed of breakdown. Nearly all AD systems require post pasteurisation to kill pathogens and this process will breakdown any residual Hydropol™ material in both systems.

Landfill

Films tested pass criteria for disintegration in anaerobic conditions. This data allowed a calculation to meet the requirements of anaerobic landfill conditions according to ASTM D5526 AD.

Solubility

With the chemistry that Aquapak has developed, the speed and temperature at which Hydropol™ will fully dissolve can be tailored according to the application needs. This solubility will be primarily dictated by the hydrolysis of the grade. Please contact Aquapak for more specific details.

Furthermore, we can confirm that Hydropol™ meltblown fibers[6] have been tested according to OECD 120 method for solubility and has passed the requirement.

EU 2023/2055 restricts synthetic polymer microparticles with the aim of reducing microplastics in everyday products to protect the environment. Within the regulation it states that since water soluble polymers lose their solid state after their release into the environment, they therefore do not contribute to the identified concern on microplastics in the environment.

The regulation proposes that internationally accepted methods such as proving solubility according to OECD 120 can be used to exclude water soluble polymers from the scope of the restriction and although Hydropol™ does not form harmful microplastics, (please see our Microplastics statement), we view this to be out of scope of EU 2023/2055.

Marine Safe

PVOH is a hydrophilic polymer unlike most conventional polymers which are hydrophobic. There are many documented studies confirming the accumulation of toxins and harmful pathogens onto the surfaces of hydrophobic plastics like polyethylene. Hydrophilic plastics like Hydropol™ show no bioaccumulation.

A collaborative project with Heriott-Watt University has confirmed Hydropol™ non-toxicity to marine life at any concentrations reasonably expected to be present in the environment based on an extensive study on marine fish larvae exposed to Hydropol™. Please contact us for further details.

Flushability

In the absence of a harmonised method for flushability, the Edana GD4 Guideline, Fourth Edition, May 2018 was taken to be the industry standard to evaluate the compatibility of Hydropol™ with plumbing fixtures and municipal wastewater conveyance. The guideline stipulates that the following criteria must be tested and met for the test item to conform to the standard.

FG501: Toilet and Drain line Clearance Test

FG502: Slosh Box Disintegration Test

FG503: Household Pump Test

FG504: Settling Test

FG505A: Aerobic Disintegration Test

FG506A: Anaerobic Bio-disintegration Test

FG507: Municipal Sewage Pump Test

We can confirm that, Hydropol™ melt blown fibers[6] have passed the below tests and has been certified as flushable according to Edana GD4 method.

It is worth noting that not only were the acceptance criteria met for these tests, they were exceeded. For an example, the pass criteria for disintegration is 'average percent of initial dry mass to pass through 1mm sieve should exceed 95% after 14 and 28 days, where for Hydropol™ melt blown fibers[6] it was 100%

Summary

It should be noted that Aquapak has not moved to fully certify Hydropol™ as the samples were internally produced on our pilot equipment for indicative purposes only. The testing was undertaken to establish the behaviour of Hydropol™ in its expected end-of-life environments. It is normal commercial practice that the final product entering the market is certified to substantiate the claim.

Aquapak regularly screens and independently tests its materials for a wide number of end of life and disposal options to help customers who are producing their own finished goods based on Hydropol™ to obtain certification.

[1] 33101P (20-25µm)
[2] 33100 series
[3] 30100 series
[4] 50100 series & 55100 series
[5] 55218 coated on starkraft paper (60GSM paper + 25 microns coating) and 55218 coated on starkraft paper (50GSM paper + 20 microns coating)
[6] 50302P 40 & 60GSM
[7] 30164
[8] 33104