Frequently Asked Questions on AQUAPAK

1. ABOUT AQUAPAK

Aquapak is a polymer manufacturer specialising in the development and production of a range of formulated polyvinyl alcohol-based products suitable for use in most plastic applications and using conventional processing equipment.

Aquapak has a new and modern 50,000 sq. ft. compounding production facility in Birmingham, UK.

The site will ultimately have a total capacity to produce in excess of 30,000 MT of Aquapak's specially formulated pelletised resin. The first production line has been installed and is in commercial production for its first products and customers.

2. EXPLAINING PLASTICS

What are Plastics?

'Plastic' is the term commonly used to describe a wide range of synthetic or semi-synthetic materials that are used in a huge and growing range of applications. Everywhere you look, you will find plastics. We use plastic products to help make our lives cleaner, easier, safer and more enjoyable. We find plastics in the clothes we wear, the houses we live in, and the cars we travel in. The toys we play with, the televisions we watch, the computers we use and the DVDs we watch all contain plastics.
Plastics are organic materials, just like wood, paper or wool. The raw materials used to produce plastics are natural products such as starch, sugar, cellulose, coal, natural gas, and, of course, crude oil. Plastics have become the modern material of choice because they make it possible to balance today's needs with environmental concerns.

The term ''plastic'' is derived from the Greek word ''plastikos'', meaning fit for moulding. This refers to the material's malleability, or plasticity during manufacture, which allows it to be cast, pressed, or extruded into a variety of shapes - such as films, fibres, plates, tubes, bottles, boxes, and much more.

What is a Polymer?
A polymer is a large molecule, made from connecting many small molecules called monomers. Polymers are very common and can be naturally occurring, like starch, cellulose, rubber and protein or can be man-made, like plastic and some fibres.

What is a bioplastic?
Early plastics were manufactured from available natural materials like cellulose, but the discovery of crude oil and natural gas deposits and subsequent refining technology gave birth to the modern plastics industry. Plastics could then be manufactured at large scale and economically. In the last 20 years the drive towards alternative carbon sources (starch, cellulose, lignin, etc.) and improved biorefining has enabled the development and early stage production of bioplastics. Nearly all 'petro' derived plastics such as PE and PP can be manufactured from bio feedstocks but currently production at scale is a challenge. ***Hydropol*** is currently based on petro-derived feedstock but ultimately will be renewable (see Section 3 below).

What is a hydrophilic polymer?
A hydrophilic polymer is attracted to water and in the right conditions (temperature, agitation etc.) will be dissolved in water. This property is important in enhancing biodegradation and other properties such as compatibility with other materials such as cellulose.

What is a hydrophobic polymer?
Most of the commonly used traditional plastics like PE are hydrophobic i.e. attracted to oil or other water repelling materials. This hydrophobic property does cause issues in the environment by attracting often hazardous and toxic products to them, as products such as pesticide residues etc. are also hydrophobic. It also makes them very durable in the natural environment taking 10's-1000's of years to fully biodegrade.
Aquapak's material is hydrophilic.

Where are Plastics used?
Plastics are extremely versatile materials and are ideal for a wide range of consumer and industrial applications. The relatively low density of most plastics gives plastic products the advantages of light weight, and, although most have excellent thermal and electrical insulation properties, some plastics can be made to conduct electricity when required.

Plastics are corrosion resistant to many substances which attack other materials, making them durable and suitable for use in harsh environments.
Some are transparent, making optical devices possible.

They can easily be moulded into complex shapes, allowing other materials to be integrated into plastic products, and making them ideal for a wide range of functions. Furthermore, if the physical properties of a given plastic do not quite meet the specified requirements, its balance of properties can be modified with the addition of reinforcing fillers, colours, foaming agents, flame retardants, plasticisers, etc., to meet the

demands of the specific application.

In principle, plastics can be developed with virtually any combination of properties to accommodate almost any application you can think of. As a result of these attractive properties, plastics are increasingly being used in the following applications:

Packaging;
Building and Construction;
Transport;
Electronics;
Agriculture;
Healthcare;
Sport and Leisure;
Energy

How much Plastic is manufactured?
Total Global Production is around 350 M tonnes per year with China being the largest producer. (European production is 65 M tonnes per year).
Plastic is then converted into products via converters who produce the items we recognise.

The converted product demand is:

Packaging	39.7%;
Building and Construction	19.8%;
Automotive:	10.1%;
Electronics	6.2%;
Household, Leisure and Sport	4.1%;
Agriculture	3.4%;
Others	16.7%

3. AQUAPAK – MATERIAL, PROPERTIES AND TECHNOLOGY

What are Aquapak materials made from?
Aquapak's ***Hydropol*** range is based on specialty hydrophilic (water-liking) polyvinyl alcohol.

What is polyvinyl alcohol?
Polyvinyl alcohol (PVOH) is a water-soluble polymer, sold in both fully and partially hydrolyzed forms. Its technical properties vary depending on molecular weight (degree of polymerization) and fraction of acetate groups that are removed (degree of hydrolysis).

Uses of polyvinyl alcohol?
PVOH is used in diverse applications, including textiles for warp sizing, adhesives, polymerization aids, pigment binders for paper. Another major application involves converting PVOH to polyvinyl butyral (PVB), which is used as a coating to generate laminated safety glass for automotive and architectural applications

Why are Aquapak's polyvinyl alcohol products different from others?
Aquapak has perfected the thermal processing of polyvinyl alcohol to enable the production of standard pellets for use in the mainstream plastics industry. The global IP covers both the process and the special formulation chemistry. This has opened up the availability of a highly functional plastic with a number of viable end of life options – traditional plastics simply don't have these combinations of properties.

Normally polyvinyl alcohol is restricted to a limited number of applications because of its processing problems, and in many must be combined with other polymers to make a usable form. Often this combination compromises the base properties and restricts its use even further.

Interestingly evaluation of Hydropol in several applications has concluded that the special thermal process to create the pellet improves the properties (strength and barrier) of the final material.

In what form is *Hydropol* available?
Hydropol is available in pellet form allowing it to be used in any thermoplastic process, for example, blown film, co-extrusion, melt extrusion coating, thermoforming and injection moulding.

What are the properties of the material?
Hydropol has notable barrier properties for oils, solvents, fats and gases (Oxygen, Nitrogen, Carbon Dioxide). Other properties are reflective on the form. For example, in film form it has exceptional tensile strength (2.5 x PE of the same gauge), excellent puncture and tear resistance. Naturally electrostatically dissipative and has very good uv resistance. The film has very good clarity and can be printed without surface treatment.

The tensile performance and melt strength are also advantageous in more rigid forms such as injection moulding.

See specific data sheets which are available on request.

Can *Hydropol* be used in combination with other materials?
Hydropol is very compatible with many other plastics and materials. It is particularly compatible with cellulosic materials such as paper. However, it's use as a strength and barrier combination with both traditional plastics and bioplastics opens the potential to

retain or enhance primary properties and have a viable route to recycling or composting and anaerobic digestion

Is the base polymer derived from bio-based resources?
Aquapak sources its polymers from the major polyvinyl alcohol manufacturers. Their processes currently use oil and gas feedstocks to manufacture the starting monomer (vinyl acetate). This enables the polyvinyl alcohol to be available economically and at scale. A considerable amount of development work has already been undertaken by the major producers in developing viable routes to bio-based versions and it is expected that these will become commercially available and allow ***Hydropol*** to be 100% renewable.

Does *Hydropol* form microplastics?
Microplastics are simply small pieces of plastic.

The term '*microplastics*' first mentioned in 2004, is used to describe the smaller plastic particles recorded, however there is still no all-inclusive definition.

In technical literature it has evolved to mean something a bit more specific:
R.C Thompson et al initially used the term microplastics to describe the accumulation of microscopic pieces of plastic in marine sediments and in the water column of European waters. In 2009, Arthur et al., proposed an upper size limit to the initial term and microplastics where known as "*plastic particles smaller than 5 mm*". This definition was further refined in 2011, when Cole distinguished microplastics, according to their origin, into primary (produced to be of microscopic dimensions) or secondary (resulting from degradation and fragmentation processes in the environment). The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), defines microplastics as '*plastic particles <5 mm in diameter*, *which include particles in the nano-size range* (*1 nm*)'.

Depending on the environment, ***Hydropol*** in solid form may break down to small particles but **without the formation of toxins or the subsequent absorption of toxins associated with traditional plastics**. These small particles will not persist in the environment unlike conventional plastics whose long lasting hydrophobic micro particles absorb and concentrate toxins.

When in solution ***Hydropol*** **cannot form microplastics**.

4. FOOD CONTACT

Is *Hydropol* food safe?
All raw materials used in the manufacture are approved for direct food contact under FDA and European regulations.

Based on information from our raw material suppliers this product can be used in:

21 CFR 175.105	Adhesives
21 CFR 175.300	Resinous and polymeric coatings
21 CFR 175.320	Resinous and polymeric coatings for polyolefin films.
21 CFR 176.170	Components of paper and paperboard in contact with aqueous and fatty foods.
21 CFR 176.180	Components of paper and paperboard in contact with dry food
21 CFR 177.1200	Cellophane Restricted
21 CFR 177.1670	Polyvinyl alcohol film
21 CFR 177.2260	Filters, resin-bonded
21 CFR 177.2800	Textiles and textiles fibres

The composition of the ***Hydropol*** **30 and 33 series** meets the requirements of Commission Regulation (EU) No.10/2011 on Plastic materials intended to come into contact with food including its updates1282/2011, 1183/2012, 202/2014, 174/2015, 2016/1416, 2017/752, 2018/79, 2018/213 and2018/831.

5. END OF LIFE

Hydropol **dissolves in water?**

Depending on the ***Hydropol*** product there are three ranges of water temperature for dissolving the product.

(I) Hot water soluble will dissolve in water at temperatures greater than 70°C (158°F),

(II) intermediate at greater than 35°C (95°F) and

(III) cold water soluble at greater than 5°C (40°F).

Water solubility depends on the hydrolysis level of the grade and the thickness of the film in flexible formats.

Aquapak's unique and patented process allows the full range of hydrolysis levels to be processed into pellet form.

Can Aquapak's plastics be recycled?

Hydropol can be readily identified by sorting methods such as infra-red and laser sorting and can therefore be separated and reprocessed. In less sophisticated waste handling facilities, the use of a hot water wash enables ***Hydropol*** to be taken into solution. Once in solution the polymer can either be recovered (Aquapak's own technology) or the solution allowed to go to normal waste water treatment or anaerobic digestion.

Are Aquapak's plastics biodegradable?
By its nature the base polymers are inherently biodegradable and there is a large amount of historical work undertaken by academic and other researchers in this area detailing the microorganisms which breakdown the polymer in various conditions. Aquapak cannot make specific claims regarding the final product but we are working with application partners, third-party test houses and certifiers to ensure compliance claims are verified for the application.

Testing on Aquapak's own produced film indicated that a 15µ film meets the requirements of EN13432 and up to 30µ are compatible in thermophilic anaerobic digestion systems.

Further work is ongoing with independent test and certification institutes (OWS and TUV) looking at the behaviour of ***Hydropol*** in soil, freshwater and landfill.

Do *Hydropol* pellets biodegrade?
The pellets will biodegrade but, in this form, may take longer to do so depending on the conditions.

***Hydropol* biodegrades to carbon dioxide, water and mineralised biomass. What is mineralised biomass?**
In this case of polymer degradation, the term mineralisation indicates a natural biological breakdown step of the carbon in the polymer to carbon dioxide and water. So, via a process of oxidation the polymer breaks down via chain breaking to form smaller oxidised polymer chains (mineralised biomass) which then break down further to carbon dioxide and water. ***Hydropol*** does not yield any harmful products in any stage of breakdown and biodegradation.

Are Aquapak plastics safe in waste water treatment systems?
The base polymer has been used for many years in applications where the disposal route is through the waste water system and there are no reported problems, and this has been confirmed by a historical literature review as well as work conducted at two UK Universities on ***Hydropol*** film.

The polymer is entirely compatible with aerobic and anaerobic treatments. Recent work, as part of a programme of independent testing of ***Hydropol*** coated board to prove repulpability also looked at the effluent from dissolving the coating and demonstrated the capability of the waste water system to handle it without problem.

Are Aquapak plastics safe in the ocean?
Aquapak is very much aware of the ocean plastics problem and is in touch with several organisations looking at this problem. Work has already been undertaken with a UK University in toxicology testing using standardised marine fauna and no deleterious effects were found.

Clearly the advantage with the material is it is hydrophilic and therefore does not form harmful microplastics. A two-year programme of work will commence in October 2019 working with global experts in the marine behaviour of materials at Herriot-Watt University to understand exactly how ***Hydropol*** but also compare how other common plastics behave. ***Hydropol*** film has already been tested at OWS for toxicity screening using the Daphnia test protocol for ASTM D6691 and OK Marine. The environmental safety requirement of the OK biodegradable MARINE certification scheme of TÜV AUSTRIA Belgium was fulfilled.

If a turtle eats *Hydropol* what happens?

The work undertaken so far by independent laboratories including the OK Marine certification scheme indicates that ***Hydropol*** is non-toxic to marine species which would include turtles. The mechanism of breakdown would also decease the possibility of the turtle accumulating levels which would be harmful unlike most conventional plastics.

6. SUSTAINABILITY AND THE CIRCULAR ECONOMY

What does Aquapak mean by a plastic for the Circular Economy?

The drive towards a Circular Economy means the development of a sustainable materials chain which has all the advantages of modern highly functional materials in their primary and secondary uses but combines it with real end of life options.

Hydropol has excellent primary functionality in combination with a number of end of life options from recycling to controlled biodegradation. It's ready combination with other polymers and paper allows for simplification of layers for easier separation and recycling/recovery.