ISOPLAS
Crosslinkable Polyethylene

25 Years

Serving the Pipe Industry

MICROPOL

ISOPLAS CROSSLINKABLE POLYETHYLENE

ISOPLAS crosslinkable polyethylene is produced by grafting of organo-silanes on to polyethylene.

MICROPOL'S development of this technology has created a range of easily processable polyethylenes that have outstanding resistance to rigorous environments caused by:-

LARGE TEMPERATURE CHANGES e INCREASED PRESSURE e INCREASED PHYSICAL LOADS e EXPOSURE TO ULTRA VIOLET LIGHT e CONTACT WITH AGGRESSIVE CHEMICALS e AND ABOVE ALL EXCEPTIONAL RESISTANCE TO COMBINATIONS OF ALL OR SOME OF THESE RIGOROUS ENVIRONMENTS WHERE CONVENTIONAL THERMOPLASTIC MATERIALS HAVE PREVIOUSLY FAILED

The place of ISOPLAS crosslinkable polyethylene in the field of thermoplastic materials can best be seen by comparing it briefly with other thermoplastics and other types of crosslinkable polyethylenes.

All thermoplastic materials, such as PVC, polypropylene, nylon, polycarbonate, polybutylene, low and high density polyethylene, soften and finally flow at elevated temperatures. Crosslinking of polyethylene prevents this thermal flow by converting a thermoplastic material into a thermoelastic one. This can be visualised as the joining together of the long chain of polymer molecules with covalent bonds. This interlinking of the polymer structure significantly enhances its properties over a range of conditions.

ISOPLAS crosslinkable polymer supplied by Micropol has two components:- silane grafted polyethylene (VPE-b or **Graft Copolymer**) and **Catalyst Masterbatch**. These are supplied as granules which are blended together (normally by dosing equipment) and simply fed into the pipe extruder, moulding machine or other polyethylene processing equipment for converting to finished products. No crosslinking takes place at this stage which means that the full range of conventional process equipment and conditions can be used, without the limitations imposed by other crosslinking processes or the need for expensive machine modifications.

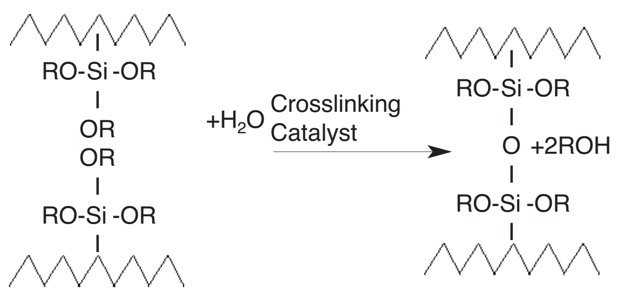
The finished product (which is still thermoplastic at this stage) can now be chemically crosslinked by reacting it with hot water or steam baths or saunas in a separate process. ISOPLAS crosslinkable polyethylenes have been established for twenty five years for the production of tubes for central heating, domestic hot and cold water and underfloor heating systems. The heating industry has exploited the outstanding high temperature physical properties and long service life of our grade range in many different pipe constructions.

Other industries including gas, oil and water supply, automotive, plumbing fittings, pipe insulations and refurbishment, building laminates and tie layer structures are now starting to utilise the other performance benefits of ISOPLAS

The ISOPLAS grade range is detailed on page 4 of this brochure. As well as the original range developed for the pipe extrusion industry, many modified formulations have been developed for other industries and applications. The Micropol Technical Services Department will be pleased to answer any enquiries for specialist applications. An **ISOPLAS MANUAL** is available which advises on the use and applications of ISOPLAS as well as detailing sources of process machinery, testing, applications, approvals, co-extrusion materials etc.

CHEMISTRY

Polyfunctional organo-silanes, containing unsaturated Vinyl groups with easily hydrolysable alkoxy functionality are chemically grafted onto the polyethylene backbone according to the following reaction.



After grafting the material is still thermoplastic and can be processed in the same way as normal (non-crosslinkable) polyethylene.
Crosslinking of this grafted material is subsequently induced by exposure to trace amounts of water at elevated temperatures which cause hydrolysis and condensation of the alkoxy groups to form siloxane crosslinks.
This crosslinking reaction is normally accelerated by the incorporation of a catalyst.
These diagrams imply a polyfunctional character for the grafted silane with three alkoxy groups present at each silicon atom. Therefore, the grafted polyethylene chain is capable of reacting with two or more similar chains to form a "bunch like" crosslink structure.

The behaviour of this three dimensional crosslinked network structure is significantly different to that of the planar structure of the peroxide and radiation crosslinked polyethylenes. Hence to achieve the same low hot elongation and low deformation under load, the degree of crosslinking of peroxide crosslinked p.e. has to be 15-20% greater than that of ISOPLAS.
We can also conclude that the "bunch like" crosslink structure of ISOPLAS will give superior high temperature creep performance compared to other crosslinking techniques or the molecular entanglement employed by thermoplastic alternatives such as polybutylene, linear p.e. or polypropylene.

MANUFACTURING PROCESS

The two components that make up ISOPLAS crosslinkable polyethylene are made on compounding equipment specially designed to provide optimum mixing and control of processing conditions. Purpose built reciprocating and twin screw extruders achieve the high quality dispersions vital for handling the sensitive chemicals utilised in the grafting process and the catalyst masterbatch production.

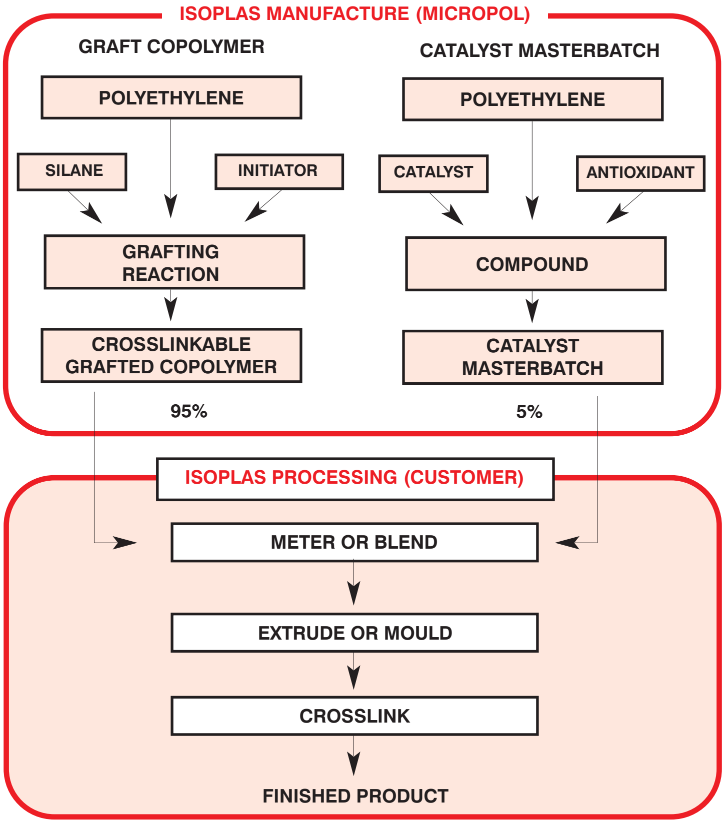
1 GRAFT COPOLYMER

This is the most critical component of the whole process and can only be made on sophisticated extrusion compounding equipment that incorporates advanced process control systems. This stage of the process demands much higher levels of technology than normal compounding processes. The controls and technology are necessary because in this process the compounding equipment is being used as a chemical reactor in addition to its normal functions of mixing, dispersing and pumping. The higher level of technology has also been applied to product packaging to guarantee long term storage and protection of the product.

2 CATALYST MASTERBATCH

The range of ISOPLAS catalyst masterbatches produced by Micropol is manufactured on simular high technology compounding equipment. This ensures that the **catalyst** itself is consistently dosed and dispersed.
The function of the **catalyst** is to accelerate the crosslinking of the **graft copolymer** by the chemical action of water in the water bath or steam chamber.

In addition to the catalyst this masterbatch may contain process and product stabilisers to protect the pipe at the extrusion stage and in service. **Process aid** can be incorporated to improve the flow, extrusion quality and gloss of pipes produced, and even coloured pigments can be added, matched to customers' requirements. Micropol recognise that ISOPLAS will be processed on a range of equipment with different capabilities and mixing options, so we have developed a wide range of catalyst masterbatches to give the best possible results during production.



GUIDE TO PRODUCTION AND PROCESSING

PROCESS EQUIPMENT

Fabrication of crosslinkable components such as pipes, injection mouldings etc. is carried out on a wide range of conventional equipment. In contrast to other types of crosslinkable polyethylene, **no special equipment modifications are required**. ISOPLAS will process similarly to conventional polyethylenes of comparable melt flow index and density. A blend of 95 parts of graft copolymer and 5 parts of catalyst masterbatch (together with any colour masterbatch required) is prepared by either tumble blending or metering and this is simply extruded, injection moulded, extrusion blow moulded etc. A guide to typical process conditions and equipment follows:-

PRODUCTION ADVANTAGES

ISOPLAS can simplify, reduce costs and improve safety standards of production in comparison to peroxide crosslinked polyethylene in several ways:-
1) No health hazards are present at any stage of processing, crosslinking or end usage.
2) Separation of the fabricating and crosslinking steps avoids the use of complicated continuous vulcanisation systems which in turn will yield the following advantages.
3) Output rates can be selected independent of the crosslinking rate and so maximum production rates can be achieved.
4) Temperature profiles can be set without the fear of premature crosslinking occurring somewhere in the processing equipment.
5) Start-up scrap and out of tolerance material is kept to a minimum.
6) Maintenance downtime is reduced due to the simpler nature of the equipment.

	EQUIPMENT	PROCESS TEMPERATURES	PRODUCTION RATES
PIPE EXTRUSION	Conventional single screw extruders with single or twin start polyethylene screws. L/D ratios preferably 25:1 minimum for good mixing characteristics. Obstructions to straightforward melt flow paths, such as mixing tips, basket dies, restrictor blocks, etc. should be avoided.	Barrel 150-180°C Head/Die 190-210°C Hopper throat cooling desirable	For 10-30m/min pipes typical line speeds are from 10-20 m/min on outputs from 50-200 kph
INJECTION MOULDING	Screw preplasticising machines capable of running low melt flow materials. Generously proportioned runners and gates. Hot runner systems can be used.	Plastication temperatures of 175-225°C on the barrel.	Comparable with moulding conventional HDPE injection grades.

CROSSLINKING

Crosslinking is carried out off line after processing by a simple batch process of exposure to water at elevated temperatures. Diffusion of trace amounts of water into the article, together with the action of heat, acts via hydrolysis and condensation of the alkoxy groups to form siloxane crosslinks. The presence of the catalyst from the masterbatch accelerates this process.

Crosslinking can be achieved by:-
1) Immersion in hot water;
2) The action of low pressure steam;
3) Circulation of hot water through the interior of pipes.

The time to complete crosslinking is reduced by:-
1) Increase in temperature of water/steam;
2) Reduction in thickness of section to be crosslinked;
3) Reduction in density of Isoplas grade;
4) Modification of the catalyst system supplied.

The rate of crosslinking depends on the rate of diffusion of water molecules into the wall of the article. This in turn is proportional to the square root of the wall thickness . In practice, if the wall thickness is doubled then the time for full crosslinking is increased fourfold. Crosslinking by exposing both sides of the article's surface to water/steam is therefore much more efficient than from one side only. Rate of crosslinking graphs for the major ISOPLAS grades at a range of water temperatures are available from Micropol's technical department.

HOUSE KEEPING

1) Storage
The two components of ISOPLAS should be stored separately in cool, dry conditions to prevent crosslinking before processing. After fabrication no special storage precautions are necessary.
2) Rework
In common with other crosslinkable polyethylenes ISOPLAS scrap material is not re-useable or recyclable.
3) Purging and Cleaning
After short production stops, run ISOPLAS to waste for a short period. After longer stops and after all production runs the extruder should be purged with stiff flow conventional HDPE. Die head, screw and barrel should then be stripped down and physically cleaned.

PACKAGING

ISOPLAS P is supplied in the form of two granular components. Graft copolymer is packed inside vacuum-sealed aluminium-laminated sacks inside 500 Kgs or 1 tonne octabins. This product is therefore protected against moisture ingress which could trigger premature crosslinking of the granules.

Catalyst masterbatch is packed in 25Kgs HDPE sacks.
This product is not chemically affected by moisture vapour.

PROPERTIES

Fully crosslinked finished articles made from ISOPLAS crosslinkable polyethylene will exhibit outstanding resistance to rigorous environments.
The major areas of property improvement in comparison with conventional and many other thermoplastics are:-

IMPROVED HEAT RESISTANCE
IMPROVED OXIDATION RESISTANCE
IMPROVED WEATHERING RESISTANCE
IMPROVED LOW TEMPERATURE STRENGTH
IMPROVED CHEMICAL RESISTANCE
IMPROVED ENVIRONMENTAL STRESS CRACK RESISTANCE
IMPROVED LONG TERM STRENGTH AT ELEVATED TEMPERATURES
IMPROVED STRESS RESISTANCE AT ELEVATED TEMPERATURES
IMPROVED PERMEATION RESISTANCE

The results of detailed studies into the property achievements described above are available from Micropol's Technical Services Department.

One example of the improved performance of ISOPLAS GRADES is given by data on STRESS RUPTURE AT ELEVATED TEMPERATURES.

The most important property of a pipe is its pressure performance. This property is an outstanding feature of ISOPLAS crosslinkable polyethylene's performance and has been a major reason for its acceptance in the pipe industry in Europe for underfloor heating and domestic hot and cold water pipe systems. The improvement in comparison with conventional polyethylene has allowed it to be used under conditions previously thought to be beyond any polyethylene material.

Long term stress rupture tests on ISOPLAS at 95°C have so far failed to reproduce conventional polyethylene's characteristic fall or "knee". Thus the life of ISOPLAS crosslinkable polyethylene pipes can be successfully extrapolated beyond a design lifetime of 50 years.

Compared with other thermoplastic materials that could be used for pipes to carry hot water, ISOPLAS crosslinkable polyethylene has the major characteristic of the best predictable long term stress rupture resistance. In addition the change from a thermoplastic to a thermoelastic structure considerably improves its performance over polypropylene and polybutylene which will always retain their thermoplastic behaviour. Together with this exceptional stress rupture resistance other improved properties such as resistance to oxidation and outstanding thermal stability have led to ISOPLAS finding an increasing number of outlets in high quality systems and installations where long term security is essential.

Our current customers are offering 10 year warranties on pipe made from ISOPLAS for use in underfloor heating and are guaranteeing a permitted temperature range of -60ºC to +92ºC under a continuous pressure of 3 bar and are allowing for 50 years working life at conditions within this range. They are also guaranteeing short term exposure to 110ºC at the same pressure. Pipe systems based on ISOPLAS ensure optimum quality and safety.

ISOPLAS Grades designed for central heating systems and for hot sanitary water applications have been tested in pipe form at 110ºC and have not failed at pressure exceeding the requirements of DIN 16892 at periods well over double the 8000 hours requirement of this standard. Regression curves for individual ISOPLAS grades are available from Micropol.

POTABLE WATER CONTACT APPROVALS HELD BY MICROPOL

Water Research Council UK, Water Regulations Advisory Scheme
Water Fittings and Materials Directory Reference Numbers.
P471 0310502 P501 0308513 P602 9909519

Customers of Micropol have their own approvals from the following countries:

Italy	Gazette Ufficiale No. 104 Certificate of the Laboratorio di Igiene e Profilassi di Milano
France	L'Institut D'Analyses et D'Essais du Centre-Ouest
Germany	D.V.G.W. K.T.W. Certificate
Switzerland	Bundesamt für Gesundheitswessen (B.A.G.)
Hungary	Staat Liches fur Umweltschultz
Portugal	Instituto Nacional de Saude
Belgium	Examen des Polluant de l'Eau
USA	NSF International ANSI/NSF Standard 61
Australia	AS 3855 or AS 4020
EC	**Formulations now available to meet the new EAS (harmonised) water regulations.**

Details of the approvals and the various migration limits imposed by the National authorities are available.

PROPERTIES

Physical Properties	Test Method	Units	Grade Range				
Mechanical			P381	P471	P501	P651	P602
Density	ASTM D792	g/cm³	0.944	0.947	0.952	0.960	0.964
Tensile Strength at Yield	ASTM D638	MN/m²					
at 23ºC			23.0	24.0	26.0	31.0	31.0
at 100ºC					6.5	9.0	
Elongation at break	ASTM D638	%	250	200	200	70	250
Modulus of Elasticity	ASTM D638	MN/m²					
at -40ºC					1400	2000	
at 0ºC					1200	1500	
at +20ºC			1100	780	1000	1800	1750
Thermal							
Melt Flow Index	ASTM D1238 190/2.16	g/10 mins					2.0
	190/5		1.75	0.30	5.0	1.5	8.0
Vicat Softening Point	ASTM D1525	ºC	126	120	124	130	127
Specific Heat		KJ/kg/ºC	1.9	2.0	2.1	2.1	2.0
Coefficient of Linear Expansion	ASTM D696						
at -20ºC		PER ºC			9.0×10^{-5}	9.0×10^{-5}	
at +20ºC				1.3×10^{-4}	1.4×10^{-4}	1.4×10^{-4}	2.5×10^{-4}
at 100ºC					5.0×10^{-4}	5.0×10^{-4}	
Thermal Conductivity	BS 874	cal/s/cm/ºC	1.03×10^{-3}	1.03×10^{-3}	1.1×10^{-3}	1.1×10^{-3}	1.03×10^{-3}

APPLICATION AREA:
P602 - Injection mouldings
P381 - Pipes for underfloor heating
P501 - Pipes for Hot Sanitary Water
P471 - Alupex Pipes
P651 - Rigid pipes for District Heating Systems

The information given above is typical for the material. It should only be used to compare one material with another and does not guarantee performance under end-use conditions.

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