



A TO Z OF POLYETHYLENE

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## **INTRODUCTION**

Those who are not directly involved with PE (polyethylene), need simple information about the different sorts of polyethylene and their processing techniques.

We have made that information available in Dutch, but also in English, French and German, is meant to clarify the most important terms relating to polyethylene in plain language and with clear illustrations.

It has become apparent that customers of SABIC, schools and environmental organisations are also interested in this kind of information. We have therefore decided to make it available on a wider scale. We hope that this electronic booklet will put everyone in the picture about polyethylene.

SABIC Europe

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## WHAT IS POLYETHYLENE?

More polyethylene is produced in the world than any other polymer and everyone comes into contact with it daily. Right from the start, it was seen as real addition to the world of materials, although initially, its value was established as insulation cables. Nowadays the strength of polyethylene lies in its subtle solidity, its obvious usefulness, and its almost unlimited application potential. We are so used to this modern material and it is something so ordinary and familiar, that we do not even think about it.

polyethylene can be made into soft and supple, as well as tough, hard and sturdy products. It is found in objects of all dimensions with simple and complicated designs. Among others, it can be turned into useful, every day objects, packaging, pipes and toys. Everyone uses things like a squeeze bottle or a bin bag in the home every day. Without realising, we buy quite a lot of things wrapped in polyethylene in the shops.

When we leave the shop, our purchases are placed in a carrier bag...made from polyethylene. Our life has become a lot safer because many of our cables, pipes and fuel tanks are made from the solid and reliable polyethylene.

In whatever form the polyethylene is used, everyone agrees about its favourable properties. polyethylene insulates well, is resistant against aggressive substances and damage, it is virtually unbreakable and spares the environment. polyethylene is reliable under all circumstances and it withstands tropical temperatures as easily as it does the freezing cold of the Arctic Circle. This sturdy material can easily take a knock. Nevertheless, it is remarkably light and can be used in many products. The qualities of polyethylene can be summarised in three words: it is strong, it is safe and it is versatile.



*Soft and supple*



*Though, hard and sturdy*



*Strong and versatile.*

## THE RAW MATERIAL: FROM NAPHTHA TO POLYETHYLENE

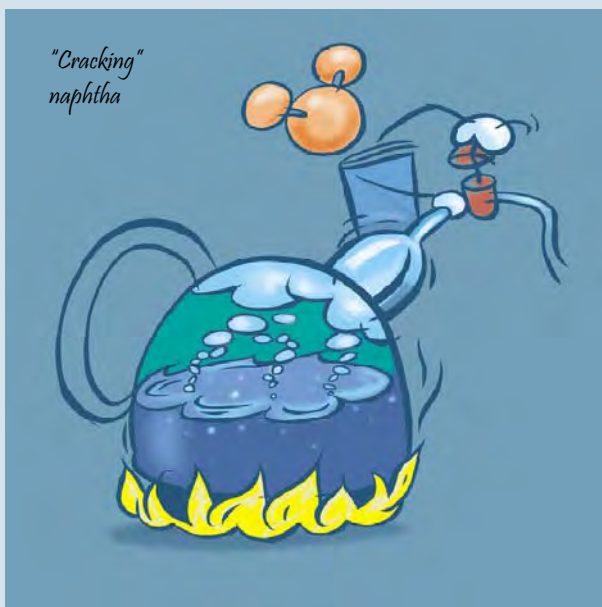
You get naphtha from crude oil. Naphtha is another word for petroleum. By heating naphtha very intensely ("cracking") you get ethylene. This ethylene is turned into polyethylene in the factory. The word polyethylene means: "many parts of ethylene". These invisibly tiny parts of ethylene are the building blocks for polyethylene during production. If we could look inside the material during this process, we would see that these building blocks thread together like a string of beads. When the strings are ready, they are shaped like branches.

The picture shows how these building blocks are joined together in polyethylene. Such building blocks are called molecules. Each polyethylene building block contains

carbon and water, which form a tight unit together.

## THE RAW MATERIAL: WHERE DO THE GRANULES COME FROM?

The ethylene enters the factory in gas form. When this gas has turned into polyethylene it looks like a warm, liquid porridge. A constant stream of this porridge is pressed through a plate with holes before it sets. The setting threads of polyethylene, which come out at the other side, are immediately cut into small pieces by a rotating blade. The result is a mass of white, transparent granules, which look a lot like coarse hailstones. These granules are the raw material, which goes to companies, where they are melted and processed into all sorts of products.







## BASIC PROPERTIES: DENSITY AND FLOW PROPERTIES

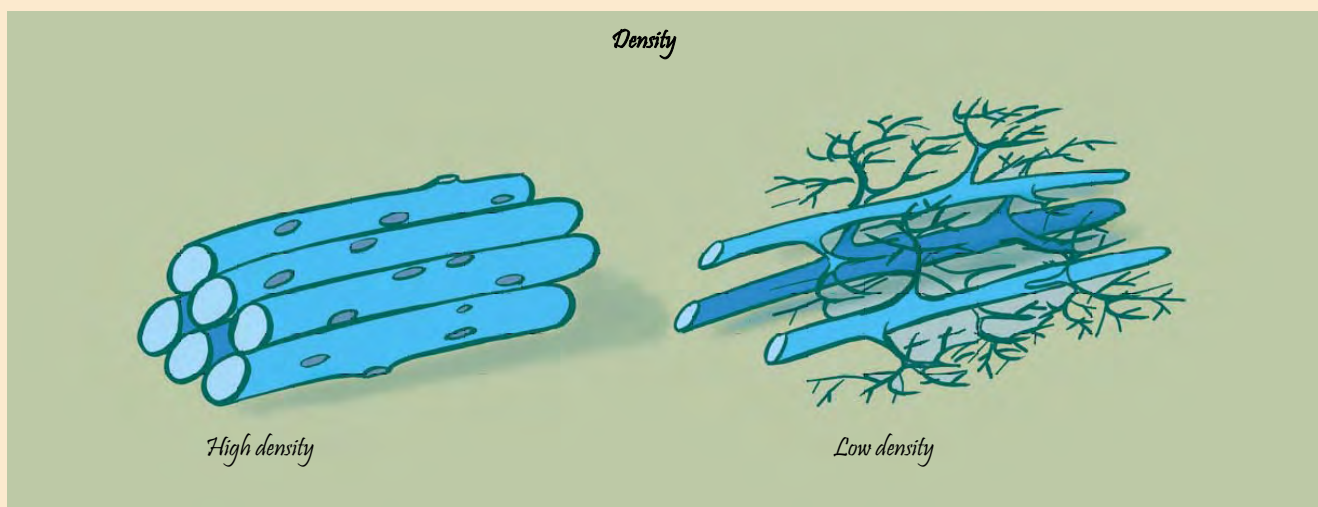
Polyethylene can be given a certain character during production. A stiffer or a more elastic type can be chosen. These properties don't just determine what kind of things can be made from the polyethylene but also very important how easily this can be done.

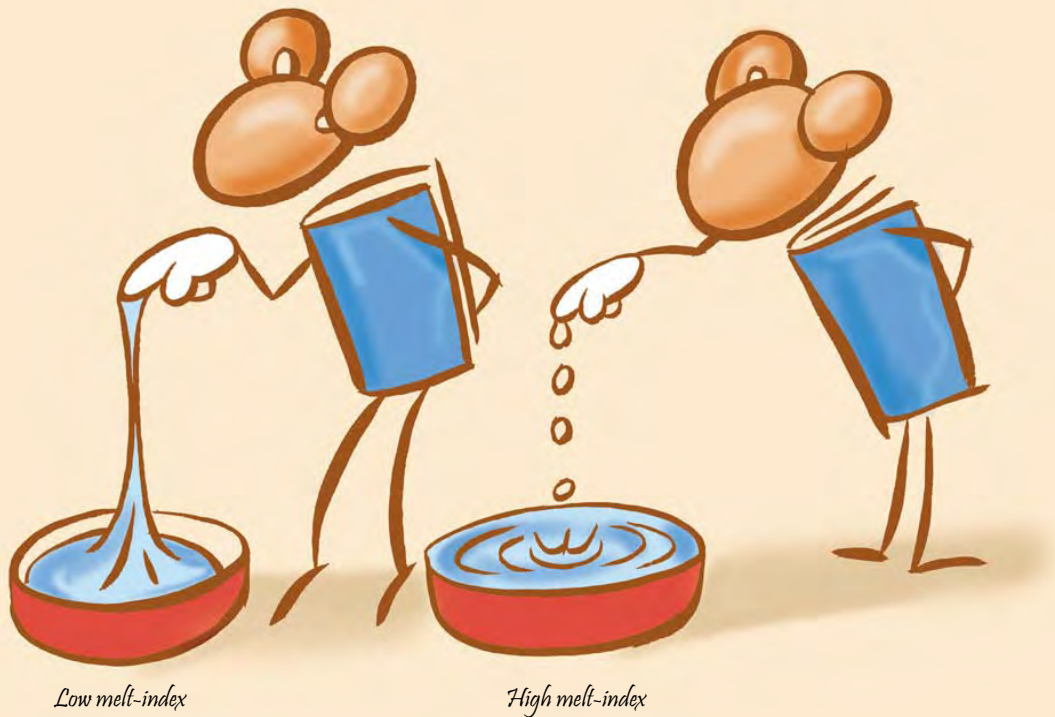
Whether polyethylene has a stiff or elastic character, depends on the "density" of the material and how "liquid" it is in melted form. The density and flow properties largely depend on the amount of pressure, which is applied during the manufacture of polyethylene. The result of a "low" or a "high" pressure is as follows:

- By producing polyethylene under low pressure, it gets a high density. The invisibly tiny particles of the substance then form "straight", strong branches, which are packed closely together. The result is a "dense" polyethylene, which has a firm and stiff structure and can be compared to a bundle of straight

branches, which cannot be pushed down any further.

- Producing polyethylene under high pressure leads to a low density. The particles then form a mixture of branches and side branches, which are literally not "straightforward". This less "dense" polyethylene is lighter. It is looser and is comparable to a bunch of fresh, young and springy branches with many side branches, which in turn are branched. When you push down such a bundle and let go again, it bounces back into its original shape. The elasticity is therefore naturally in it. Whether polyethylene has a liquid character or not, depends on the so-called "melt-index". This technical word indicates how slowly or how fast the melted mass flows through an opening. It is not surprising that the "denser", more solid polyethylene flows with difficulty and slowly. After all, it has a stiff and rigid character. The "less dense" and looser polyethylene flows much easier. When this has set, it feels more supple and stretchy.

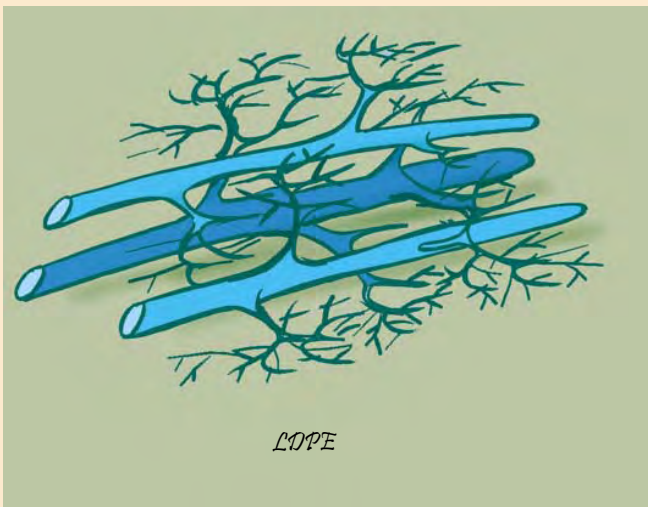




### THREE MAIN KINDS

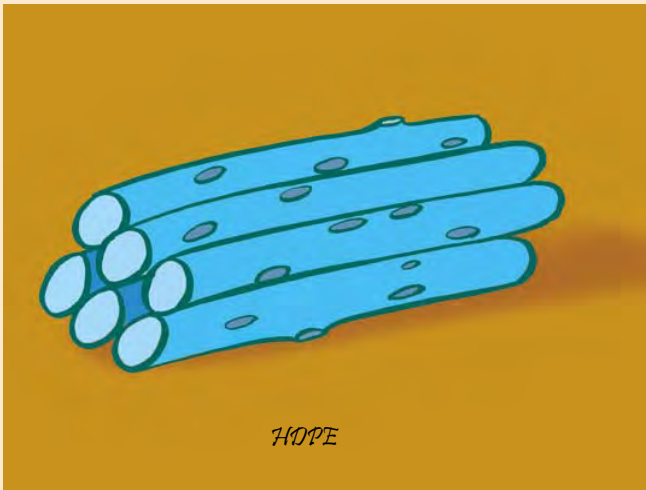
By making the polyethylene more or less “dense” in the factory, a suitable material can be found for every application. In reality, one of the following kinds of polyethylene is used in 90 percent of applications.

### LDPE: POLYETHYLENE WITH A “LOW DENSITY”



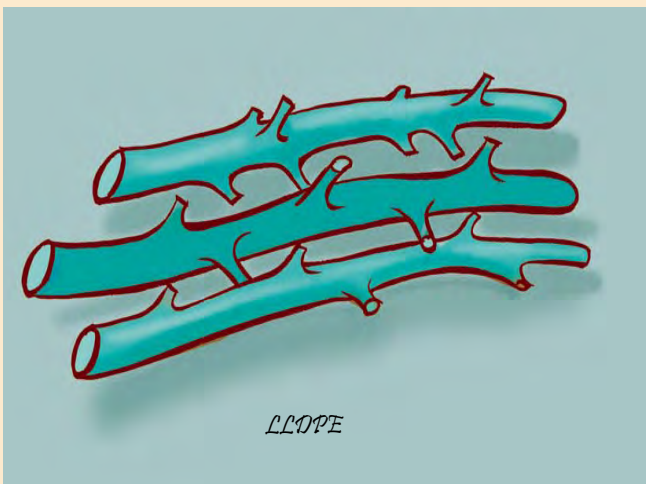
The oldest type. It is a soft, tough and flexible kind of polyethylene. It is used for strong, supple things like screw caps and lids. We have known it as insulation material for a long time. Nowadays, the most popular applications is the films, from which, among others, carrier bags, packaging material and agricultural film covers are made. During the high water levels in Holland during the past years, the tough, stiff film made from LDPE proved useful as improvised reinforcement of the dykes.

## HDPE: POLYETHYLENE WITH A "HIGH DENSITY"



This is the sturdiest and the least bendable kind. The stiff and somewhat hard character is useful for a wide range of applications. It is used to make the containers for fruit, vegetable and garden waste which are well known in Holland and in everyday domestic things like bottles, clothes pegs and the handle of the washing up brush. Although HDPE is quite heavy, you can also make very thin film from it, which is very light and crackles. We all handle this kind of film almost daily in the form of a sandwich bag, a pedal bin liner or packaging for vegetables, fruit or meat.

## LLDPE: A MIXTURE OF THE TWO PREVIOUS TYPES



With this PE you can really do a wide range of things, because it has some of the properties of both LDPE and HDPE. You can make supple as well as stiff products from it. LLDPE is normally used in mixtures ("blends") with one of the materials mentioned previously. Among others, thinner films can then be made from it. It is also used in packaging made up of more layers. LLDPE is very tough and keeps its shape. The properties are useful for the manufacture of large objects like lids, boxes and certain type of container.

## NEW DEVELOPMENTS

The fact that time does not stand still is demonstrated by the developments of new kind of polyethylene, which have been adapted to suit the current needs and which are made possible by new production techniques.

- A top performer among the new materials is UHMwPE. This polyethylene can really withstand a few knocks and is resistant against higher temperatures. Ideal for applications where the utmost is required from the material like cogs, gaskets, bearings, filters, chopping boards and hammers.
- The latest polyethylenes are so-called metallocene polyethylenes. These materials have remarkable properties due to their very regular pattern of branches and side-branches. Special kind of these are elastomers. The characteristics of these polyethylenes is their extremely low density, which makes them very tough. They are also as clear as glass. In practice, these materials will often be added to other polymers to make them stronger.





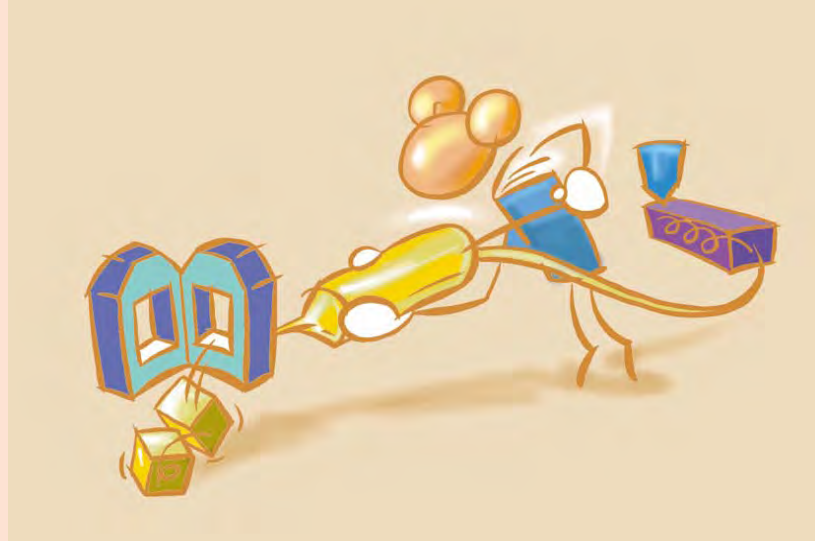
## HOW IS POLYETHYLENE TURNED INTO PRODUCTS

With most of the processing methods the polyethylene granules are brought into a machine with a cylinder via a funnel and are then heated. Inside this cylinder, a rotating screw pushes the melted mass through an opening at the end, after which the polyethylene can be turned into all sorts of products before it cools down and sets. The cylinder with the screw, which pushes out the mass, is called an

extruder. The principle of an extruder is a bit like that of a sausage-making machine.

You can make objects of different shapes from melted polyethylene, and it does not matter whether they are hollow or solid, large or small. A crate, a screw top, a door handle or a squeeze bottle. The most diverse shapes and dimensions are possible.

The material can also be rolled out into a sheet or stretched into a film while it is pushed out.



## MAKING MOULDED OBJECTS

**Injection moulding:** At the end of the extruder, a certain amount of melted polyethylene is pressed into a cooled mould. The contents set, the mould

opens and an all-ready product is ejected. This method is suitable for large and small things like tops, lids, handles, garden furniture, buckets and containers for fruit, vegetables and garden waste.



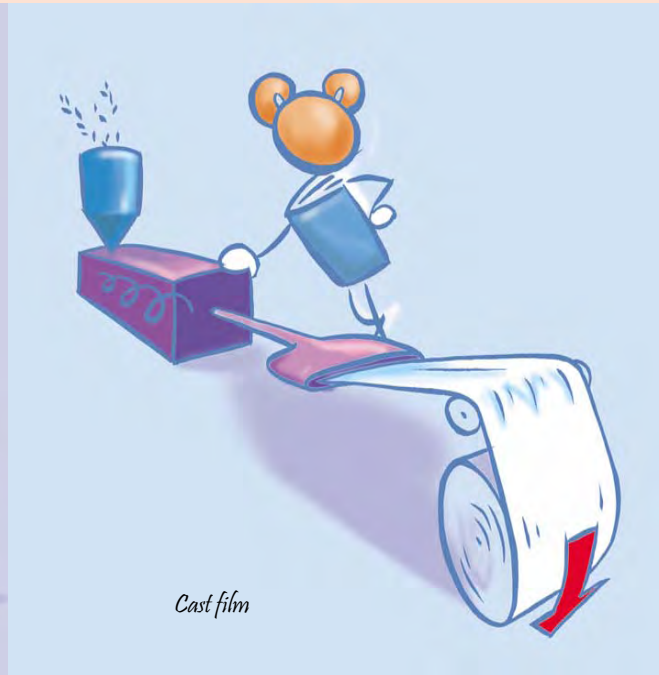
*Blow Moulding*

- **Blow moulding:** At the end of the extruder certain amount of melted polyethylene is “squeezed off” at one end and closed in the shape of the tube. Through the opening of the tube the polyethylene is blown against the walls of the mould with compressed air. It sets immediately and is also ejected from the mould. Bottles are usually made in this way



*Rotational Moulding*

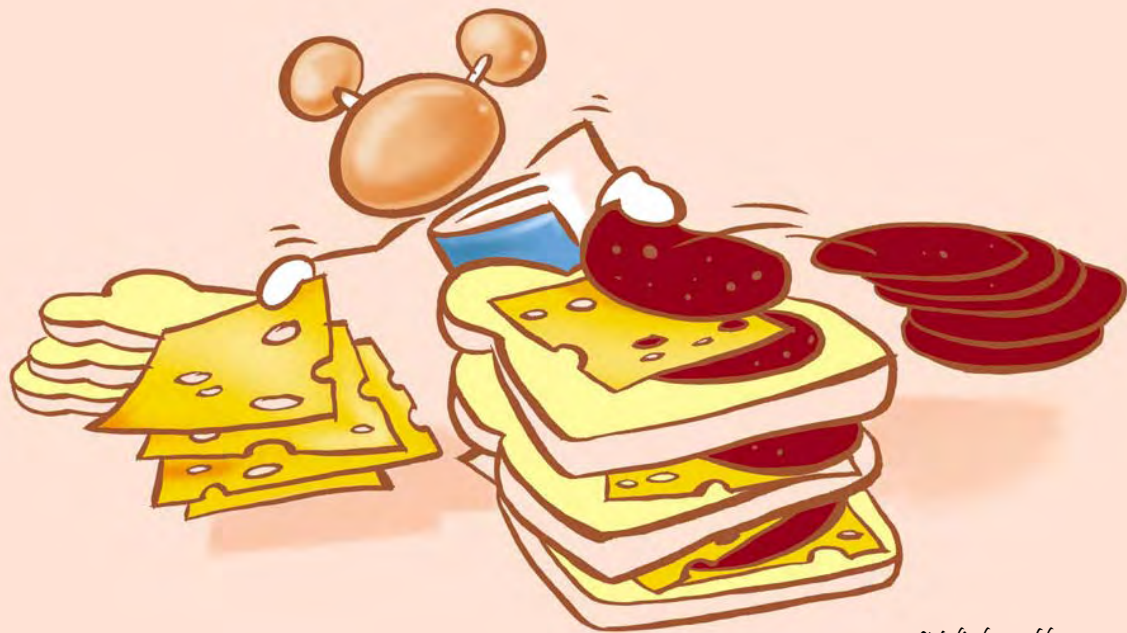
- **Rotational moulding:** This is a suitable method for large hollow objects, like containers or toilet cabins. The polyethylene is brought into the mould in powder form. The mould rotates in a large heated oven until the powder has melted and coated the inside evenly. After cooling the product is ready.



## MAKING FILM

- Blown film. The melted material is blown through the opening of a mould with compressed air and then rises like a tube of film. After cooling, the rollers flatten the film into a double layer, after which it is wound and is ready for further processing. This method is very suitable for making film for dustbin bags and carrier bags for example

- Cast film. Here the melted material is pushed out through a very narrow slit. This creates a single layer of very thin film, which is immediately winded after cooling. This film, contrary to blown film, can only be stretched in one direction. Cast film is often used for pallet wrapping to secure the load or to stick onto layers of other material.



*Multi-layer film*

## **MAKING FILM WHICH CONSIST OF MORE LAYERS**

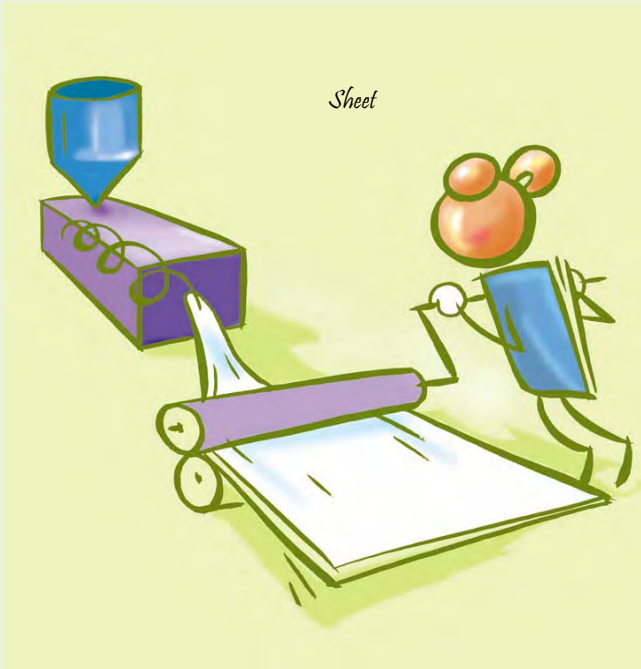
Films made from polyethylene are suitable to use in combination with layers of paper, aluminium or other polymers. This often happens in food packaging to give it extra strength, to be able to print on it or to ensure that the content stays fresh longer. There are three kinds of this multi-layer film.

- Lamination film. This is glued as a layer of aluminium, paper or another polymer. An example of this is the famous coffee packaging.

- Coating. Melted polyethylene is immediately pressed onto a layer of aluminium or paper. Such a coated film is used in photographic paper and for packaging of products, which contain oil or grease, for example.

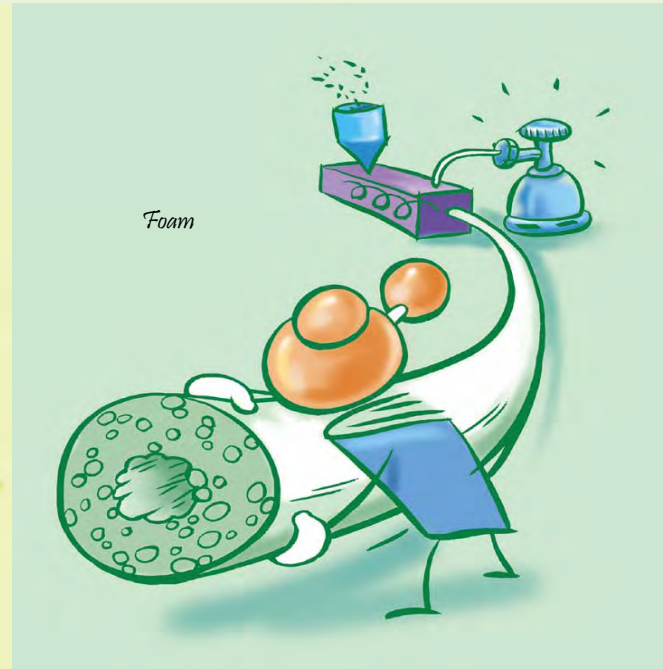
- Coextrusion film. Besides polyethylene, this film can contain one or more layers of another polymer. It is different from lamination film because all the layers of this material are pressed together in melted form. They then set together and form one strongly bonded film. An example is this multi-layer packaging for cheese.





## MAKING SHEET

This happens in the same way as cast film, except that the slit, through which the material is pushed, is wider and the width depends on the desired thickness of the sheet. Sheet material from polyethylene is often used to make things with relief. For large straight pieces of polyethylene, for example, wall segments, the relief design is pulled into the plate by vacuum formers. For smaller objects, where every groove of relief has to be clear, a kind of stamp is used.



## MAKING FOAM APPLICATIONS FOR INSULATION

For a long time polyethylene has been recognised as insulation material for electricity as well as heat. You get the foam effect by adding a foaming agent or a gas to the melted polyethylene. The material then gets a cell structure, which makes it very suitable as heat insulation. The foamed, warm mass is pressed out of an extruder through a frame- or tube shape. It immediately cools and is then cut to size.



## ADDITIVES

Polyethylene can sometimes be processed as it is in its natural state but usually it needs something extra to make it more suitable for certain applications. Sometimes substances are added which prevent objects that are exposed to the open air from fading or becoming weather beaten. Sometimes a substance is added to make a film extra smooth, or to prevent the films from sticking together. Often substances are added to reduce flammability. Colours are frequently added. In every case, they are useful and necessary additives.



## **POLYETHYLENE AND THE ENVIRONMENT**

From an environmental point of view, polyethylene is one of the friendliest materials. After all

- It is an economic raw material. For the world production of polyethylene, not even 1 percent of the total production of crude oil and natural gas is used annually.
- The production of polyethylene is relatively clean and efficient: the emission of harmful substances is minimal and there is virtually no waste.

- Polyethylene is extremely suitable for reuse. It is a thermoplastic material, which means that it can be melted down and used for making products virtually indefinitely.


- Nowadays many carrier bags and dustbin bags are made from recycled polyethylene in this way.
- When polyethylene is collected after use and it cannot be processed again, it supplies a high-grade fuel for the provision of energy.

## **POLYETHYLENE: THE MATERIAL OF TODAY AND TOMORROW**

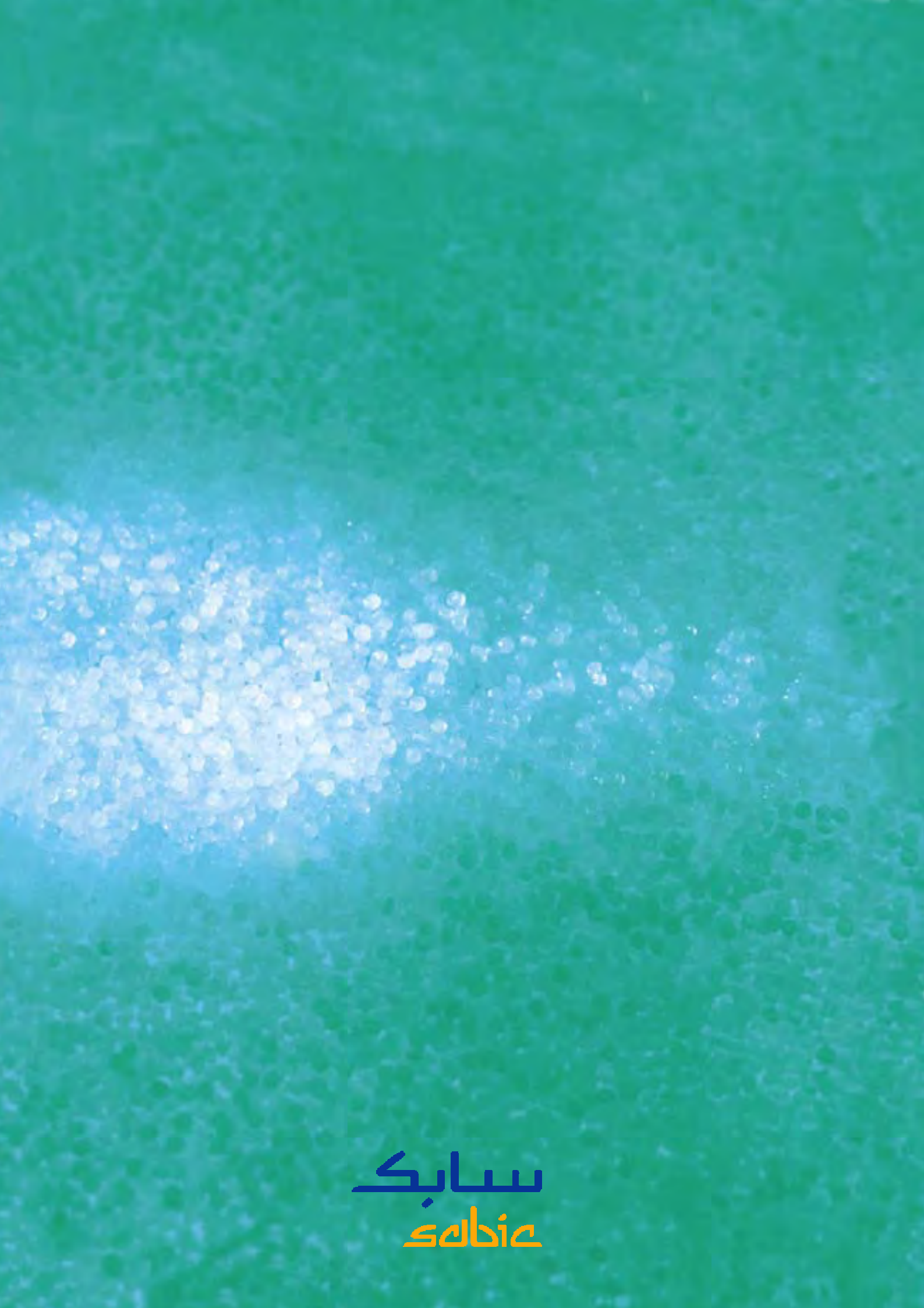
It is a fact that we cannot do without polyethylene in the world today. It has conquered a steady and undisputed place in the material market. Which other material has ensured so many useful innovations in the field of packaging and insulation?

The question how we can store or transport our valuable food, water and energy without loss of perishing and in the safest way possible – it is easier to answer since the use of polyethylene. Life without films, coatings or cable insulation made from polyethylene or without the wide assortment of strong, light packaging and the domestic uses of polyethylene is unimaginable. Due to the superior properties of polyethylene, these kinds of products cannot really be made better or cheaper with other materials.

Undoubtedly, tomorrow we will put bigger demands on our products today. As far as durability, safety, hygiene and environmental friendliness are concerned, polyethylene is the material, which can withstand the strictest test. Everything points to the fact that we can expect a lot from this valuable material in the future.



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