POROUS BIAXIALLY DRAWN UHMW-PE FILMS

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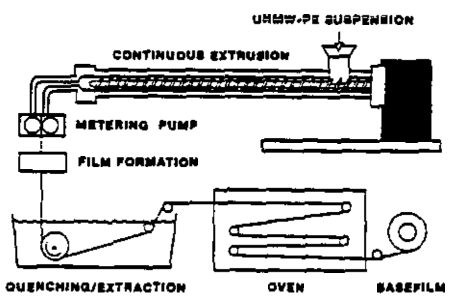
INTRODUCTION

Nowadays microporous polymer films are extensively used as membrane materials, waterproof breathable articles and also for several (di)electric purposes.
Normally the incorperation of pores in a polymeric matrix is done by controlled demixing of solvent/non-solvent/polymeric systems.
In recent years methods, other than solvent casting, have been developed for producing microporous materials. For example track-etching (Nudeopore), paste-extrusion (W.L. Gore), the introduction of a series of microcracks by consecutive steps of cold and hot drawing in tight polymeric films (Hoechst Celanese) and the use of (in)organic filler material as stress-concentrators during the drawing proces (PPG and others).
It was found, at DSM Research, that porous UHMW-PE [Ultra High Molecular Weigth PolyEthylene] films can be manufactured from solution-crystallized UHMW-PE.

GELTRUSION



The process, called geltrusion, involves the continuous extrusion of a solution of UHMW-PE in a volatile solvent, followed by thermoreversible gelation/crystallization to produce a so called wet gelfilm. This material is dried by evaporating the solvent and it appeared that microporosity can be induced by geometrically restricting the shrinkage of the gel.
Biaxially drawing of these gelfilms is possible with build-up of extreme porosities, without disturbing the mechanical integrity.

SEQUENTIAL VERSUS SIMULTANEOUS BIAXIAL DRAWING

Porosity and poresize:

During, either sequential or simultaneous, biaxial drawing the porosity increases steeply in the early stages of the drawing proces. At high draw ratios porosity levels off at about 80-85%. Sequentially drawn samples show a somewhat higher porosity. The maximum poresize (bubble point), as measured on a Coulter Porometer by liquid displacement, of samples, obtained via simultaneous biaxial drawing levels off at a maximum poresize of about 0.12 µm, whereas the sequentially drawn samples show an almost linear relationship between bubble point and draw ratio.

Permeability:

If the pressureless ability to transport water vapour through a microporous film, expressed as Moisture Vapour Transmission Rate (MVTR), is plotted against the biaxial draw ratio the moisture vapour transmission rate for both sequentially and simultaneously drawn samples gradually increases, although the sequentially drawn samples show a higher transmission rate in the earlier stages of the drawing process. At high draw ratios, where the build-up of porosity is already smoothening, there is a steep rise for sequentially drawn samples to high MVTR-values.
Permeability data for a pressure-driven process show that after reaching plateaudensity the airpermeability can only be increased if the sequential mode is applied.

Mechanical properties:
Plotting the tensile strength in Transverse Direction (corrected for porosity), against the biaxial draw ratio reveals that above a draw ratio of 5*5 the tensile properties for simultaneously drawn samples deflect to higher values, whereas the sequentially drawn samples show lower mechanical properties. The modulus, again in Transverse Direction and corrected for porosity for simultaneously drawn samples gradually increases with draw ratio, whereas the modulus for sequentially drawn samples reaches a plateau value.

SKIN CORE PHENOMENON

The explanation for the differences in morphological and mechanical properties are interpreted by an asymmetric structure of the film. A relative tight skin leads to higher mechanical properties, lower permeability, a smaller poresize and an almost equal porosity.

Skinless porous UHMW-PE film

Skinned porous UHMW-PE film

From the comparative experiments it is concluded that, during simultaneous drawing, film performance gradually varies with draw ratio, whereas the sequentially drawn samples show a distinct change in performance at high draw ratio. Both maximum poresize and permeability, during sequential drawing increase significantly at the expense of mechanical properties. This increase in poresize and permeability during sequential drawing is attributed to a controlled deterioration of this skin layer, which was highly oriented during the drawing in machine direction.
The extent of skin core formation is determined by the quenching/cooling conditions, for example temperature. atmosphere and quench medium. By this means a poresize control is possible.
Depending on the extent of skin core formation liquid barrier properties vary from 2 to 50 meter of H_2O.

APPLICATIONS FOR POROUS UHMW-PE FILMS

Applications for the microporous UHMW-PE films are seen in the textile world. either laminated to textiles for durable waterproof breathable fabrics or laminated to non wovens for limited use/disposable protective apparel, in the field of membranes (ultra/microfiltration and composite membranes) and as a battery separator.

Compared to currently existing products the microporous UHMW-PE films, processed by the Geltrusion route, offer. next to the possibilty of poresize control, an unique combination of porosity, strength and thickness.
Lamination of this microporous UHMW-PE film to different types of textiles/non wovens lead to waterproof laminates with an extreme low vapour resistance (few millimeters of still air)