Sudan University of Sciences Technology

College of Graduate Studies

Modeling and Analysis of Film Blowing process

نمذجه وتحليل عملية نفخ الكيس

A Thesis submitted for the requirement of fulfillment of the master degree in fiber and polymer engineering

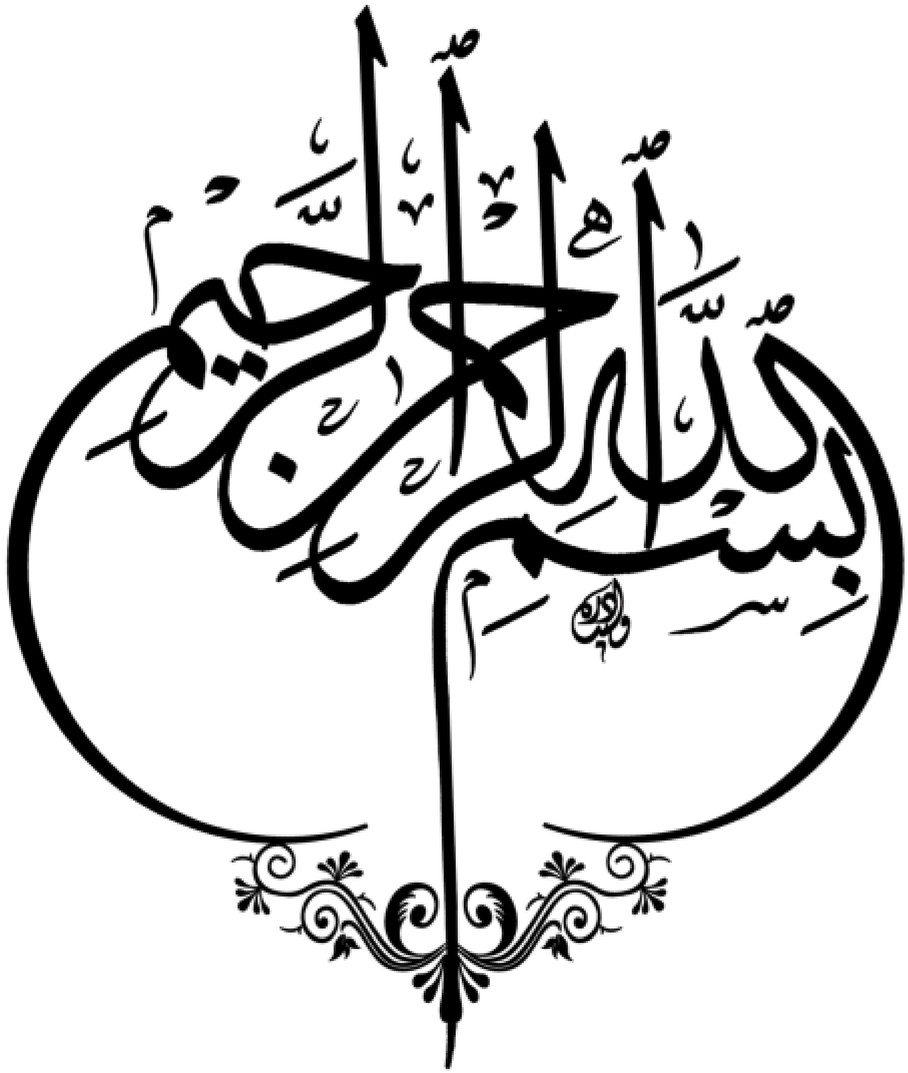
By:

Nehad Fadulallah Alsadig Alamin

Supervisor:

Dr. Mohamed din Hussein

November 2018


بسم الله الرحمن الرحيم

الأية

قَالَ تَعَالَى: ﴿ بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ ١ ٱلۡحَمۡدُ لِلَّهِ رَبِّ ٱلۡعَٰلَمِينَ ٢ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ ٣ مَٰلِكِ
يَوۡمِ ٱلدِّينِ ٤ إِيَّاكَ نَعۡبُدُ وَإِيَّاكَ نَسۡتَعِينُ ٥ ٱهۡدِنَا ٱلصِّرَٰطَ ٱلۡمُسۡتَقِيمَ ٦ صِرَٰطَ ٱلَّذِينَ أَنۡعَمۡتَ
عَلَيۡهِمۡ غَيۡرِ ٱلۡمَغۡضُوبِ عَلَيۡهِمۡ وَلَا ٱلضَّآلِّينَ ٧ ﴾ الفاتحة: ١ - ٧

صدق الله العظيم

Dedication

All praise to Allah, today we fold the days' tiredness and the errand summing up between the cover of this humble work.

To the utmost knowledge lighthouse, to our greatest and most honored prophet Mohamed - May peace and grace from Allah be upon him

To the Spring that never stops giving, to my mother who weaves my happiness with strings from her merciful heart... to my mother.

To whom he strives to bless comfort and welfare and never stints, what he owns to push me in the success way who taught me to promote life stairs wisely and patiently, to my dearest father

To whose love flows in my veins, and my heart always remembers them, to my brothers, sisters and my fiancé.

To those who taught us letters of gold and words of jewel of the utmost and sweetest sentences in the whole knowledge. Who reworded to us their knowledge simply and from their thoughts made a lighthouse guides us through the knowledge and success path, To our honored teachers and professors

Acknowledgements

MOHAMMED DEEN HUSSAIN YOU ARE AS A CANDLE BURNING TO GIVE US LIGHTING , THANKS FROM MY DEEPLY HEART.....

YOUR STUDENT

Abstract

The manufacture of plastic bags (HDPE, LDPE, LLDPE) is one of the leading industries in the world and has a strong consumer demand for packaging and packaging. The research examined the design of the film machine by analyzing the model of the bag blowing machine. Since the emergence of the rough and the formation of the balloon focus on the cooling area when the formation of the balloon and to make the roll to be ready for the stage of cutting (finished product). And compared this analysis with machines on the ground.

المستخلص

تصنيع اكياس البلاستيك من مادة البولي ايثلين الخطي والمتدني والعالي الكثافه (HDPE,LDPE,LLDPE) من الصناعات الرائده في العالم والتي تلاقي رواج كبير من قبل المستهلك في تعبئه وتغليف المواد الغذائيه. تناول هذا البحث تصميم ماكينه رقائق قابله للنفخ عن طريق تحليل نموذج لماكينه نفخ الاكياس.منذ انبثاق الخام وتشكيل البالون لتركيز على منطقه التبريد عند تشكيل البالون وحتى تكون اللفة لتكون جاهزه لمرحله القص(المنتج بالشكل النهائي) . ومقارنه هذا التحليل بالماكينات على أرض الواقع.

Table of Contents

Chapter Four
Analysis of the process

Chapter Five
Conclusion and Recommendations

Appendix

Table of Figures

Chapter One

Introduction

1.1 Introduction

Film blowing, by which thin biaxial orientated films are produced, is an important industrial process with applications in a variety of areas. A couple of applications (of many) of the thin films produced are uses in the packaging industry and plastic bags. The most common polymer used in the film blowing process is low-density polyethylene (LDPE). Other polymers commonly used include linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE) and polypropylene (PP).

In this thesis, simplified models to the real world process will be considered. Namely, these are the Newtonian, power law and Maxwell models. The models are all based on the theory of thin shells [1]. It is assumed that the film is thin enough.h that variations in the flow field across the thickness are negligible. In each model the assumption of axial symmetry is imposed, i.e. the film is assumed symmetric around the centerline of the bubble. In the models considered here, the assumption is made that gravity effects, surface tension, air drag and inertia of the film are all negligible. In most operations, these are valid assumptions. Gravity is more significant for example in thick large bubbles being drawn slowly [2]. The effect of a thermal variation along the film is included in the Newtonian and power law models with an isothermal viscoelastic model being considered with the Maxwell model. A photograph of a blown film is shown in Figure 1.1. This shows a blown film operation using an experimental apparatus. Real-world industrial blown film processes are several.

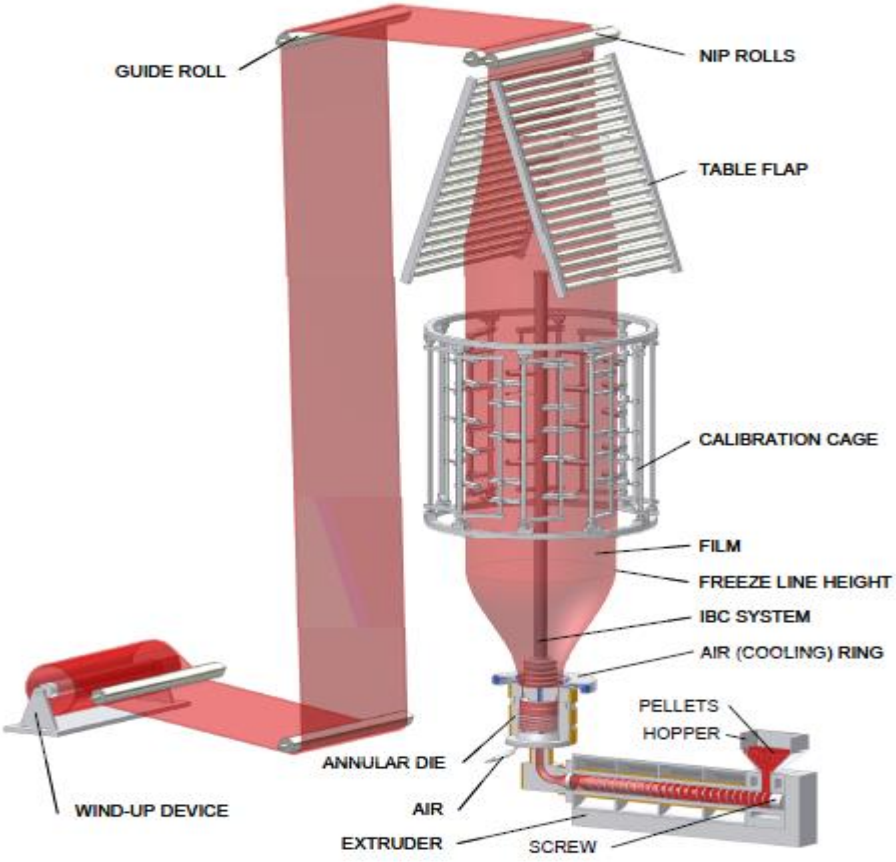


Figure 1.1: film blowing

1.2 Plastic Film Processing

Plastic films can be manufactured using different converting processes such as extrusion, co-extrusion, casting, extrusion coating. These processes have advantages and disadvantages depending on the material type in use, the width and thickness of film and the required film properties. However, blown film extrusion is the first and most suitable process for polyethylene film production (Regulation of Food Packaging in Europe and the USA, Rapra Technology, 2004).

1.3 Blown Film Processing

Blown film process involves the biaxial stretching of annular extradite to make a suitable bubble according to the product requirements. During this film blowing process molten polymer from the annular die is pulling upward applying the take up force; air is introduced at the bottom of the die to inflate the bubble and an air ring is utilized to cool the extradite. The nip rolls are used to provide the axial tension needed to pull and flat the film into the winder. The speed of the nip rolls and the air pressure inside the bubble are adjusted to maintain the process and product requirements[3]. At a certain height from the die exit, molten polymer is solidified due to the effect of cooling followed by crystallization, called freeze line height (FLH) and after this point the bubble diameter is assumed to be constant although there may be a very little or negligible deformations involved. Molecular properties such as molecular weight (both number and weight average), molecular weight distribution (MWD), main chain length and its branches, molecule configuration and the nature of the chain packing affect crystallinity, processing and final film properties. Molecular entanglement plays an important role in polymer processing, as it affects zero shear viscosity and subsequent strength of the processed film. Branched chain polymers usually have fewer entanglements than linear polymers for a given molecular weight, resulting in lower tensile strength and elongation to break. The behavior of the branched chain polymers in melt state is of major interest with respect to both technological problems and basic theoretical questions. Branching, which may be characterized as long chain or short chain, can arise through chain-transfer reactions during Page 6 of 249

Free radical polymerization at high pressure or by copolymerization with α-olefins. Short chain branches influence the morphology and solid-state properties of semi crystalline polymers, whereas long-chain branching has a remarkable effect on solution viscosity and melt rheology. Hence, it is essential to get as much information as possible concerning the nature and number of these branches. At a specific draw down ratio (DDR), polymer with narrow molecular weight distribution (MWD) shows better blow ability than polymer with broad MWD[4]. Molecular orientation imparted during the blown film processing from the shearing and biaxial stretching action is also known to have a major effect on the physical properties of the film. Therefore, molecular properties are important for stable blown film processing, film crystallinity and film strength properties. For food packaging application, polymeric film must have better optical properties (more glossy and less haze) as well as suitable strength and barrier properties. Film crystallinity has been discovered as the main factor for surface roughness, which affects optical properties of the blown film. The crystalline morphology in the blown film is influenced by the cooling rate or freezing line height (FLH) along with the molecular structure of the polymer. Increasing the cooling rate will result with lower FLH which shows a decrease in the diameter of the spherules and will provide lower Crystallinity in the film[5].

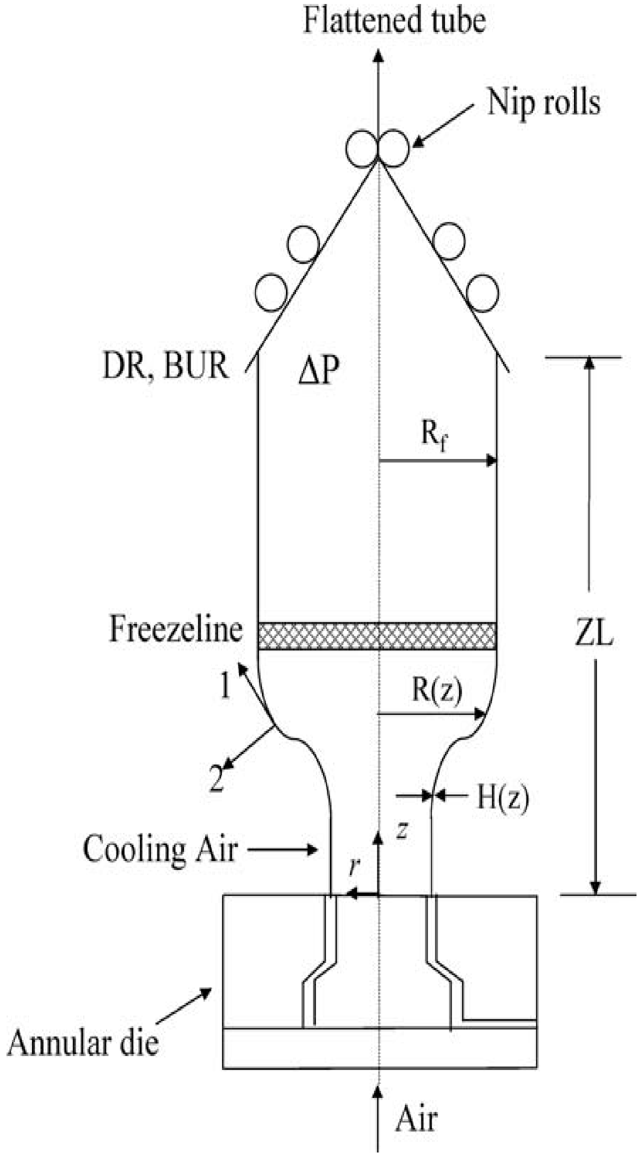


Figure 1.2: film-blowing process[1]

1.4 Objective of the Research

The objective of this research in to analyses the process of film blowing in order to determine the parameters that affect the design of the film . These parameters are the freeze line position, the blowing air pressure needed, the draw ratio needed in the upper drawing rolls. The analytical solution is the tool used in this research[6]. In doing this analytical analysis the instabilities in the produced film is avoided.

Chapter Two

Literature Review

2.1 Literature Review

The thermodynamic behavior of linear and branched polyethylene (BPE) blends using rheological methods has been the subject of many studies (Yamaguchi and Abe 1999; Lee and Denn 2000; Liu et al. 2002; Ho et al. 2002; Hussein et al. 2003; Hussein and Williams 2004a, b; Fang et al. 2005). It has been reported that the thermo rheological and processing properties of the blend are largely determined by molecular parameters, which include: (1) long chain branching content (LCB), which is the number of long branches, typically branches which have a number of carbon atoms more than 13 (Wagner et al. 2004; Kissin 2005), (2) compositional distribution (CD), which is the number and length of long chain branches for a given LCB macromolecule, or the amount and type of commoner in the case of LLDPE (Gabriel and Münstedt 2003; Hussein and Williams 2004b; Fang et al. 2005; Kissin 2005), (3) molecular weight, Mw (Hussein and Williams 2004b; Gabriel and Lilge 2006)[13], and (4) molecular weight distribution (MWD; Dealy and Wissbrun 1990). Most studies agree that linear low-density polyethylene and low-density polyethylene (LLDPE/LDPE) are miscible blends at low LDPE contents, which become immiscible at higher LDPE. [7] (Lee and Denn 2000; Ho et al. 2002). Hexene commoner promotes immiscibility (Hussein et al. 2003; Hussein and Williams 2004b), whereas octane commoner promotes miscibility (Fang et al. 2005). In addition, low molecular weight LLDPEs promote miscibility better than high Mw ones (Hussein and Williams 2004a). In a recent review, Zhao LDPE blends were immiscible in the melt state, with LCB being the determining factor of their immiscibility behavior. [8]

Recently, Wagner et al. (2004) performed a quantitative analysis of melt elongation behavior of LLDPE/LDPE blends. They have reported that the complex behavior of these blends can be understood by assuming the existence of two phases; one phase composed of the highly branched low Mw chains of both polyethylenes and a second phase composed of the high Mw chains (mostly linear) of both polyethylenes. Differential scanning calorimetry (DSC) thermograms of LLDPE/LDPE blends reported by Fang et al. (2005) support the existence of a third phase composed of chains from the two polyethylenes that have the ability to cocrystallize, additionall[9] Enhancement in the crystallization behavior of BPE blended with linear polyethylene (LPE) was explained in terms of co-crystallization due to the incorporation of the linear segments of BPE into rich-LPE lamellae and the segregation of the most branched chains (Puig 2001). The LLDPE/LDPE blend miscibility studies mentioned above make use of thermal techniques, such as DSC, and rheometrical techniques, such as linear viscoelasticity of blends at different temperatures (Van Gurp and Palmen 1998; Mavridis and Shroff 1992; Hatzikiriakos 2000). Failure of time–temperature superposition can be interpreted as an immiscibility criterion (Van Gurp and Palmen 1998; Peón et al. 2003; Wagner et al. 2004; Pérez et al. 2005). Positive deviation of zero shear rate viscosity from the logadditivity-mixing rule is also an indication of immiscibility (Lee and Denn 2000; Liu et al. 2002; Hussein et al. 2003). The Cole–Cole plot, representation between the imaginary (η0) and real part (η00) of the complex viscosity, has been used by several authors as criteria for miscibility in polyethylene blends (Kim et al. 2000; Ho et al. 2002). The determination of the weighted relaxation spectra based on linear viscoelasticity is another method used to infer the thermo rheological behavior of polyethylene blends. The spectra have been used to determine whether the blend components are immiscible due to an additional relaxation mechanism associated with interfacial tension (Gramespacher and Meissner 1992; Lacroix et al. 1997; Fang et al. 2005). In this paper, we study systematically the thermorheological behavior of a LLDPE with four LDPEs that have viscosity curves that lie above, about the same, and below that of the LLDPE. The miscibility of the various blends is studied with DSC and linear viscoelastic measurements with the application of several thermo rheological complexity criteria [time–temperature superposition (TTS), VanGurp plot, Cole–Cole plot, zero-shear viscosity vs composition, and relaxation spectrum]. All the methods are compared to check consistency of the results. The extensional rheological properties of the blends are also studied to examine the effects of LCB and Choi (2006) have reported that LLDPE. [10] M.Sabetzadeh et al in his research Study on Ternary Low Density Polyethylene/Linear Low Density Polyethylene/Thermoplastic Starch Blend Films.

In 2014, in his work, low-density polyethylene/linear low-density polyethylene/thermoplastic starch (LDPE/LLDPE/TPS) films are prepared with the aim of obtaining environmentally friendly materials containing high TPS content with required packaging properties. Blending of LDPE/LLDPE (70/30 wt/wt) with 5-20 wt% of TPS and 3 wt% of PE-grafted maleic anhydride (PE-g-MA) is performed in a twin-screw extruder, followed by the blowing process. Differential scanning calorimetric results indicate starch has more pronounced effect on crystallization of LLDPE than LDPE. Scanning electron micrograph shows a good dispersion of TPS in PE matrices. Fourier transfer infrared spectra confirm compatibility between polymers using PE-g-MA as the compatibilizer. Storage modulus, loss modulus and complex viscosity increase with incorporation of starch. Tensile strength and elongation-at-break decrease from 18 to 10.5 MPa and 340 to 200%, respectively when TPS increases from 5 to 20%. However, the required mechanical properties for packaging applications are attained when 15-wt% starch is added, as specified in ASTM D4635. Finally, 12% increase in water uptake is achieved with inclusion of 15 wt% starch.

Ulku Yilmazer effects of blending low-density polyethylene (LDPE) with linear low-density polyethylene (LLDPE) were studied on extrusion blown films[11]. The tensile strength, the tear strength, the elongation at break, as well as haze showed more or less additively between the properties of LDPE and LLDPE except in the range of 20–40% where synergistic effects were observed. The LLDPE had higher tensile strength and elongation at break than did the LDPE in both test directions, as well as higher tear strength in the transverse direction. The impact energies of the LLDPE and the LDPE were approximately the same, but the tear strength of the LLDPE was lower than that of LDPE in the machine direction. The comparative mechanical properties strongly depend on the processing conditions and structural parameters such as the molecular weight and the molecular weight distribution of both classes of materials. The LLDPE in this study had a higher molecular weight in comparison to the LDPE of the study, as implied from its lower melt flow index (MFI) in 0comparison to that of the LDPE. The effects of processing conditions such as the blow-up ratio (BUR) and the draw-down ratio (DDR) were also studied at 20/80 (LLDPE/LDPE) ratio. Tensile strength, elongation at break, and tear strength in both directions became equalized, and the impact energy decreased as the BUR and the DDR approached each other[12].

Chapter Three

Methodology

3.1 **Raw Material**

Polyethylene is a relatively old plastic. Because of the developments in the La.st decades many grades of PE are available. The properties of all these Grades differ one way or another and can be controlled by:

- Variation in the degree of short chain branching
- Variation in the degree of long chain branching
- Variation in the average molecular weight
- Variation in the molecular weight distribution
- The presence of a small amount of commoner residues
- The presence of additives or polymerization residues

A-High a density polyethylene (LDPE)

B- Low density polyethylene (LDPE)

C- Linear Low-density polyethylene (LLDPE)

D- Polypropylene (PP)

3.1.1 High-Density Polyethylene (HDPE)

Polyethylene high-density (PEHD) is a polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes or blow molding. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, and plastic lumber.

3.1.1.1 Properties

HDPE is known for its large strength-to-density ratio. The density of HDPE can range from 0.93 to 0.97 g/cm3 or 970 kg/m3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/ 248 °F for short periods). High-density polyethylene, unlike polypropylene, cannot withstand normally required autoclaving conditions. The physical properties of HDPE can vary depending on the molding process that is used to manufacture a specific sample; to some degree a determining factor are the international standardized testing methods employed to identify these properties for a specific process. For example, in Rotational Molding, to identify the environmental stress crack resistance of a sample the Notched Constant Tensile Load Test (NCTL) is put to use.

3.1.1.2 Applications

HDPE is resistant to many different solvents and has a wide variety of applications:

- Swimming pool installation
- Blow molding film
- Backpacking frames
- Ballistic plates
- Food storage containers
- Fuel tanks for vehicles
- Corrosion protection for steel pipelines
- Folding chairs and tables
- Geothermal heat transfer piping systems
- Heat-resistant firework mortars
- Last for shoes

- Natural gas distribution pipe systems
- Fireworks
- It is used to produce shopping bags, which are the highest consumed bags. The trademarks used in Sudan are:
- ➢ Sabic (KSA).
- ➢ Altasne (Qatar).
- ➢ Rawia.
- ➢ Petro rabh.
- ➢ Kwaiti.
- ➢ Marlex.
- ➢ Borouge.

Each material has different processing technique for example Sabic HDPE extrusion temperature is (190-200) °C, while kwaiti HDPE extrusion temperature is 220°C.

3.1.2 Low-Density Polyethylene

Locally it is called the soft polyethylene all this is material imported form sabic .its price is the highest among all polyethylene.

The low density poly ethylene is used to produce film winded on rolls and then cutter and sealed in small shops to produce small bags used for packaging of homemade ice-cream , peanuts , sapwood etc.

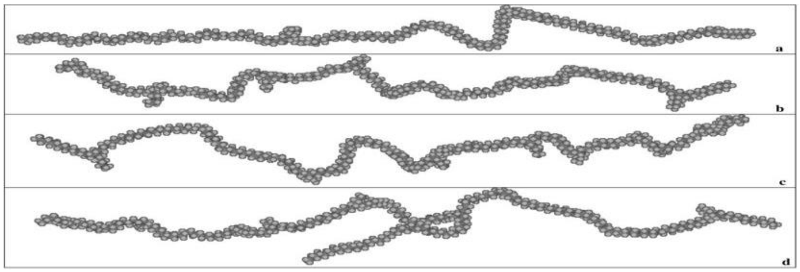


Figure 3.1 Molecular structures for linear and branched poly ethylenes

3.1.2.1 LDPE Branching Structure

Low-density polyethylene (LDPE) is a thermoplastic made from the monomer ethylene. It was the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high-pressure process via free radical polymerization. Its manufacture employs the same method today. The EPA estimates 5.7% of LDPE (recycling number 4) is recycled. Despite competition from more modern polymers, LDPE continues to be an important plastic grade. In 2013, the worldwide LDPE market reached a volume of about US$33 billion.

3.1.2.2 Properties

A density range of 0.910–0.940 g/cm3 defines LDPE. It is not reactive at room temperatures, except by strong oxidizing agents, and some solvents cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. Made in translucent or opaque variations, it is quite flexible and tough.

LDPE has more branching (on about 2% of the carbon atoms) than HDPE, so its intermolecular forces (instantaneous-dipole induced-dipole attraction) are weaker, its tensile strength is lower, and its resilience is higher. [16]

3.1.2.3 Applications:

LDPE is widely used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic bags for computer components, and various molded laboratory equipment. Its most common use is in plastic bags. Other products made from it include:

- Blowing film
- A piece of packaging foam made from LDPE
- Trays and general-purpose containers
- Corrosion-resistant work surfaces
- Parts that need to be weld able and machinable
- Parts that require flexibility, for which it serves very well
- Very soft and pliable parts such as snap - on lids

3.1.3 Linear Low-Density Polyethylene

It is the best raw material to produce film. it is added to HDPE and low density poly ethylene . When added to HDPE the material becomes softer and the elongation increase. It is added to LDPE for economic reasons and to produce stable bubble.

There is a major difference between the die used for HDPE and LDPE. The HDPE die contains a torpedo while LDPE die does not this because, the material of LDPE stick to the torpedo causing trouble. This problem is overcome if the LDPE contains anti –tack.

Linear low-density polyethylene (LLDPE) granules.

Linear low-density polyethylene (LLDPE) is a linear polymer (polyethylene), with significant numbers of short branches, commonly made by copolymerization of ethylene with longer-chain olefins. Linear low-density polyethylene differs structurally from conventional low-density polyethylene (LDPE) because of the absence of long chain branching. The linearity of LLDPE

Results from the different manufacturing processes of LLDPE and LDPE. In general, LLDPE is produced at lower temperatures and pressures by copolymerization of ethylene and such higher alpha-olefins as butane, hexane, or octane. The copolymerization process produces an LLDPE polymer that has a narrower molecular weight distribution than conventional LDPE and in combination with the linear structure, significantly different rheological properties.

3.1.3.1 Production and Properties

The production of LLDPE is initiated by transition metal catalysts, particularly Ziegler or Philips type of catalyst. The actual polymerization process can be done either in solution phase or in gas phase reactors. Usually, octane is the commoner in solution phase while butane and hexane are copolymerized with ethylene in a gas phase reactor. LLDPE has higher tensile strength and higher impact and puncture resistance than does LDPE. It is very flexible and elongates under stress. It can be used to make thinner films, with better environmental stress cracking resistance. It has good resistance to chemicals. It has good electrical properties. However, it is not as easy to process as LDPE, has lower gloss, and narrower range for heat sealing.

3.1.3.2 Processing

LDPE and LLDPE have unique rheological or melt flow properties. LLDPE is less shear sensitive because of its narrower molecular weight distribution and shorter chain branching. During a shearing process, such as extrusion, LLDPE remains more viscous and, therefore, harder to process than an LDPE of equivalent melt index. The lower shear sensitivity of LLDPE allows for a faster stress relaxation of the polymer chains during extrusion, and, therefore, the physical properties are susceptible to changes in blow-up ratios. In melt extension, LLDPE has lower viscosity at all strain rates. This means it will not strain harden the way LDPE does when elongated. As the deformation rate of the polyethylene increases, LDPE demonstrates a dramatic rise in viscosity because of chain entanglement. This phenomenon is not observed with LLDPE because of the lack of long-chain branching in LLDPE allows the chains to slide by one another upon elongation without becoming entangled. This characteristic is important for film applications because LLDPE films can be down gauged easily while maintaining high strength and toughness. The rheological properties of LLDPE are summarized as "stiff in shear" and "soft in extension". It is not taken in most curbside pickups in communities. LLDPE can be recycled though into other things like trash can liners, lumber, landscaping ties, floor tiles, compost bins, and shipping envelopes.

3.1.3.3 Application

LLDPE has penetrated almost all traditional markets for polyethylene; it is used for plastic bags and sheets (where it allows using lower thickness than comparable LDPE), plastic wrap, stretch wrap, pouches, toys, covers, lids, pipes, buckets and ,blowing film, covering of cables, geomembranes and mainly flexible tubing. In 2013, the world market for LLDPE reached a volume of $40 billion.

LLDPE manufactured by using metallocene catalysts is labeled m LLDPE.

Chapter Four

Analysis of the Process

4.1 Film Blowing

One method to produce film is by extruding a polymer through annular die to produce a tube and then stretching in two directions by inflation using air flowing from inside the annular die (pressure is slightly higher than atmospheric pressure)and drawing of the bubble formed .the bubble is cooled by an air jet flowing from an air ring towards the outside .

As a result the polymer solidity forming a frost line . beyond the foist lire the determine of the bubble is practically zero. The bubble is then flattened by a set of guide rolls and a set of rubber rip rolls that form an air tight seat at the upper and of bubble . the take off at the rip rolls maybe either of constant seed or constant torque .

The film blowing is biaxial orientation .the axial (machine direction) and the air circumferential (traverse direction). The main two parameters are

i. The blow up ratio BUR (BR)
ii. Drawing in the machine direction ratio(DR)

H_o , R_o ≡ initial film thickness (die gap) and die radius.

H_f, R_f ≡ Final film thickness and bubble radius

V_0,V_f ≡ Velocity at die and the upper and end of bubble

$$B_R = \frac{R_f}{R_o} \quad \text{and} \quad D_R = \frac{V_f}{V_o}$$

Volumetric flow rate is constant

$$2\pi\, R_o\, H_o V_O = 2\pi\ R_f\ \ H_f\ \ V_f$$

$$H_o = \frac{R_f}{R_o}\ .\ \frac{V_f}{V_o}$$

$$H_{\ o} = B_r.\ \ D_r$$

The thick guage film thickness is grater or equal to 70 µm . it is in green hoase film.

Garden bags, chemical packaging and heavy duty shrink film. Material used is HDPE and PP the thin film thickness is from 25 µm to 60 µm. material used is HDPE, LLDPE and LDPE.

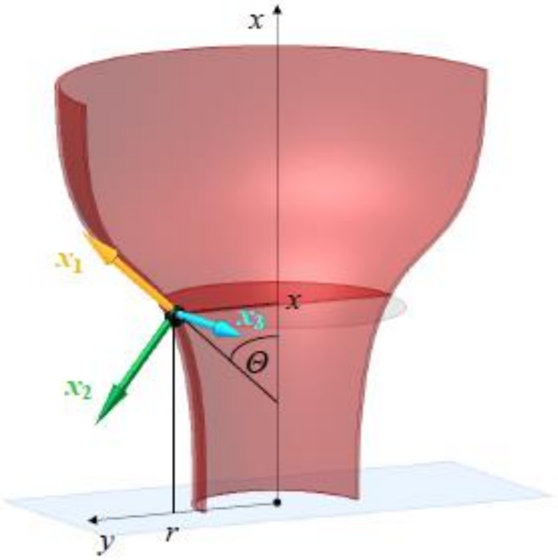


Figure 4.1: Elements of blown film

Die recommendation for film blowing:

Film thickness $X10^6$ m	Die gap (mm)	Length Mm
12.5 ~ 20	0.4	38
25 ~ 50	0.5	38
50 ~ 175	0.75	

Source: Polymer processing page 60

Plastic engineering data book:

Thickness	Die gap
25 µm	0.5 mm
250 µm	1.0Mm

The mechanical properties of film is tested by the flowing test methods :

1) Tear test : Elmendorf tear test
2) Impact test : Dart drop test

ASTM D-1938

3) Tensile test : ASTM D-882

The best melt temp.

LDPE	170 ± 5 ^{O}C
HDPE	190 ± 5 ^{O}C

Outside these range the mot. Strength decreases in both directions.

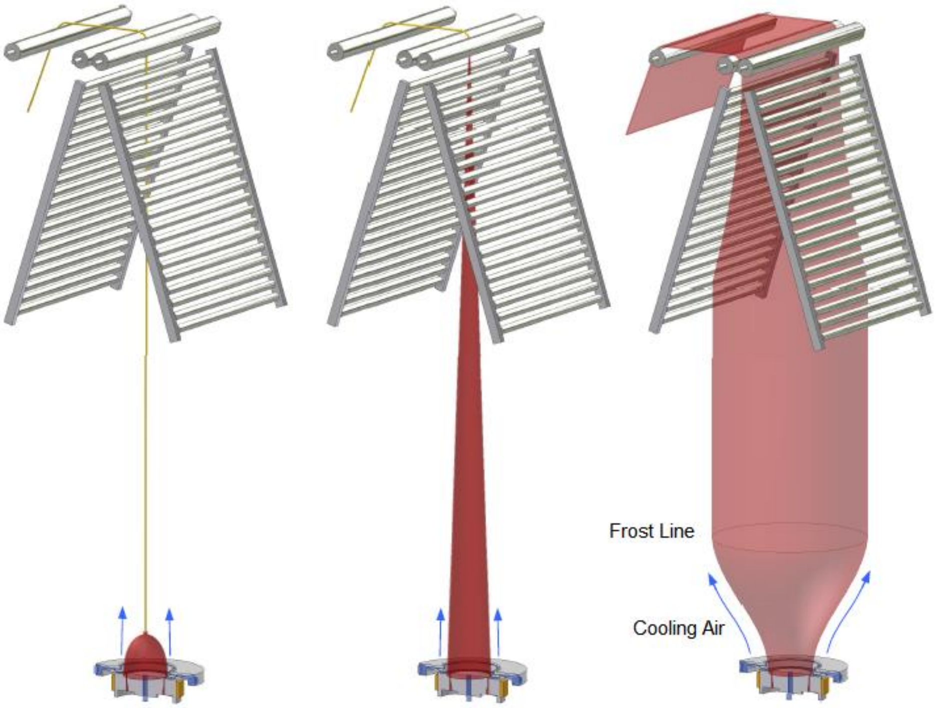


Figure 4.2: Procedure used to start the film Blowing Process

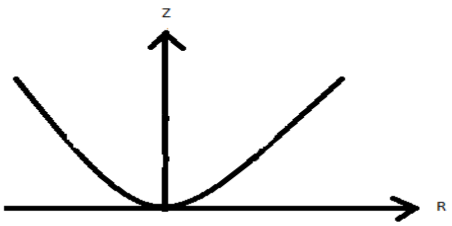
The drawing shows the start-up of film blowing .

About the frost line the bubble is cylindrical and below it the bubble is the surface of parabloid . such surface is generated by the revolution of parabola about the vertical axis

Check : piskenov , differential and integral calculus

Page 457

$Z = \frac{R^Z}{C}$ C- constant



The surface of revolution about

Z ~ axis is :

$$A = \int_{\mathrm{Zo}}^{\mathrm{Zf}} 2\,\pi\,R\,\sqrt{1+R^{`2}} \quad dZ \quad \rightarrow (1)$$

$$R = c^{1/2}\ Z^{-1} \ \rightarrow R' = c^{1/2}\ (\frac{1}{2})\ Z^{-1/2}$$

$$R'^{2} = \frac{c}{z} \quad Z^{-2}$$

$$1 + R'^{2} = 1 + \frac{c}{4\,Z}$$

$$R\sqrt{1+\ R'^{\,2}} = c^{1/2} \quad z^{1/2}\ \sqrt{\frac{4z+c}{4z}}$$

$$= \frac{c^{1/2}}{2}\sqrt{4z+c}$$

Substitute in (1)

$$A = 2\pi \int_{Z_o}^{Z_f} \frac{c^{1/2}}{2}\ \sqrt{4\,z+c} \quad dz$$

$$= \pi c^{1/2} \int (4z+c)^{1/2} \quad dz$$

put y = 4z + c ⟶ dy = 4 dz

$$A = \frac{\pi}{4}\, C^{1/2}\ \int y^{1/2}\, dy$$

$$A = \frac{\pi}{4}\ C^{1/2}\ \ (\frac{2}{3})\ [\ y^{3/2}\ ]_{y_o}^{y_f}$$

$$A = \frac{\pi}{6}\ C^{1/2}\ [\ (4z_f + c\ )^{3/2} - (\ 4z_c\ + c\ )^{3/2}\ ]\ \rightarrow (2)$$

Review : binomial expansion

$$(1+u)^n = 1 + nu + \frac{n(n-1)}{2!}u^2 + \frac{n(n-1)(n-2)}{3!}u^3 + \cdots + u^n$$

Example

$$(a + b)^{1/2} \;=\; a^{1/2}\ [1 + (\tfrac{b}{a})]^{1/2}$$

$$= a^{1/2}\ [\ 1 + \frac{1}{2}\ \left(\frac{b}{a}\right) + \frac{\frac{1}{2}\,(\frac{1}{2}-1\,)}{2}\ \left(\frac{b}{a}\right)^2 \ + \ \frac{\frac{1}{2}(\frac{1}{2}-1)(\frac{1}{2}-2)}{6}\left(\frac{b}{a}\right)^3 \ + \ldots.\ ]$$

$$= a^{1/2}\ [\ 1 + \frac{b}{2a} - \frac{b^2}{8a} + \frac{b^3}{16a^3} + \cdots\ ]$$

Return to the problem

$$(4z + c)^{3/2} \ = c^{3/2}\ \left(1 + \frac{4z}{c}\right)^{3/2}$$

$$= c^{3/2}\ \left[1 + \frac{3}{2}\ \left(\frac{4z}{c}\right) + \frac{\frac{3}{2}\left(\frac{1}{2}\right)}{2}\ \left(\frac{4z}{c}\right)^2 + \cdots\right]$$

$$= \quad c^{3/2}\ \left[1 + 6\left(\frac{z}{c}\right) + 6\left(\frac{z}{c}\right)^2 + \cdots\right]$$

$$A = \frac{\pi\ c^{1/2}}{6}\ [\left(4z_f + c\right)^{3/2} - (4z_o + c)^{3/2}\ ]$$

$$= \ \frac{\pi c^2}{6}\ [\{1+6(\frac{z_f}{c})\ +6(\frac{z_f{}^2}{c^2})\} - \{1+\ 6\ \frac{z_o}{c} + 6\ \frac{z_o^2}{c^2}\}]$$

$$= \ \frac{\pi}{6}c^2\ \left[6\ \left(\frac{z_f - z_o}{c}\right) + 6\ \left(\frac{z_f^2 - z_o^2}{c^2}\right)\right]$$

$$= \pi\ c^2\ c^2\left[\ c\ \left(z_f - z_c\right) + \ z_f^2 - z_o^2\right]$$

But $z_f = \ \frac{R_f{}^2}{c}\ z_o = \ \frac{R_o{}^2}{c}$

$$C\left(\ z_f - z_c\right) = \ R_f{}^2 - R_C{}^2$$

$$z_f{}^2 - z_o{}^2 = \frac{1}{c^2}\ \left(\ R_f{}^4 - \ R_o{}^4\ \right)$$

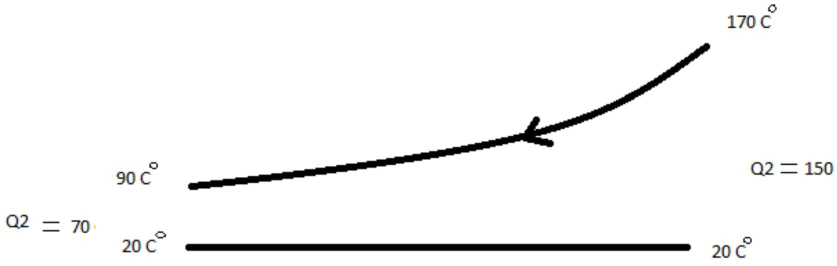
$$\therefore A = \pi \, [{R_f}^2 - {R_o}^2 + \frac{1}{c^2} \left({R_f}^4 - {R_o}^4 \right)$$

$$\frac{A}{\pi} - \left({R_f}^2 - {R_o}^2\right) = \frac{1}{c^2} \left({R_f}^4 - {R_o}^4\right)$$

$$c^2 = \frac{{R_f}^4 - {R_o}^4}{\frac{A}{\pi} - \left({R_f}^2 - {R_o}^2 \right)}$$

Calculate the heat transfers are from heat transfer:

$$Q = A \, h \, \theta m$$



$$\theta_m = \frac{O_1 - O_2}{ln \frac{O_1}{O_2}} = \frac{150-70}{ln\left(\frac{150}{70}\right)} = 105 \ {}^oK$$

Q = latent heat of fusion

LDPE = $13.8 \times 10^4 J/Kg$

HDPE=$23.15 \times 10^4 J / Kg$

Source : polymer pressing page 107 table 5.9

The transfer coefficient h for forced air

$10 \sim 100 \frac{W}{m^2 \ oK}$. crawferd page 393

For still air is 5 ~10 $\frac{w}{m^2}$ °K

$$A = \frac{Q}{h\,\theta_m}$$

For a mass flow rate of 8.33 $\times\ 10^{-3}\ kg/s$

(design problem page 247 polymer processing)

$$Q = 13.8\ \times 10^4 \frac{J}{KG} \times 8.33\ \times 8.33 \times\ 10^{-3}\, kg/s$$

A= (13.8 ×8.33 ×10 J/S)/(50 (J/s)/(m^(2)°K) ×105 °K) =0.219 m^2

$$R_{_0} = 3.39\ \times 10^{-2}\ m \qquad R_f = 19.1\ \times\ 10^{-2} m$$

$$c^2 = \frac{(\ 19.1\ \times 10^{-2})^4 - (3.39\ \times 10^{-2}\ )^4}{\frac{0.219}{\pi} - [\ (19.1\ \times 10^{-2})^2 - (3.39\ \times 10^{-2})^2]}$$

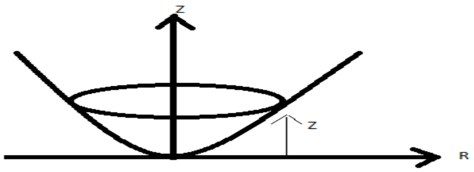
$$= \frac{1.329543\ \times 10^{-3}}{0.034378} = 0.038674$$

C = 0.1967

The frost line height $Z_f = \frac{{R_f}^2}{0.1967}$

$Z_f = \frac{(0.191)^2}{0.1967} = 0.185$ m$= 18.5$ cm

Near the die before the frost line it is a parotid



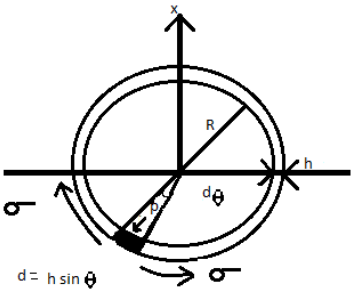
Take a differential element of height dz at distance Z , it's thickness is h and radio R .

The hoop stress $\sigma = \frac{PR}{h}$

$P = \sigma\, h/R$ —3

$\sigma = \lambda\, \varepsilon^{o}$

$$\varepsilon^{o} = \frac{change\ of\ length\ per\ unit}{original\ length}$$



Top view element

$$\varepsilon^{o} = \frac{(R+dR)\, d\theta - R d\theta}{R d\theta \cdot dt}$$

$$= \frac{1}{R} \quad \frac{dR}{dZ}$$

$$= \frac{1}{R} \quad \frac{dR}{dt} \quad \frac{dz}{dz} = \frac{1}{R} \; \frac{dR}{dz} \;\; \mathrm{Vz}$$

$$\sigma = \lambda\, \varepsilon^{o} \;=\; \frac{\lambda}{\mathrm{R}} \frac{dR}{dZ} \;\; Vz$$

Substitute in (3)

$$\mathrm{p} = \frac{\lambda}{R^2}\, h \frac{dR}{dZ}\, Vz$$

$$z = \frac{R^2}{c} \rightarrow \frac{dZ}{dR} = \frac{2R}{c}$$

$$p = \frac{\lambda \mathrm{h}}{R^2} \cdot \frac{c}{2R} V_z$$

$$p = \frac{\lambda \mathrm{h\ c}}{2\, R^2} \mathrm{V}_z \text{ ——— (4)}$$

Chapter Five

Conclusion and Recommendations

5.1 Conclusion and Recommendations

Many factories depend on trial and error processing parameters .this is not a scientific method and consume a lot of time and produce a lot of scrap (recycle) material, instead the analytical method to determine the values of the design parameters is the efficient way and it is must be employed. Concerning the effect of material property on the design it was discussed in the research of Mustafa y. Bakhet that is reference (3) in this study.

This study shows the role of experience in blending different materials. However when doing so the scientific.

Approach for blending must be used . In fact there is a complicated link between processing conditions , machinery design and material properties. This need to be studied.

The best BUR rate is the one at which

strength in = strength in

MD TD

Best BUR for LDPE is 2.5

Best BUR for HDPE is 4.0

Outside these values greater MD > TD

The MFI is with the range 0.05 ~ 2

5.2 References

1. Hussein IA, Williams MC (2004a) Rheological study of heterogeneities in melt blends of ZN-LLDPE and LDPE: influence of Mw and comonomer type, and implications for miscibility. Rheol Acta 43:604–614
2. Hussein IA, Williams MC (2004b) Rheological study of the influence of branch content on the miscibility of octene m-LLDPE and ZNLLDPE in LDPE. Polym Eng Sci 44:660–672
3. Marhom.M.Y (2017). The effects of linear low. Density polyethylene (LLDPE) on the Mechanical properties of low – density polyethylene (LDPE) film Blends.
4. Fang Y, Carreau PJ, Lafleur PG (2005) Thermal and rheological properties of LLDPE/LDPE blends. Polym Eng Sci 45:1254–1269
5. Hussein IA, Hameed T (2005) Influence of branching characteristics on thermal and mechanical of Ziegler-Natta and metallocene hexene linear low density polyethylene blends with low density polyethylene. J Appl Polym Sci 97:2488–2498
6. Wagner MH, Kheirandish S, Yamaguchi M (2004) Quantitative analysis of melt elongational behavior of LLDPE/LDPE blends. Rheol Acta 44:198–218
7. Ferry JD (1980) Viscoelastic properties of polymers. Wiley, New York
8. Gabriel C, Lilge D (2006) Molecular mass dependence of the zero shear-rate viscosity of LDPE melts: evidence of an exponential behavior. Rheol Acta 45:995–1002
9. Pérez R, Rojo E, Fernández M, Leal V, Lafuente P, Santamaría A(2005) Basic and applied rheology of m-LLDPE/LDPE blends: miscibility and processing features. Polymer 46:8045–8053
10. Sentmanat ML (2003) Dual windup extensional rheometer. US Patent 6,578,413
11. Gabriel C, Lilge D (2006) Molecular mass dependence of the zero shear-rate viscosity of LDPE melts: evidence of an exponential behavior. Rheol Acta 45:995–1002
12. Sentmanat M (2004) Miniature universal testing platform: from extensional melt rheology to solid state deformation behavior. Rheol Acta 43:657–699

Appendix

SAFETY DATA SHEET

Chevron Phillips Chemical Company LP

Marlex® HHM TR-131 Polyethylene

Version 1.4 Revision Date 2016-11-11

SECTION 1: Identification of the substance/mixture and of the company/undertaking

Product information

Product Name	:	Marlex® HHM TR-131 Polyethylene
Material	:	1025163, 1017043, 1035873

Company : Chevron Phillips Chemical Company LP
10001 Six Pines Drive
The Woodlands, TX 77380

Local : Chevron Phillips Chemicals International N.V.
Airport Plaza (Stockholm Building)
Leonardo Da Vincilaan 19
1831 Diegem
Belgium

SDS Requests: (800) 852-5530
Technical Information: (832) 813-4862
Responsible Party: Product Safety Group
Email:sds@cpchem.com

Emergency telephone:

Health:
866.442.9628 (North America)
1.832.813.4984 (International)
Transport:
CHEMTREC 800.424.9300 or 703.527.3887(int'l)
Asia: +800 CHEMCALL (+800 2436 2255) China:+86-21-22157316
EUROPE: BIG +32.14.584545 (phone) or +32.14583516 (telefax)
South America SOS-Cotec Inside Brazil: 0800.111.767 Outside Brazil: +55.19.3467.1600

Responsible Department	:	Product Safety and Toxicology Group
E-mail address	:	SDS@CPChem.com
Website	:	www.CPChem.com

MEDICAL APPLICATION CAUTION: Do not use this material in medical applications involving permanent implantation in the human body or permanent contact with internal body fluids or tissues fluids or tissues.

Do not use this material in medical applications involving brief or temporary implantation in the human body or contact with internal body fluids or tissues unless the material has been provided directly from Chevron Phillips Chemical Company LP or its legal affiliates under an agreement which expressly acknowledges the contemplated use.

Chevron Phillips Chemical Company LP and its legal affiliates makes no representation, promise, express warranty or implied warranty concerning the suitability of this material for use in implantation in the human body or in contact with internal body fluids or tissues.

SECTION 2: Hazards identification

Classification of the substance or mixture
REGULATION (EC) No 1272/2008

Not a hazardous substance or mixture according to Regulation (EC) No 1272/2008.

Label elements

Labeling (REGULATION (EC) No 1272/2008)

Not a hazardous substance or mixture according to Regulation (EC) No 1272/2008.

SECTION 3: Composition/information on ingredients

Mixtures

Hazardous ingredients

Chemical name	CAS-No. EC-No. Index No.	Classification (REGULATION (EC) No 1272/2008)	Concentration [wt%]
Polyethylene Hexene Copolymer	25213-02-9		95 - 100
Contains no hazardous ingredients according to GHS. :			

SECTION 4: First aid measures

If inhaled	: Move to fresh air in case of accidental inhalation of dust or fumes from overheating or combustion. If symptoms persist, call a physician.
In case of skin contact	: If the molten material gets on skin, quickly cool in water. Seek immediate medical attention. Do not try to peel the solidified material from the skin or use solvents or thinners to dissolve it.
In case of eye contact	: In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
If swallowed	: Do not induce vomiting without medical advice.

SECTION 5: Firefighting measures

Flash point : No data available

Autoignition temperature : No data available

Suitable extinguishing media : Water. Water mist. Dry chemical. Carbon dioxide (CO2). Foam. If possible, water should be applied as a spray from a fogging nozzle since this is a surface burning material. The application of high velocity water will spread the burning surface layer. Avoid the use of straight streams that may create a dust cloud and the risk of a dust explosion. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

Specific hazards during fire fighting : Risks of ignition followed by flame propagation or secondary explosions can be caused by the accumulation of dust, e.g. on floors and ledges.

Special protective equipment for fire-fighters : Use personal protective equipment. Wear self-contained breathing apparatus for firefighting if necessary.

Further information : This material will burn although it is not easily ignited.

Fire and explosion protection : Treat as a solid that can burn. Avoid generating dust; fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Hazardous decomposition products : Normal combustion forms carbon dioxide, water vapor and may produce carbon monoxide, other hydrocarbons and hydrocarbon oxidation products (ketones, aldehydes, organic acids) depending on temperature and air availability. Incomplete combustion can also produce formaldehyde.

SECTION 6: Accidental release measures

Personal precautions : Sweep up to prevent slipping hazard. Avoid breathing dust. Avoid dust formation.

Environmental precautions : Do not contaminate surface water. Prevent product from entering drains.

Methods for cleaning up : Clean up promptly by sweeping or vacuum.

Additional advice : Dust deposits should not be allowed to accumulate on surfaces, as these may form an explosive mixture if they are released into the atmosphere in sufficient concentration. Avoid dispersal of dust in the air (i.e., clearing dust surfaces with compressed air).

SECTION 7: Handling and storage

Handling

Advice on safe handling : Use good housekeeping for safe handling of the product. Keep out of water sources and sewers.

Spilled pellets and powders may create a slipping hazard.

Electrostatic charge may accumulate and create a hazardous condition when handling this material. To minimize this hazard, bonding and grounding may be necessary, but may not by themselves be sufficient. At elevated temperatures (>350°F, >177°C), polyethylene can release vapors and gases, which are irritating to the mucous membranes of the eyes, mouth, throat, and lungs. These substances may include acetaldehyde, acetone, acetic acid, formic acid, formaldehyde and acrolein. Based on animal data and limited epidemiological evidence, formaldehyde has been listed as a carcinogen. Following all recommendations within this SDS should minimize exposure to thermal processing emissions.

Advice on protection against fire and explosion : Treat as a solid that can burn. Avoid generating dust; fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Storage

Requirements for storage areas and containers : Keep in a dry place. Keep in a well-ventilated place.

Advice on common storage : Do not store together with oxidizing and self-igniting products.

SECTION 8: Exposure controls/personal protection

Engineering measures

Consider the potential hazards of this material (see Section 2), applicable exposure limits, job activities, and other substances in the work place when designing engineering controls and selecting personal protective equipment. If engineering controls or work practices are not adequate to prevent exposure to harmful levels of this material, the personal protective equipment listed below is recommended. The user should read and understand all instructions and limitations supplied with the equipment since protection is usually provided for a limited time or under certain circumstances.

Personal protective equipment

Respiratory protection : No respiratory protection is normally required. If heated material generates vapor or fumes that are not adequately controlled by ventilation, wear an appropriate respirator. Use the following elements for air-purifying respirators: Organic Vapor and Formaldehyde. Use a positive pressure, air-supplying respirator if there is potential for uncontrolled release, exposure levels are not known, or other circumstances where air-purifying respirators may not provide adequate protection. Dust safety masks are recommended when the dust concentration is excessive.

Eye protection : Use of safety glasses with side shields for solid handling is good industrial practice. If this material is heated, wear chemical goggles or safety glasses with side shields or a face shield. If there is potential for dust, use chemical goggles.

Skin and body protection : At ambient temperatures use of clean and protective clothing is good industrial practice. If the material is heated or molten, wear thermally insulated, heat-resistant gloves that are able to withstand the temperature of the molten product. If this material is heated, wear insulated clothing to prevent skin contact if engineering controls or work practices are not adequate.

SECTION 9: Physical and chemical properties

Information on basic physical and chemical properties

Appearance

Form : Pellets
Physical state : Solid
Color : Opaque
Odor : Mild to no odor
Odor Threshold : No data available

Safety data

Flash point : No data available

Lower explosion limit : Not applicable

Upper explosion limit : Not applicable

Autoignition temperature : No data available

Thermal decomposition : Low molecular weight hydrocarbons, alcohols, aldehydes, acids and ketones can be formed during thermal processing.

pH : Not applicable

Melting point/range : 90 - 140 °C (194 - 284 °F)

Freezing point Not applicable

Initial boiling point and boiling range : Not applicable
Vapor pressure : Not applicable

Relative density : Not applicable

Density : 0,91 - 0,97 g/cm3

Water solubility : Negligible

Partition coefficient: n-octanol/water : No data available
Solubility in other solvents : No data available

Viscosity, dynamic	Not applicable
Viscosity, kinematic	Not applicable
Relative vapor density	Not applicable
Evaporation rate	Not applicable

SECTION 10: Stability and reactivity

Reactivity	This material is considered non-reactive under normal ambient and anticipated storage and handling conditions of temperature and pressure.
Chemical stability	This material is considered stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.

Possibility of hazardous reactions

Conditions to avoid	Avoid prolonged storage at elevated temperature.
Materials to avoid	Avoid contact with strong oxidizing agents.
Thermal decomposition	Low molecular weight hydrocarbons, alcohols, aldehydes, acids and ketones can be formed during thermal processing.
Hazardous decomposition products	Normal combustion forms carbon dioxide, water vapor and may produce carbon monoxide, other hydrocarbons and hydrocarbon oxidation products (ketones, aldehydes, organic acids) depending on temperature and air availability. Incomplete combustion can also produce formaldehyde.
Other data	No decomposition if stored and applied as directed.

SECTION 11: Toxicological information

Marlex® HHM TR-131 Polyethylene
Acute oral toxicity : Presumed Not Toxic

Marlex® HHM TR-131 Polyethylene
Acute inhalation toxicity : Presumed Not Toxic

Marlex® HHM TR-131 Polyethylene
Acute dermal toxicity : Presumed Not Toxic

Marlex® HHM TR-131 Polyethylene
Skin irritation : No skin irritation

Marlex® HHM TR-131 Polyethylene

Eye irritation : No eye irritation

Marlex® HHM TR-131 Polyethylene

Sensitization : Did not cause sensitization on laboratory animals.

Marlex® HHM TR-131 Polyethylene

Further information : This product contains POLYMERIZED OLEFINS. During thermal processing (>350°F, >177°C) polyolefins can release vapors and gases (aldehydes,ketones and organic acids) which are irritating to the mucous membranes of the eyes, mouth, throat, and lungs. Generally these irritant effects are all transitory. However, prolonged exposure to irritating off-gases can lead to pulmonary edema. Formaldehyde (an aldehyde) has been classified as a carcinogen based on animal data and limited epidemiological evidence.

SECTION 12: Ecological information

Ecotoxicity effects

Elimination information (persistence and degradability)

Bioaccumulation : Does not bioaccumulate.

Mobility : The product is insoluble and floats on water.

Biodegradability : This material is not expected to be readily biodegradable.

Ecotoxicology Assessment

Additional ecological information : This material is not expected to be harmful to aquatic organisms., Fish or birds may eat pellets which may obstruct their digestive tracts.

SECTION 13: Disposal considerations

The information in this SDS pertains only to the product as shipped.

Use material for its intended purpose or recycle if possible. This material, if it must be discarded, may meet the criteria of a hazardous waste as defined by US EPA under RCRA (40 CFR 261) or other Stale and local regulations. Measurement of certain physical properties and analysis for regulated components may be necessary to make a correct determination. If this material is classified as a hazardous waste, federal law requires disposal at a licensed hazardous waste disposal facility.

SECTION 14: Transport information

The shipping descriptions shown here are for bulk shipments only, and may not apply to shipments in non-bulk packages (see regulatory definition).

Consult the appropriate domestic or international mode-specific and quantity-specific Dangerous Goods Regulations for additional shipping description requirements (e.g., technical name or names, etc.) Therefore, the information shown here, may not always agree with the bill of lading shipping description for the material. Flashpoints for the material may vary slightly between the SDS and the bill of lading.

US DOT (UNITED STATES DEPARTMENT OF TRANSPORTATION)

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

IMO / IMDG (INTERNATIONAL MARITIME DANGEROUS GOODS)

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

IATA (INTERNATIONAL AIR TRANSPORT ASSOCIATION)

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

ADR (AGREEMENT ON DANGEROUS GOODS BY ROAD (EUROPE))

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

RID (REGULATIONS CONCERNING THE INTERNATIONAL TRANSPORT OF DANGEROUS GOODS (EUROPE))

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

ADN (EUROPEAN AGREEMENT CONCERNING THE INTERNATIONAL CARRIAGE OF DANGEROUS GOODS BY INLAND WATERWAYS)

NOT REGULATED AS A HAZARDOUS MATERIAL OR DANGEROUS GOODS FOR TRANSPORTATION BY THIS AGENCY.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

SECTION 15: Regulatory information

National legislation

Major Accident Hazard Legislation : 96/82/EC Update: 2003
Directive 96/82/EC does not apply

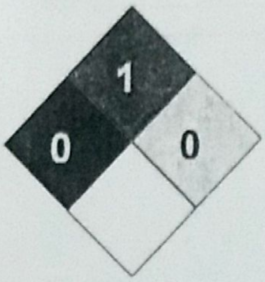
Water contaminating class (Germany) : nwg not water endangering

Notification status

Europe REACH : Not in compliance with the inventory
United States of America (USA) TSCA : On the inventory, or in compliance with the inventory
Canada DSL : On the inventory, or in compliance with the inventory
Australia AICS : On the inventory, or in compliance with the inventory
New Zealand NZIoC : On the inventory, or in compliance with the inventory
Japan ENCS : On the inventory, or in compliance with the inventory
Korea KECI : On the inventory, or in compliance with the inventory
Philippines PICCS : On the inventory, or in compliance with the inventory
China IECSC : On the inventory, or in compliance with the inventory

SECTION 16: Other information

NFPA Classification : Health Hazard: 0
Fire Hazard: 1
Reactivity Hazard: 0



Further information

Significant changes since the last version are highlighted in the margin. This version replaces all previous versions.

The information in this SDS pertains only to the product as shipped.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Key or legend to abbreviations and acronyms used in the safety data sheet			
ACGIH	American Conference of Government Industrial Hygienists	LD50	Lethal Dose 50%
AICS	Australia, Inventory of Chemical Substances	LOAEL	Lowest Observed Adverse Effect Level
DSL	Canada, Domestic Substances List	NFPA	National Fire Protection Agency
NDSL	Canada, Non-Domestic Substances List	NIOSH	National Institute for Occupational Safety & Health
CNS	Central Nervous System	NTP	National Toxicology Program
CAS	Chemical Abstract Service	NZIoC	New Zealand Inventory of Chemicals
EC50	Effective Concentration	NOAEL	No Observable Adverse Effect Level
EC50	Effective Concentration 50%	NOEC	No Observed Effect Concentration
EGEST	EOSCA Generic Exposure Scenario Tool	OSHA	Occupational Safety & Health Administration
EOSCA	European Oilfield Specialty Chemicals Association	PEL	Permissible Exposure Limit
EINECS	European Inventory of Existing Chemical Substances	PICCS	Philippines Inventory of Commercial Chemical Substances
MAK	Germany Maximum Concentration Values	PRNT	Presumed Not Toxic

GHS	Globally Harmonized System	RCRA	Resource Conservation Recovery Act
>=	Greater Than or Equal To	STEL	Short-term Exposure Limit
IC50	Inhibition Concentration 50%	SARA	Superfund Amendments and Reauthorization Act.
IARC	International Agency for Research on Cancer	TLV	Threshold Limit Value
IECSC	Inventory of Existing Chemical Substances in China	TWA	Time Weighted Average
ENCS	Japan, Inventory of Existing and New Chemical Substances	TSCA	Toxic Substance Control Act
KECI	Korea, Existing Chemical Inventory	UVCB	Unknown or Variable Composition, Complex Reaction Products, and Biological Materials
<=	Less Than or Equal To	WHMIS	Workplace Hazardous Materials Information System
LC50	Lethal Concentration 50%		

SABIC® LDPE HP0722NN

LOW DENSITY POLYETHYLENE FOR BLOWN FILM

DESCRIPTION

HP0722NN is an additive free low density polyethylene grade suitable for producing medium duty films. It gives good toughness and optical properties in the film.

TYPICAL APPLICATIONS

HP0722NN can be used for medium duty bags, shrink films, shopping bags, lamination films and frozen food packaging.

TYPICAL PROPERTY VALUES

Revision 20170706

PROPERTIES	TYPICAL VALUES	UNITS	TEST METHODS
POLYMER PROPERTIES			
Melt Flow Rate at 190°C and 2.16kg	0.75	g/10 min	ASTM D1238
Density at 23°C	922	kg/m³	ASTM D1505
MECHANICAL PROPERTIES			
Dart Impact Strength (1)	2	g/µm	ASTM D1709
OPTICAL PROPERTIES			
Haze	9	%	ASTM D1003
Gloss @ 45°	60	-	ASTM D2457
FILM PROPERTIES			
Tensile Properties			
stress at break, MD	26	MPa	ASTM D882
stress at break, TD	24	MPa	ASTM D882
strain at break, MD	235	%	ASTM D882
strain at break, TD	560	%	ASTM D882
stress at yield, MD	12	MPa	ASTM D882
stress at yield, TD	11	MPa	ASTM D882
1% secant modulus, MD	190	MPa	ASTM D882
1% secant modulus, TD	220	MPa	ASTM D882
Tear Resistance			
MD	6	g/µm	ASTM D1922
TD	4	g/µm	ASTM D1922
THERMAL PROPERTIES			

PROPERTIES	TYPICAL VALUES	UNITS	TEST METHODS
Vicat Softening Temperature	95	°C	ASTM D1525

(1) Properties have been measured by producing 50 µ film with 2.5 BUR using 100% HP0722NN

PROCESSING CONDITIONS

Typical processing conditions for HP0722NN are:
Barrel temperature: 170 - 185°C
Blow up ratio: 2.0 - 4.0

MEDICAL & FOOD REGULATION

HP0722NN is suitable for Food contact application. Detailed information is provided in relevant Material Safety Datasheet and for additional specific information please contacts SABIC local representative for certificate. DISCLAIMER: This product is not intended for and must not be used in any pharmaceutical/medical applications.

STORAGE AND HANDLING

Polyethylene resin should be stored in a manner to prevent a direct exposure to sunlight and/or heat. The storage area should also be dry and preferably do not exceed 50°C. SABIC would not give warranty to bad storage conditions, which may lead to quality deterioration such as color change, bad smell and inadequate product performance. It is advisable to process PE resin within 6 months after delivery.

DISCLAIMER

The information contained herein may include typical properties of our products or their typical performances when used in certain typical applications. Actual properties of our products, in particular when used in conjunction with any third party material(s) or for any non-typical applications, may differ from typical properties.
It is the customer's responsibility to inspect and test our product(s) in order to satisfy itself as to the suitability of the product(s) for its and its customers particular purposes. The customer is responsible for the appropriate, safe and legal use, processing and handling of all product(s) purchased from us.
Nothing herein is intended to be nor shall it constitute a warranty whatsoever, in particular, warranty of merchantability or fitness for a particular purpose.
SABIC as referred to herein means any legal entity belonging to the group of companies headed by Saudi Arabia Basic Industries Corporation.

(1) Properties have been measured by producing 30 µm film with 2.5 BUR using 100% 218BJ.

PROCESSING CONDITIONS

Typical processing conditions for 218BJ are:

Melt temperature: 250 - 300°C

Chill roll temperature: 20°C

HEALTH, SAFETY AND FOOD CONTACT REGULATIONS

Detailed information is provided in the relevant Material Safety Datasheet and or Standard Food Declaration, available on the Internet (www.SABIC.com). Additional specific information can be requested via your local Sales Office."

DISCLAIMER: This product is not intended for and must not be used in any pharmaceutical/medical applications.

QUALITY

SABIC® Europe is fully certified in accordance with the internationally accepted quality standard ISO 9001.

ENVIRONMENT AND RECYCLING

The environmental aspects of any packaging material do not only imply waste issues but have to be considered in relation with the use of natural resources, the preservations of foodstuffs, etc. SABIC Europe considers polyethylene to be an environmentally efficient packaging material. Its low specific energy consumption and insignificant emissions to air and water designate polyethylene as the ecological alternative in comparison with the traditional packaging materials. Recycling of packaging materials is supported by SABIC Europe whenever ecological and social benefits are achieved and where a social infrastructure for selective collecting and sorting of packaging is fostered. Whenever 'thermal' recycling of packaging (i.e. incineration with energy recovery) is carried out, polyethylene -with its fairly simple molecular structure and low amount of additives- is considered to be a trouble-free fuel.

STORAGE AND HANDLING

Polyethylene resin should be stored in a manner to prevent a direct exposure to sunlight and/or heat. The storage area should also be dry and preferably do not exceed 50°C. SABIC would not give warranty to bad storage conditions, which may lead to quality deterioration such as color change, bad smell and inadequate product performance. It is advisable to process PE resin within 6 months after delivery.

DISCLAIMER

Any sale by SABIC, its subsidiaries and affiliates (each a "seller"), is made exclusively under seller's standard conditions of sale (available upon request) unless agreed otherwise in writing and signed on behalf of the seller. While the information contained herein is given in good faith, SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, INCLUDING MERCHANTABILITY AND NONINFRINGEMENT OF INTELLECTUAL PROPERTY, NOR ASSUMES ANY LIABILITY, DIRECT OR INDIRECT, WITH RESPECT TO THE PERFORMANCE, SUITABILITY OR FITNESS FOR INTENDED USE OR PURPOSE OF THESE PRODUCTS IN ANY APPLICATION. Each customer must determine the suitability of seller materials for the customer's particular use through appropriate testing and analysis. No statement by seller concerning a possible use of any product, service or design is intended, or should be construed, to grant any license under any patent or other intellectual property right.

SABIC® LLDPE 218BJ

LINEAR LOW DENSITY POLYETHYLENE
REGION ASIA

DESCRIPTION

SABIC® LLDPE 218BJ is a butene linear low density polyethylene resin with an additive package typically designed for a broader range of food applications (TNPP free). The good thermal stability allows to use the resin in critical extrusion processing conditions. Films produced from SABIC® LLDPE 218BJ have better draw-down ability compared to lower MFR LLDPE resins. This product is not intended for and must not be used in any pharmaceutical/medical applications.

TYPICAL APPLICATIONS

SABIC® LLDPE 218BJ is typically used for food applications (lamination film, barrier film), melt embossed films, but can also be used in industrial packaging such as cling film and stretch film for manual and pallet wrap. It can also be used as a blending partner with other SABIC® PE resins in general purpose blown and cast film applications.

TYPICAL PROPERTY VALUES

Revision 20181012

PROPERTIES	TYPICAL VALUES	UNITS	TEST METHODS
POLYMER PROPERTIES			
Melt Flow Rate			
at 190 °C and 2.16 kg	2	g/10 min	ASTM D1238
Density	918	kg/m³	ASTM D1505
MECHANICAL PROPERTIES			
Dart Impact Strength (1)	110	g/µm	ASTM D1709
OPTICAL PROPERTIES (1)			
Haze	7	%	ASTM D1003
Gloss			
at 60 °C	80	-	ASTM D2457
FILM PROPERTIES (1)			
Tensile Properties			
stress at break, MD	31	MPa	ASTM D882
stress at break, TD	22	MPa	ASTM D882
strain at break, MD	550	%	ASTM D882
strain at break, TD	670	%	ASTM D882
stress at yield, MD	12	MPa	ASTM D882
stress at yield, TD	10	MPa	ASTM D882
1% secant modulus, MD	200	MPa	ASTM D882
1% secant modulus, TD	240	MPa	ASTM D882
Puncture resistance	60	J/m	SABIC method
Elmendorf Tear Strength			
MD	135	g	ASTM D1922
TD	400	g	ASTM D1922
THERMAL PROPERTIES			
Vicat Softening Temperature	98	°C	ASTM D1525

CHEMISTRY THAT MATTERS™