Promyde®
PROGRESSING POLYAMIDE

POLYAMIDE 6
FOR PACKAGING & FILM

NUREL
ENGINEERING POLYMERS

INNOVATION IN POLYAMIDE

NUREL ENGINEERING POLYMERS

50 years of polymers production expertise

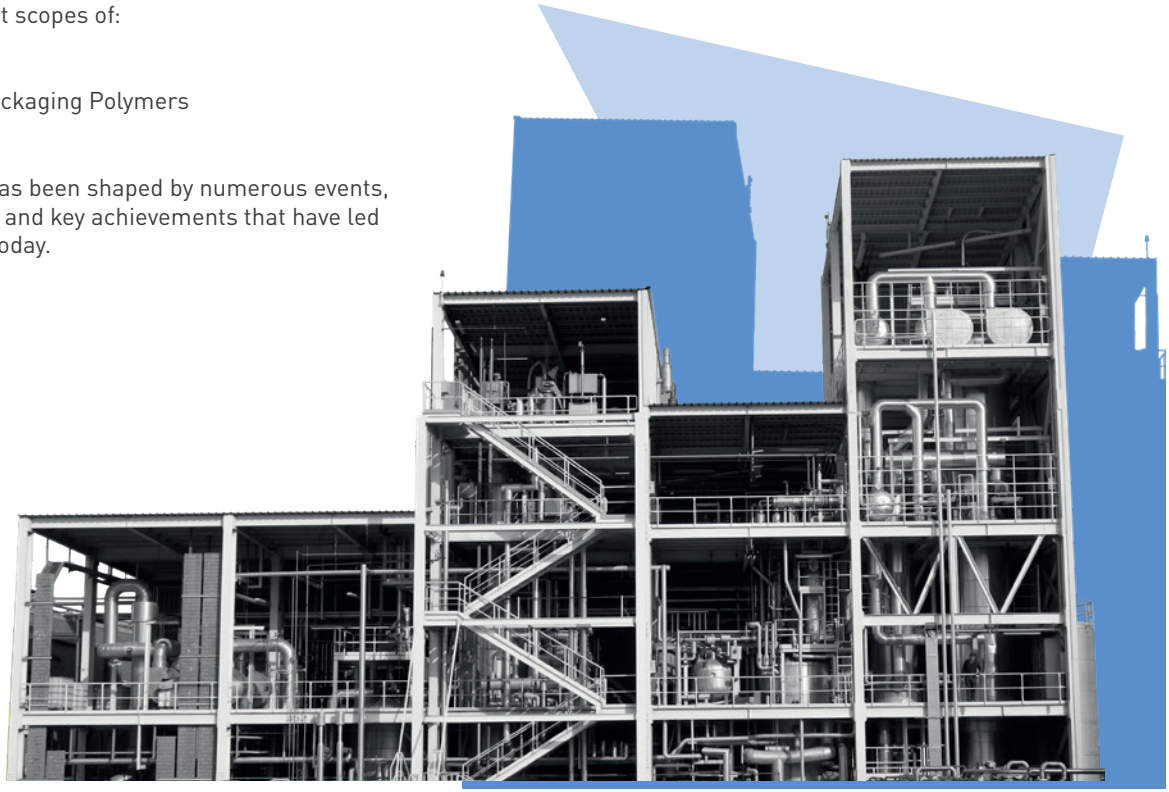
NUREL has gone through various stages since its establishment in 1968 under the name ESSO Fibers, and its acquisition by SAMCA Group in 1999, up to the present day. We have consistently adjusted to the rapid changes observed in our social, economic, and industrial environments.

Nowadays, we have five decades of experience in nylon yarns and polyamide polymers, engineers polymers and, since 2015, also in sustainable biopolymers.

Thanks to the work and effort of all people that belonged and belong to NUREL, we have become a reference in the national and international market scopes of:

- Nylon 6 y 66 Yarns
- Engineering and Packaging Polymers
- Biopolymers

NUREL's development has been shaped by numerous events, changes, investigations, and key achievements that have led to the company we are today.



POLYAMIDE

SUSTAINABILITY

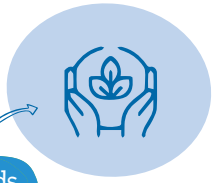
Packaging keeps our food safe and fresh. It ensures that products have a longer shelf life and allows us to minimize food waste.

But certainly, plastics have been overeused and somentimes are not correctly disposed of generating littering.

Focusing towards ECO Design

In a circular economy, every unit of packaging should be recyclable or compostable and, where possible, also reusable. Achieving this requires a combination of redesign and innovation in business models, materials, packaging design and reprocessing technologies.

1 **Your packaging**
Let's define the packaging you wish to replace



2 **Sustainable Goals**
What is the sustainable challenge your packaging needs to overcome?

3 **Solution**
We will propose you a real solution that will adapt to all your requirements

OUR FOCUS IS ON YOUR SUCCESS

RESEARCH & DEVELOPMENT

New Product Development

When developing new products, we begin by considering customer requests, taking into account the end-use of the product, processing methods, and any specific requirements. We then analyze the product definition and utilize our expertise in polymer chemistry to propose a new formulation.

After designing the process from lab scale to industrial scale, we prepare a sample for customer approval. Once we confirm that the material meets the customer's requirements, we proceed with industrial scale production. Our technical capabilities for new product development, combined with our versatility, innovation, and consistent quality, enable us to deliver in a reduced time-to-market.

Characterization Laboratory

Our **laboratory is fully equipped** to achieve a complete mechanical and chemical characterization of every polymer for any application and specifically for packaging applications.. This information helps us to assure the **quality of our products**, and it is also used to **support any customer** project or demand.

Working with our customers at every stage of the process.

Our R&D team works closely with brand owners, packaging manufacturers, packaging designers and converters to develop tailor-made solutions:

- Project definition
- Product modeling
- Pilot prototyping
- Industrial scale-up
- Product approval

Polymerization Facilities

- **Lab-scale polycondensation reactor**: Batch reactor designed for the product definition at lab-scale
- **Pilot-scale polymerization plant:** Universal polymerization pilot plant, integrated by a batch reactor, distillation tower condensers, automatic valves, vacuum line, extrusion and cutting system
- **Solid state post condensation pilot plant:** This equipment is optimum to dry or post-condensate polymers in solid state

Plastics Processing Units

- **Pilot-scale twin screw compounder:** Twin screw extruder designed for the production of plastic compounds, blends and masterbatches. Its main applications are the development of new products and sample production, or small batch production of engineering plastics
- **Injection moulding machine:** Its main function is the production of test samples or small parts
- **Cast and Blown film pilot lines:** Designed for product development and sample production
- **Blown film coextrusion pilot line**
- **Seven layer Blown film water bath pilot line**
- **Pilot thermoforming unit**

HIGH VISCOSITY GRADES FOR PACKAGING

PA 6 & PA 6/66

Expertise in polymerization

NUREL's long-term experience in polymerization processes and polymer modifications have converged to provide a wide portfolio of extrusion grades.

Promyde® PA6 for film extrusion

Promyde PA6 provides excellent gas, flavour and aroma barrier properties, as well as high mechanical and excellent thermoforming functionalities.

Promyde provides a diverse selection of viscosities, ranging from 3.3 to 4.0, coupled with varying degrees of lubrication and nucleation tailored to suit individual packaging structures.

Promyde can be **extruded alone or in combination** with other polymers such as polyethylene, polypropylene or barrier agents, such as EVOH or our new **Enoxite®** solution with excellent Oxigent Transmission Rate values.

Promyde® PA 6/66 Range

In addition to other products, NUREL manufactures **Promyde BF533 and BF540**, which are copolyamide 6/66 grades specifically designed for use in packaging. These grades can be lubricated, extra-lubricated, and nucleated to suit the requirements of each structure, whether for inner or outer layers.

Delivering solutions for any application

Promyde high performance polyamides and copolyamides deliver solutions that can **satisfy the most challenging** requirements such as punction and tear resistance, barrier solutions, sealing, improved transparency and gloss, deep thermoforming and low curling.

Our technology applied to product design allows NUREL to offer specific grades that may be processed either by **cast or blown**, in **monolayer or coextruded** and in **non-oriented or oriented** films.

OVEN BAGS

PROMYDE BF HT

The heat resistant **Promyde** nylon grades for flexible packaging are the materials used in baking bags and oven safe vacuum skin packaging (VSP), perfect for cooking moist, tender meat and vegetables. **Promyde** BF HT packaging is successfully validated in cooked food during 4h up to 205°C.

COPOLYAMIDES

HIGH TECHNICAL PERFORMANCE

TRANSPARENCY, LOW CURLING & DEEP THERMOFORMING SOLUTIONS

PROMYDE® BF933 & BF940

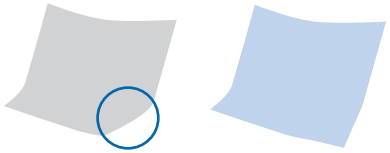
Promyde BF933 and **BF940** are the benchmark for copolyamides in the market. They are an alternative to copolyamide 6/66 and stands out for **eliminating curling**, **Promyde Bf933** and **BF940** are the perfect solution for asymmetric structures.

Promyde BF933 and **BF940** offer several advantages for your films:

- Suitable for pasteurization and retort while maintaining excellent transparency and gloss
- Higher puncture resistance at break than copolyamides 6/66 (>30%)
- Higher oxygen barrier at HR 90 % than PA 6/66

PA6 & PA6/66 Transparency	Promyde BF940 Transparency

Films made of **Promyde BF940LN** present an unique transparency and gloss due to its lower crystallization temperature and speed, especially when used on external layers and retort food treatment processes.



PA6 & PA6/66 Curling	Promyde BF940 Low Curling

Promyde BF940 low crystallization temperature **avoids curling effect** in non-symmetrical multilayer films. As a result, the production process is simpler and more energetically efficient, as there is **no need of water cooling bath.**

PA6 Thermoforming	Promyde BF940 Thermoforming

Due to its improved elongation at break, Promyde BF940 is the material of choice for demanding thermoforming applications such as deep and sharp forms.

OUTSTANDING TEAR RESISTANCE AND LOW MELTING POINT

Promyde® BF642, BF640 and **BF1540** provide excellent transparency and high mechanical properties, especially **tear strength and puncture resistance**, making them the **ideal solution for bone-in meat packaging**.

PROMYDE® BF642

Promyde BF642 is an **alternative to PA6/66/12.** Its main mechanical properties are low modulus, high deformation at break and excellent tear and puncture resistance. These mechanical properties allow deeper thermoforming and higher vacuum forming shrinkage. In addition, **Promyde BF642 is suitable for retort** while maintaining transparency.

Lower melt temperature (185ºC), suitable for coextruded films with temperature sensible polymers such as EVOH.

PROMYDE® BF640

Promyde BF640 has superior mechanical properties and is specially designed for extremely demanding applications.

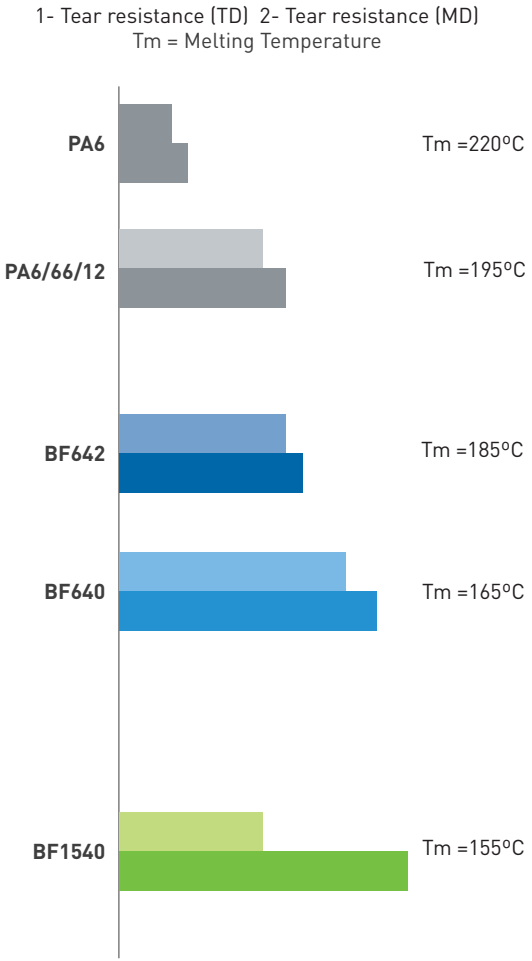
Outstanding tear resistance and better softness of **Promyde BF640** makes it possible to **downgauge the polyamide layer**.

Its low melting point (165ºC) makes this polyamide the right choice for films coextruded with temperature sensitive polymers such as EVOH.
Promyde BF640 provides a 130°C seal, which allows the design of a 100% polyamide monomaterial container.

PROMYDE® BF1540 - BIOBASED POLYAMIDE

Promyde BF1540 is a new bio-based development specially formulated for the production of cast and blown films. The main raw materials are renewable plant-based materials that do not compete with food production, making **Promyde BF1540** a 53% bio-based product, according to method 14C (ASTM D6866-21).

Additionally, the low melting temperature (155ºC) and its outstanding tear resistance properties are secured.



PACKAGING DOWNGAUGING

PLASTIC REDUCTION

BARRIER SOLUTIONS

PROMYDE® BF740

As an alternative to barrier polymers, **Promyde BF740** offers a **higher gas barrier (double than PA6)**, enabling the downgauging of the polyamide layer and increasing the shelf life. This polyamide is suitable for **retort treatments** while maintaining barrier properties, transparency and excellent thermoformability.

The process temperature is 200°C, which facilitates the co-extrusion with other polymers in both blown and cast extrusion.

ENOXITE®

Enoxite is a **high oxygen barrier, water-soluble** (50°C) polymer for multilayer food packaging structures with conventional polymers such as PE, PP, PET or PA.

Enoxite can be processed on conventional EVOH equipment for blown and cast films.

Enoxite in co extrusion with PE **maintains the barrier after pasteurization** (90°C/1h).

60 microns structure: PE/tie/PA/*4 microns barrier layer*/PA/tie/LDPE			
Test	Conditions	PE/tie/PA/***ENOXITE***/PA/tie/PE	PE/tie/PA/***EVOH***/PA/tie/PE
OTR (cc/m² day bar)	50% HR/23°C	0.18	0.56
WVTR (g/m² day)	90% RH/38°C	4.9	4.3

60 microns structure: PE/tie lyer/PA/*ENOXITE/PA (2,5 microns Enoxite)*		
Test		PE/tie layer/PA/***ENOXITE***/PA
OTR (cc/m² day bar)	0% HR/23°C	0,05
	50% HR/23°C	0,32

Processing Temperatures (°C)

Extruder	Extruder Temperature Profile	Die Temperature
LDPE	Standard process temperature	⩽ 250°C
Tie Layer	⩽ 240°C	
PA	Recommend ⩽ 240°C (Maximum process temperatures up to 250°C)	
ENOXITE	190/220/225/230/230 °C	

FOOD WASTE REDUCTION

SHELF LIFE EXTEND

RETORTABLE PACKAGING

PROMYDE® BF745

Retorting is a thermal process where low-acid food and beverages are **heated in sealed packaging** to extend their shelf life.

PA is retort-resistant. However, other plastics regularly used as PE present limited performance. As a result, other materials are evaluated, presenting other restrictions on the sealing temperatures and more difficult processing techniques.

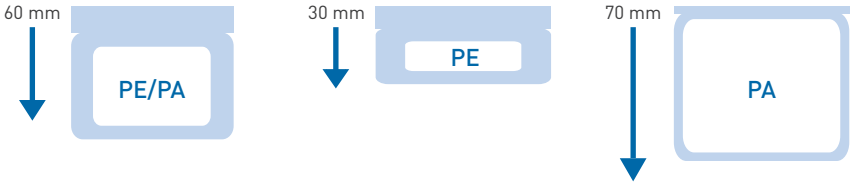
Promyde BF745 is a new copolyamide sealable at 170ºC that **enables the design of a 100% monomaterial PA packaging**, suitable for retorting while maintaining its **transparency and gloss**, higher compared to polyolefin structures, formulated for the production of cast and blown films.

Thermoforming. Successful Case:

Current Structure **PE/PA**:
- **Lid:110 µm**
- **Tray: 300 µm**

Monomaterial **PE**:
- **Lid: 105 µm**
- **Tray: 300 µm**
- **NO OK retort**

Full PA:PA6/BF745:
- **Lid: 50 µm**
- **Tray: 150 µm**
- **OK retort**



Consequently, the packaging is optimized, presenting a thinner structure, that **reduces the quantity of plastic per package** and, thus, waste, taxes, material, logistic costs and greenhouse gases.

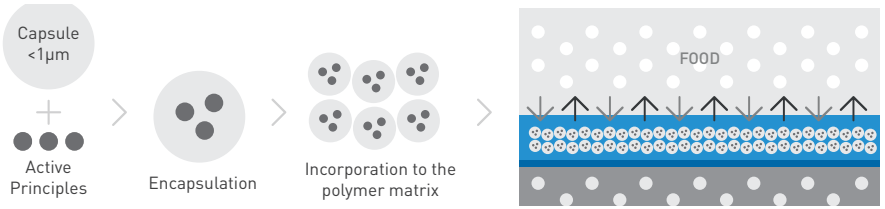
In addition, **Promyde BF745 PA** monomaterial structures have high value after their use, so it is **economically feasible to recycle** them in a closed-loop circuit.

ACTIVE PACKAGING

This innovation extends the shelf life of packed food. The Active Packaging innovation, developed entirely by NUREL, consists of incorporating **encapsulated active principles** into the polymer matrix to provide **antioxidant or antifungal properties**. The capsules can also help to remove, from packed food, undesired substances such as liquids, odors and gases.

As a result, the active packaging technology extends the shelf life of packed food.

Microencapsulation Technology



[1] Active principles are released outside the capsules by air controlled diffusion method (pressure difference inside and outside the capsule). Higher diffusion towards the food side layer occurs due to the food contact and the moisture.
[2] Gas-phase radicals permeate trough film layer containing capsules being stabilized.

SUSTAINABLE PERFORMANCE

RECYCLABILITY

PE/PA RECYCLABLE FILMS

The highlighted features of the complete range of **Promyde copolyamides** contribute to the mechanical recycling of multilayer PE/PA film structures. The **lower copolyamide's melting point** improves the compatibility between both materials.

PROMYDE® BF740

The reduced OTR level, when compared to standard polyamides, allows for the reduction of the film structure and, consequently, the percentage of PA in PE/PA film structures. This enhances their **compatibility with the PE recycling stream.**

PROMYDE® BF640 AND BF642

The remarkable mechanical properties, especially **their tear and puncture resistance**, along with their superior shrinkage and thermoforming capabilities, make it possible to optimize the layer thickness while using less PA. This results in a **reduced amount of PA** used and in turn, enhances the **recycling compatibility of PE/EVOH/PA structures**.

MONOMATERIAL PA PACKAGING

PROMYDE® BF745

Promyde BF745, thanks to its sealing capacity (170°C) **allows us to design 100% Polyamide mono-material packaging**. This is achieved with an outer layer of **Promyde BF745** of 15 microns with the body of the structure made of PA6 or PA6 and **Promyde BF940**.

The 100% Polyamide mono-material structures provide higher gloss and transparency compared to polyolefin structures and are **suitable for retorting while maintaining their transparency.** In addition, they improve shelf life and reduce waste, taxes, logistics costs and greenhouse gases.

Among the possibilities offered by **Promyde BF745** mono-material structures is **closed-loop recycling** with a high recycled product value.

DELAMINATION FOR MONOMATERIAL SEPARATION

ENOXITE®

NUREL has the solution for those multilayer barrier structures that cannot be recycled with the currently available technologies.

Enoxite is a **water-soluble high barrier polymer**, which **can replace EVOH** as it presents equivalent OTR and processing conditions.

Multilayer high barrier packaging structures containing different plastics (PE, PA, PET, PP), including **Enoxite** between them are eligible to delaminate during the water bath step of the recycling stream.

SUSTAINABLE PERFORMANCE

BIO CONTENT SOLUTIONS

BIOBASED

PROMYDE® BF1540 & BF1340

Introducing our latest innovation **Promyde BF1540 & BF1340** a new line of **partially biobased polyamides** that can help reduce dependence on fossil resources. With a renewable content **from 30% up to 53%**. Despite being environmentally conscious, it still maintains exceptional mechanical performance similar to standard polyamides, with the added benefit of **superior tear resistance**.

Melting point (°C)

	PA6	PA6/66	BF1540	BF1340
Melting point (°C)	220	195	155	180

BIOCIRCULAR

PROMYDE® BIO-C

NUREL can now provide a full range of **100% biosourced PA** materials with **ISCC Plus certification**, thanks to the recent introduction of new bio-monomers sourced from cooking oils, vegetable oils, and other sub-materials utilized in the food industry. In addition, these materials will have a reduced carbon footprint, providing further **environmental advantages**.

PROCESS GUIDELINES

CAST EXTRUSION

Cast film extrusion is a continuous operation of **melting one or more polymers through a flat die** to form a film that will be conveyed to successive rollers with different functions (cooling, film finishing, etc.), and finally wound onto a roll.

Typical film thickness ranges are between **20-200 µm and width of 400-3,000 mm**. The film thickness is controlled by the die gap and the extrusion line speed.

Casting Rolls' Temperatures

In cast film the temperature of the casting roll has an important influence on the film properties.

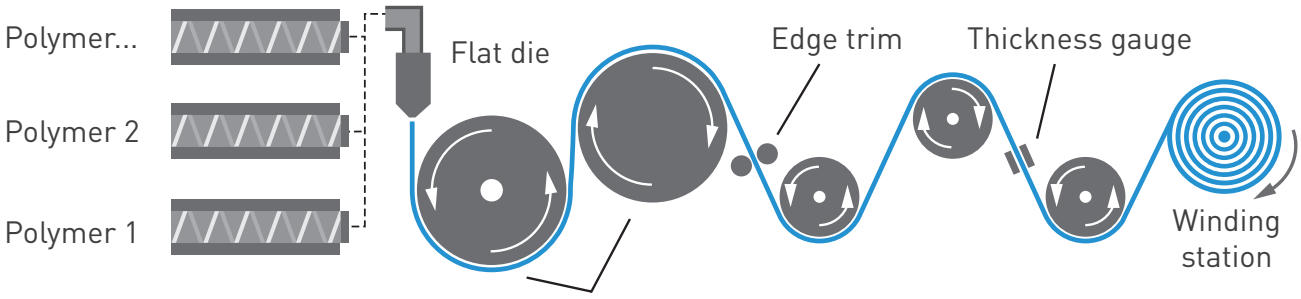
For **films requiring good dimensional stability** and strength, such as lidding films, temperature should be set to **80-120ºC**.

For good **thermoforming and high transparency**, setting to **20-40ºC** is recommended.

PROMYDE® Cast Extrusion Grades
BF33, BF36, BF38, BF40, BF933, BF940, BF640, BF642 BF740 & BF745

*All products can be lubricated (L) and/or nucleated (N).

Multi-layer extrusion



PROCESS GUIDELINES

BLOWN EXTRUSION

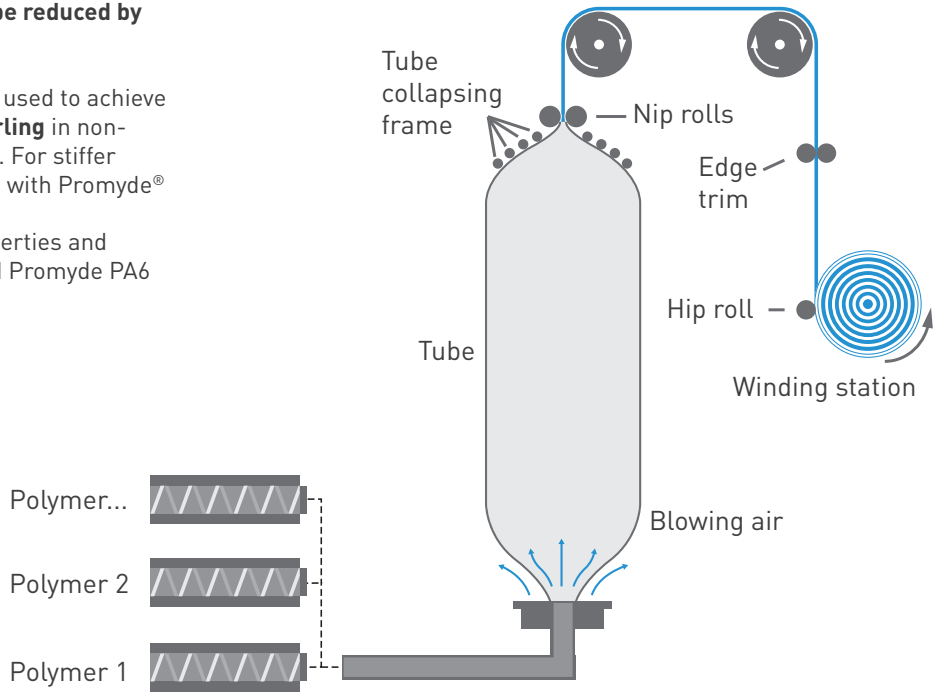
Blown film extrusion is a continuous operation of **melting one or more polymers through a circular die** to form a hollow tube. The tube is expanded with air, collapsed and finally rolled up.

PROMYDE® Blown Extrusion Grades
BF38, BF40, BF933, BF940, BF640, BF645, BF740 & BF745

*All products can be lubricated (L) and/or nucleated (N).

Processing Recommendations

- **Blown-up ratio**: 1.1-3.0
- In asymmetric structures, **curling may be reduced by wetting** the film in a warm water bath.
- Cooling:
  - **Air cooling**: copolyamides are mainly used to achieve **better optical properties and low curling** in non-symmetric structures, like PE/Tie/PA. For stiffer films, copolyamides can be combined with Promyde® PA6.
  - **Water cooling**: for better optical properties and thermoformability. Copolyamides and Promyde PA6 can be used.



PROCESS GUIDELINES

BOPA EXTRUSION

Biaxially Oriented Polyamide (BOPA) films are special structures with high **gas barrier and excellent mechanical properties** (tear and puncture resistance), also achieving thinner thicknesses. It is especially recommended for **frozen packaging, top fill for rigid trays or vacuum packaging applications**.

Processing Recommendations

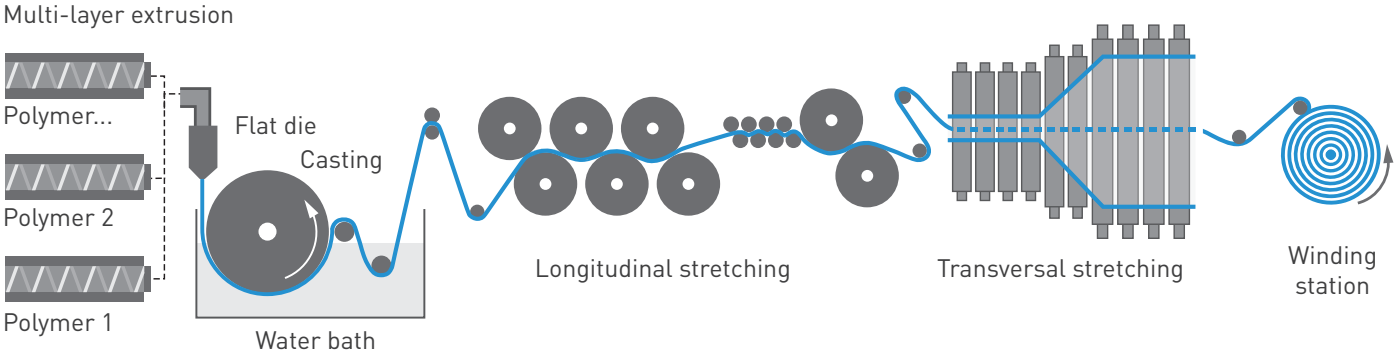
For simultaneous BOPA lines where MD and TD stretching is performed in one step, the use of lubricant is not required. For these applications we advise the use of **Promyde® BF33** or **BF33L**.

A temperature of **45-60ºC is recommended during MD stretching and 75-100ºC during TD stretching**.

BOPA sequential lines first stretch the film in MD and then, on a second step, stretch the film in a transversal direction.

In this case, during MD stretching hydrogen bonds are generated between PA chains. For this reason, we encourage the use of lubricating products to assist the TD stretching (Promyde BF33L).

PROMYDE® BOPA Extrusion Grades
BF33 & BF33L



PROCESS GUIDELINES

THREE BUBBLE EXTRUSION

The main purpose of using three-bubble technology is to get a **good controlled shrinkage** and **improve mechanical properties** of down gauging films. The use of polyamide is mainly recommended for **sausage casings and coextruded for high barrier packaging shrink film**.

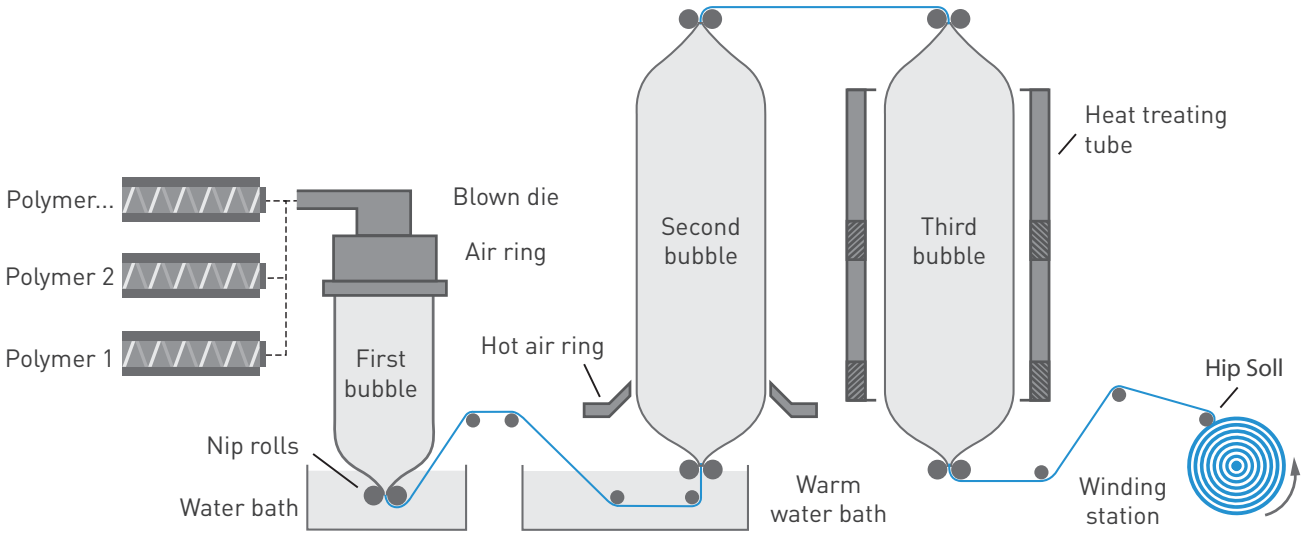
PROMYDE® Three Bubble Extrusion Grades

BF38, BF38L, BF40, BF40L, BF640, BF640L, BF642, BF642L, BF740, BF740L, BF940 & BF940L

Processing Recommendations

First bubble is collapsed and cooled down quickly in order to minimize the crystallization, then the film is warmed up in a hot water bath and then blown and oriented in a second bubble.

In this orientation step, MD: 2.0-3.3 and TD: 2.5-3.8 ratios are recommended. After the second bubble collapses, the annealing step takes place by a third bubble which is maintained at a certain temperature in order to control the % of shrinkage of the final product. **The use of all Promyde Copolyamides and PA6 is granted.**



EXTRUSION & POST-PROCESSING

PROCESSING CONDITIONS

The film extrusion industry demands the **highest quality** polyamide. **Promyde®** delivers the continuous reliability it requires.

Promyde polyamide can be processed either by CAST or BLOWN extrusion for **industrial manufacture of monolayer and multilayer film**, including both non-oriented and biaxially oriented (BOPA) film.

Promyde® is the material of choice for film production that delivers excellent mechanical and barrier properties.

Screw Recommendations

- Standard single-fligther, **three-section screws**.
- Better results can be obtained by using **high performance screws** equipped with shearing and mixing sections.
- The **screw length** should be **at least 24D**, and preferably 28-33D to guarantee optimum plasticizing and conveying with the high through-put rates of film extrusion (D: screw diameter).
- A three-section screw should have a **compression ratio** (ratio of flight depth in the feed section to flight depth in the metering section) **of 3:1 to 4:1**.
- **Screw length sections** (L: overall length of screw):
  - Feed section: 0.25 to 0.30 x L
  - Compression section: 0.15 to 0.25 x L
  - Metering section: 0.40 to 0.55 x L

Processing Temperatures (ºC)

	Extrusion Temperatures (ºC)								
PROPERTY	**BF40 (PA6)**	**BF540 (PA6/66)**	**BF940**	**BF745**	**BF740**	**BF642**	**BF640**	**BF1540**	**BF1340**
Feed section	210-240	210-235	210-235	210-235	170-205	150-190	150-190	150-190	210-235
Compression Section	240-255	240-250	235-245	235-245	200-210	200-220	200	200	235-245
Metering Section	250-260	240-250	245-250	245-250	200-210	200-220	200	200	235-245
Die	250-260	240-250	235-240	235-240	200-210	200-220	200	200	235-245
Melting Temperature	250-260	240-250	245-250	245-250	200-210	200-220	200	200	235-245

Conditioning

Before converting, cutting or laminating a PA film, it should be conditioned.

Polyamide is a hygroscopic polymer that absorbs humidity after being processed. A polyamide film reaches its equilibrium by **storing it in controlled moisture and temperature environment**. Active conditioning techniques such as in-line humidification or water quenching can also be used.

When conditioned, the film will **improve its elastic and thermoformability properties**, and achieves its final dimensions and properties.

Printing and Metallizing

PA films can be also **printed or metalized** without any special treatment. For better results **corona treatment** is recommended.

Life Cycle Assessments

NUREL currently undertakes life cycle analysis of all our products under SimaPro methodology, according to the most recognized international standards.

Handling and Storage

Material is supplied **pre-dried and ready to process**. Bags and containers should be stored in a dry place at room temperature not exceeding twelve months. Material from open or damaged containers should be dried at 75 to 80ºC.

Food Legislation

Promyde® fully complies with EU and FDA regulations related to plastic materials intended to come **into contact with foodstuffs**.

- **EU Regulations**: Regulation (EC) 1935/2004 and Commission Regulation (EU) 10/2011.
- **FDA Regulations**: Compliance with all specifications and limitations stated in USA FDA 21 CFR (B) §177.1500, (a) 6 and (b) 6.1 and 6.2 "Nylon Resins".

For further information, please **contact NUREL's team.**

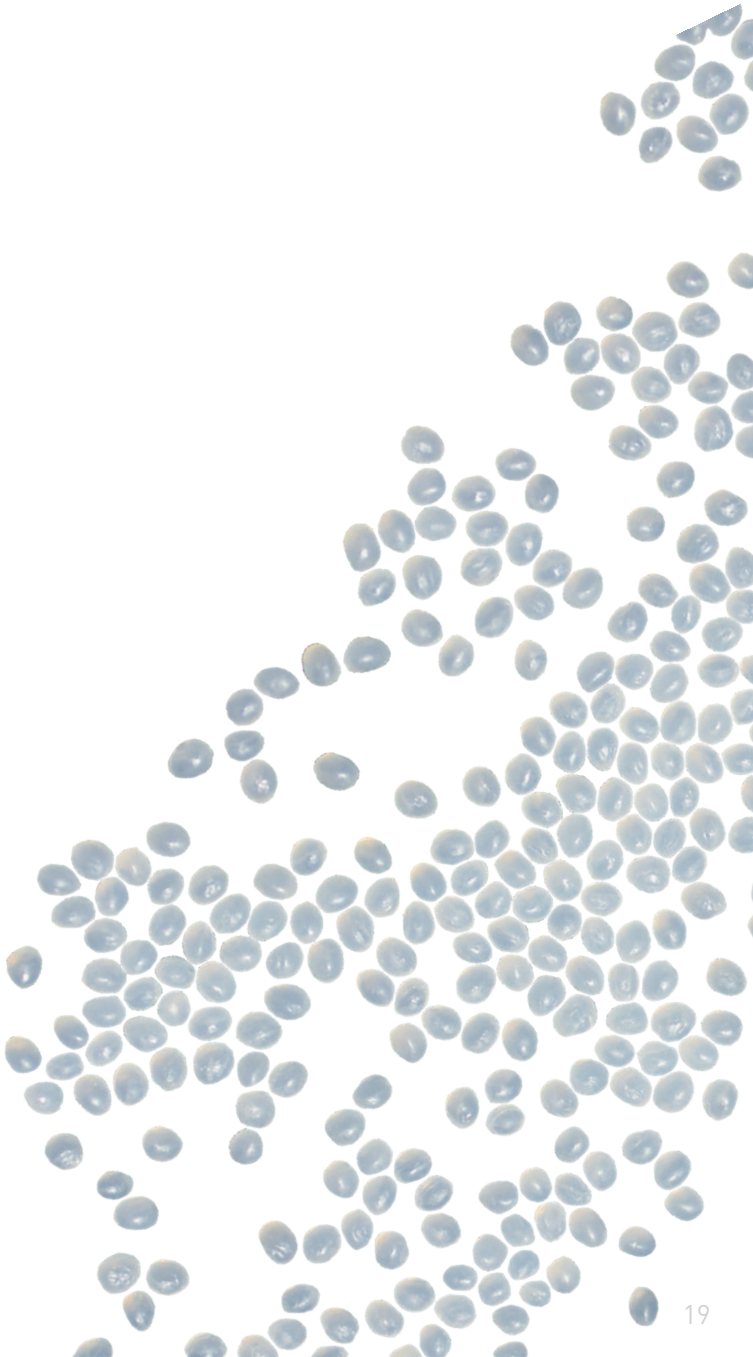
PROPERTIES

COMPARATIVE PROMYDE® POLYAMIDES & COPOLYAMIDES GRADES

	BF40 (PA6) [1]	BF540 (PA6/66) [2]	BF940 [3]	PA 6/66/12	BF642	BF640
Melting Point (°C)	220	195	210	190	185	165
Thickness, microns	50	50	50	50	50	50
Haze, %	11	5	0.8	2	0.7	0.4
Pasteurization Haze, %. 90°C/1h	13	7	1.2	2	0.8	2.5
Retort Haze, %. 121°C/20 min	20	10	1.3	3	1.7	-
OTR, 50%/23°C	12	19	14	33	35	52
OTR, 90%/23°C	39	46	32	74	73	96
WVTR, 85%/23°C	5	5	4	5	5	5
Module MD, MPa	1000	700	1700	760	600	500
Stress at break MD, MPa	50	50	50	50	50	50
Strain at break MD, %	220	265	250	340	350	400
Tear streangth MD, N/mm	21	38	18	46	62	83
Tear streangth TD, N/mm	17	31	16	54	61	72
Puncture energy, mJ	10	10	13	12	13	13
Biobased content (ASTM D6866), %	-	-	-	-	-	-

[1] Promyde PA6 for Packaging. Also available other viscosities: BF33, BF36, BF38
[2] Promyde PA 6/66. Also available viscosity: BF533
[3] Promyde Copolyamide. Also available viscosity: BF933

BF740	BF745	BF1340	BF1540
180	190	180	155
50	50	50	50
1	2	2	2
5	3	2	-
3	5	5	-
7	9	25	30
20	29	-	50
3	3	4	4
1000	1700	1000	400
55	55	50	50
300	290	390	390
18	19	45	50
17	18	60	116
11	10	12	12
-	-	30	50



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PROGRESSING POLYAMIDE

POLYAMIDE 6
FOR PACKAGING & FILM

NUREL
ENGINEERING POLYMERS

INNOVATION IN POLYAMIDE

NUREL ENGINEERING POLYMERS

50 years of polymers production expertise

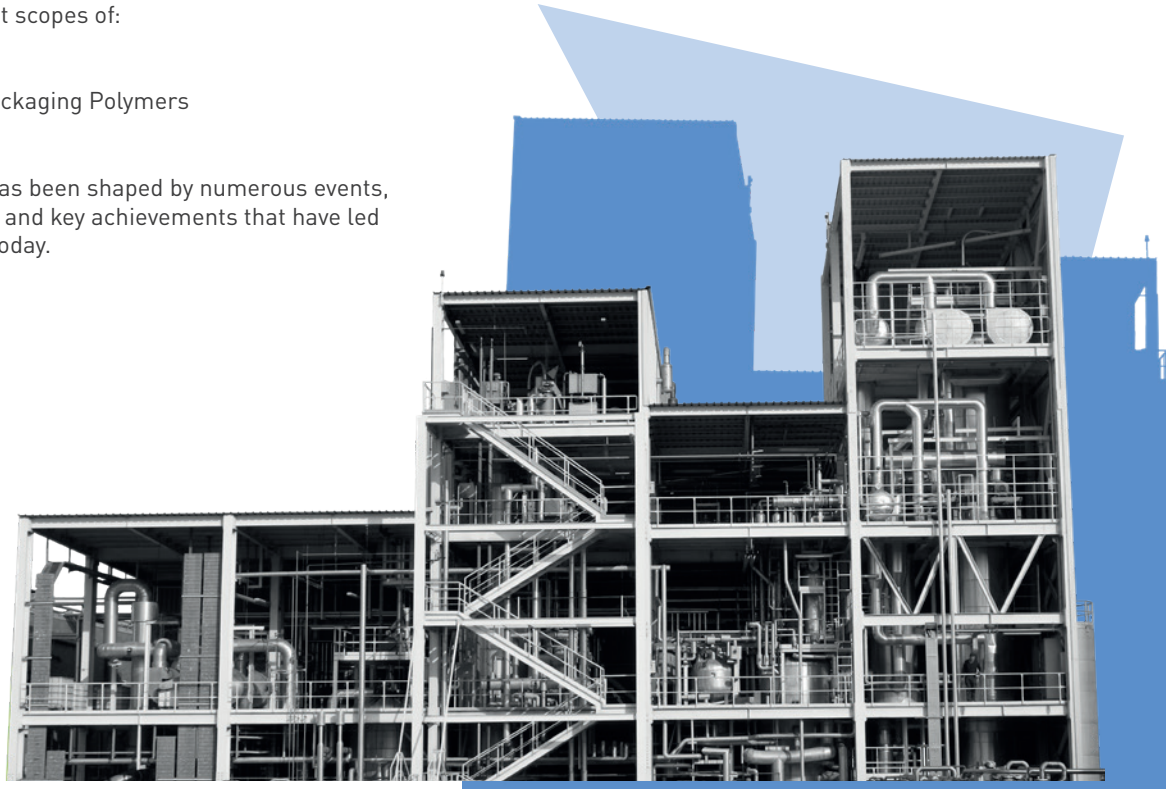
NUREL has gone through various stages since its establishment in 1968 under the name ESSO Fibers, and its acquisition by SAMCA Group in 1999, up to the present day. We have consistently adjusted to the rapid changes observed in our social, economic, and industrial environments.

Nowadays, we have five decades of experience in nylon yarns and polyamide polymers, engineers polymers and, since 2015, also in sustainable biopolymers.

Thanks to the work and effort of all people that belonged and belong to NUREL, we have become a reference in the national and international market scopes of:

- Nylon 6 y 66 Yarns
- Engineering and Packaging Polymers
- Biopolymers

NUREL's development has been shaped by numerous events, changes, investigations, and key achievements that have led to the company we are today.



POLYAMIDE

SUSTAINABILITY

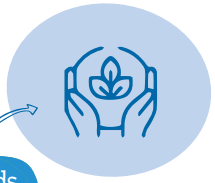
Packaging keeps our food safe and fresh. It ensures that products have a longer shelf life and allows us to minimize food waste.

But certainly, plastics have been overeused and somentimes are not correctly disposed of generating littering.

Focusing towards ECO Design

In a circular economy, every unit of packaging should be recyclable or compostable and, where possible, also reusable. Achieving this requires a combination of redesign and innovation in business models, materials, packaging design and reprocessing technologies.

1 **Your packaging**
Let's define the packaging you wish to replace



2 **Sustainable Goals**
What is the sustainable challenge your packaging needs to overcome?

3 **Solution**
We will propose you a real solution that will adapt to all your requirements

OUR FOCUS IS ON YOUR SUCCESS

RESEARCH & DEVELOPMENT

New Product Development

When developing new products, we begin by considering customer requests, taking into account the end-use of the product, processing methods, and any specific requirements. We then analyze the product definition and utilize our expertise in polymer chemistry to propose a new formulation.

After designing the process from lab scale to industrial scale, we prepare a sample for customer approval. Once we confirm that the material meets the customer's requirements, we proceed with industrial scale production. Our technical capabilities for new product development, combined with our versatility, innovation, and consistent quality, enable us to deliver in a reduced time-to-market.

Characterization Laboratory

Our **laboratory is fully equipped** to achieve a complete mechanical and chemical characterization of every polymer for any application and specifically for packaging applications.. This information helps us to assure the **quality of our products**, and it is also used to **support any customer** project or demand.

Working with our customers at every stage of the process.

Our R&D team works closely with brand owners, packaging manufacturers, packaging designers and converters to develop tailor-made solutions:

- Project definition
- Product modeling
- Pilot prototyping
- Industrial scale-up
- Product approval

Polymerization Facilities

- **Lab-scale polycondensation reactor**: Batch reactor designed for the product definition at lab-scale
- **Pilot-scale polymerization plant:** Universal polymerization pilot plant, integrated by a batch reactor, distillation tower condensers, automatic valves, vacuum line, extrusion and cutting system
- **Solid state post condensation pilot plant:** This equipment is optimum to dry or post-condensate polymers in solid state

Plastics Processing Units

- **Pilot-scale twin screw compounder:** Twin screw extruder designed for the production of plastic compounds, blends and masterbatches. Its main applications are the development of new products and sample production, or small batch production of engineering plastics
- **Injection moulding machine:** Its main function is the production of test samples or small parts
- **Cast and Blown film pilot lines:** Designed for product development and sample production
- **Blown film coextrusion pilot line**
- **Seven layer Blown film water bath pilot line**
- **Pilot thermoforming unit**

HIGH VISCOSITY GRADES FOR PACKAGING

PA 6 & PA 6/66

Expertise in polymerization

NUREL's long-term experience in polymerization processes and polymer modifications have converged to provide a wide portfolio of extrusion grades.

Promyde® PA6 for film extrusion

Promyde PA6 provides excellent gas, flavour and aroma barrier properties, as well as high mechanical and excellent thermoforming functionalities.

Promyde provides a diverse selection of viscosities, ranging from 3.3 to 4.0, coupled with varying degrees of lubrication and nucleation tailored to suit individual packaging structures.

Promyde can be **extruded alone or in combination** with other polymers such as polyethylene, polypropylene or barrier agents, such as EVOH or our new **Enoxite®** solution with excellent Oxigent Transmission Rate values.

Promyde® PA 6/66 Range

In addition to other products, NUREL manufactures **Promyde BF533 and BF540**, which are copolyamide 6/66 grades specifically designed for use in packaging. These grades can be lubricated, extra-lubricated, and nucleated to suit the requirements of each structure, whether for inner or outer layers.

Delivering solutions for any application

Promyde high performance polyamides and copolyamides deliver solutions that can **satisfy the most challenging** requirements such as punction and tear resistance, barrier solutions, sealing, improved transparency and gloss, deep thermoforming and low curling.

Our technology applied to product design allows NUREL to offer specific grades that may be processed either by **cast or blown**, in **monolayer or coextruded** and in **non-oriented or oriented** films.

OVEN BAGS

PROMYDE BF HT

The heat resistant **Promyde** nylon grades for flexible packaging are the materials used in baking bags and oven safe vacuum skin packaging (VSP), perfect for cooking moist, tender meat and vegetables. **Promyde** BF HT packaging is successfully validated in cooked food during 4h up to 205°C.

COPOLYAMIDES

HIGH TECHNICAL PERFORMANCE

TRANSPARENCY, LOW CURLING & DEEP THERMOFORMING SOLUTIONS

PROMYDE® BF933 & BF940

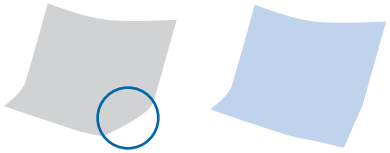
Promyde BF933 and **BF940** are the benchmark for copolyamides in the market. They are an alternative to copolyamide 6/66 and stands out for **eliminating curling**, **Promyde Bf933** and **BF940** are the perfect solution for asymmetric structures.

Promyde BF933 and **BF940** offer several advantages for your films:

- Suitable for pasteurization and retort while maintaining excellent transparency and gloss
- Higher puncture resistance at break than copolyamides 6/66 (>30%)
- Higher oxygen barrier at HR 90 % than PA 6/66

PA6 & PA6/66 Transparency	Promyde BF940 Transparency

Films made of **Promyde BF940LN** present an unique transparency and gloss due to its lower crystallization temperature and speed, especially when used on external layers and retort food treatment processes.



PA6 & PA6/66 Curling	Promyde BF940 Low Curling

Promyde BF940 low crystallization temperature **avoids curling effect** in non-symmetrical multilayer films. As a result, the production process is simpler and more energetically efficient, as there is **no need of water cooling bath.**

PA6 Thermoforming	Promyde BF940 Thermoforming

Due to its improved elongation at break, Promyde BF940 is the material of choice for demanding thermoforming applications such as deep and sharp forms.

OUTSTANDING TEAR RESISTANCE AND LOW MELTING POINT

Promyde® BF642, BF640 and **BF1540** provide excellent transparency and high mechanical properties, especially **tear strength and puncture resistance**, making them the **ideal solution for bone-in meat packaging**.

PROMYDE® BF642

Promyde BF642 is an **alternative to PA6/66/12.** Its main mechanical properties are low modulus, high deformation at break and excellent tear and puncture resistance. These mechanical properties allow deeper thermoforming and higher vacuum forming shrinkage. In addition, **Promyde BF642 is suitable for retort** while maintaining transparency.

Lower melt temperature (185ºC), suitable for coextruded films with temperature sensible polymers such as EVOH.

Promyde BF640 has superior mechanical properties and is specially designed for extremely demanding applications.

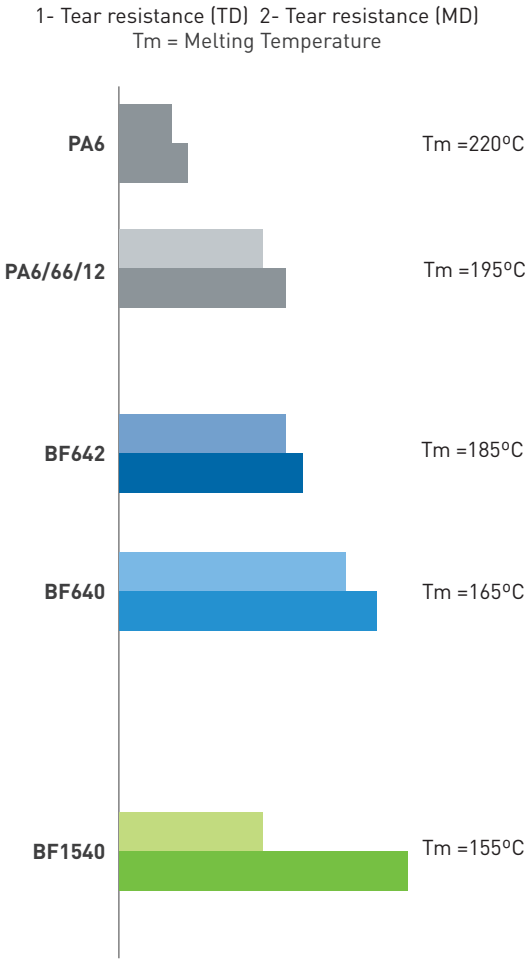
Outstanding tear resistance and better softness of **Promyde BF640** makes it possible to **downgauge the polyamide layer**.

Its low melting point (165ºC) makes this polyamide the right choice for films coextruded with temperature sensitive polymers such as EVOH.
Promyde BF640 provides a 130°C seal, which allows the design of a 100% polyamide monomaterial container.

PROMYDE® BF1540 - BIOBASED POLYAMIDE

Promyde BF1540 is a new bio-based development specially formulated for the production of cast and blown films. The main raw materials are renewable plant-based materials that do not compete with food production, making **Promyde BF1540** a 53% bio-based product, according to method 14C (ASTM D6866-21).

Additionally, the low melting temperature (155ºC) and its outstanding tear resistance properties are secured.



PACKAGING DOWNGAUGING

PLASTIC REDUCTION

BARRIER SOLUTIONS

PROMYDE® BF740

As an alternative to barrier polymers, **Promyde BF740** offers a **higher gas barrier (double than PA6)**, enabling the downgauging of the polyamide layer and increasing the shelf life. This polyamide is suitable for **retort treatments** while maintaining barrier properties, transparency and excellent thermoformability.

The process temperature is 200°C, which facilitates the co-extrusion with other polymers in both blown and cast extrusion.

ENOXITE®

Enoxite is a **high oxygen barrier, water-soluble** (50°C) polymer for multilayer food packaging structures with conventional polymers such as PE, PP, PET or PA.

Enoxite can be processed on conventional EVOH equipment for blown and cast films.

Enoxite in co extrusion with PE **maintains the barrier after pasteurization** (90°C/1h).

60 microns structure: PE/tie/PA/*4 microns barrier layer*/PA/tie/LDPE			
Test	Conditions	PE/tie/PA/***ENOXITE***/PA/tie/PE	PE/tie/PA/***EVOH***/PA/tie/PE
OTR (cc/m² day bar)	50% HR/23°C	0.18	0.56
WVTR (g/m² day)	90% RH/38°C	4.9	4.3

60 microns structure: PE/tie lyer/PA/*ENOXITE/PA (2,5 microns Enoxite)*		
Test		PE/tie layer/PA/***ENOXITE***/PA
OTR (cc/m² day bar)	0% HR/23°C	0,05
	50% HR/23°C	0,32

Processing Temperatures (°C)

Extruder	Extruder Temperature Profile	Die Temperature
LDPE	Standard process temperature	⩽ 250°C
Tie Layer	⩽ 240°C	
PA	Recommend ⩽ 240°C (Maximum process temperatures up to 250°C)	
ENOXITE	190/220/225/230/230 °C	

FOOD WASTE REDUCTION

SHELF LIFE EXTEND

RETORTABLE PACKAGING

PROMYDE® BF745

Retorting is a thermal process where low-acid food and beverages are **heated in sealed packaging** to extend their shelf life.

PA is retort-resistant. However, other plastics regularly used as PE present limited performance. As a result, other materials are evaluated, presenting other restrictions on the sealing temperatures and more difficult processing techniques.

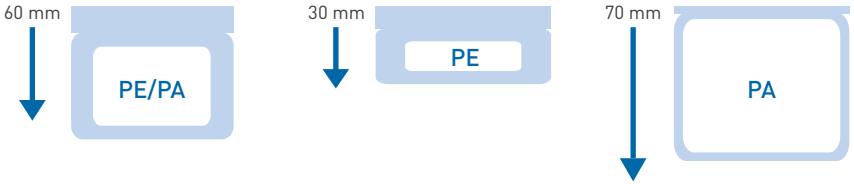
Promyde BF745 is a new copolyamide sealable at 170ºC that **enables the design of a 100% monomaterial PA packaging**, suitable for retorting while maintaining its **transparency and gloss**, higher compared to polyolefin structures, formulated for the production of cast and blown films.

Thermoforming. Successful Case:

Current Structure **PE/PA**:
- **Lid:110 µm**
- **Tray: 300 µm**

Monomaterial **PE**:
- **Lid: 105 µm**
- **Tray: 300 µm**
- **NO OK retort**

Full PA:PA6/BF745:
- **Lid: 50 µm**
- **Tray: 150 µm**
- **OK retort**



Consequently, the packaging is optimized, presenting a thinner structure, that **reduces the quantity of plastic per package** and, thus, waste, taxes, material, logistic costs and greenhouse gases.

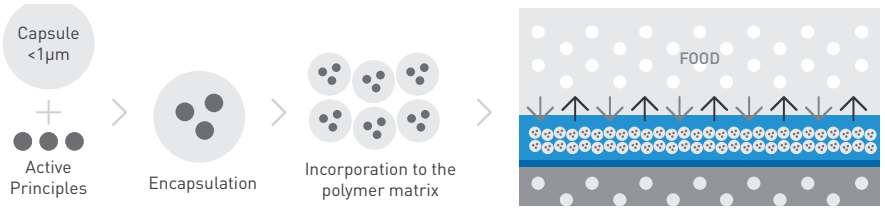
In addition, **Promyde BF745 PA** monomaterial structures have high value after their use, so it is **economically feasible to recycle** them in a closed-loop circuit.

ACTIVE PACKAGING

This innovation extends the shelf life of packed food. The Active Packaging innovation, developed entirely by NUREL, consists of incorporating **encapsulated active principles** into the polymer matrix to provide **antioxidant or antifungal properties**. The capsules can also help to remove, from packed food, undesired substances such as liquids, odors and gases.

As a result, the active packaging technology extends the shelf life of packed food.

Microencapsulation Technology



[1] Active principles are released outside the capsules by air controlled diffusion method (pressure difference inside and outside the capsule). Higher diffusion towards the food side layer occurs due to the food contact and the moisture.
[2] Gas-phase radicals permeate trough film layer containing capsules being stabilized.

SUSTAINABLE PERFORMANCE

RECYCLABILITY

PE/PA RECYCLABLE FILMS

The highlighted features of the complete range of **Promyde copolyamides** contribute to the mechanical recycling of multilayer PE/PA film structures. The **lower copolyamide's melting point** improves the compatibility between both materials.

PROMYDE® BF740

The reduced OTR level, when compared to standard polyamides, allows for the reduction of the film structure and, consequently, the percentage of PA in PE/PA film structures. This enhances their **compatibility with the PE recycling stream.**

PROMYDE® BF640 AND BF642

The remarkable mechanical properties, especially **their tear and puncture resistance**, along with their superior shrinkage and thermoforming capabilities, make it possible to optimize the layer thickness while using less PA. This results in a **reduced amount of PA** used and in turn, enhances the **recycling compatibility of PE/EVOH/PA structures**.

MONOMATERIAL PA PACKAGING

PROMYDE® BF745

Promyde BF745, thanks to its sealing capacity (170°C) **allows us to design 100% Polyamide mono-material packaging**. This is achieved with an outer layer of **Promyde BF745** of 15 microns with the body of the structure made of PA6 or PA6 and **Promyde BF940**.

The 100% Polyamide mono-material structures provide higher gloss and transparency compared to polyolefin structures and are **suitable for retorting while maintaining their transparency.** In addition, they improve shelf life and reduce waste, taxes, logistics costs and greenhouse gases.

Among the possibilities offered by **Promyde BF745** mono-material structures is **closed-loop recycling** with a high recycled product value.

DELAMINATION FOR MONOMATERIAL SEPARATION

ENOXITE®

NUREL has the solution for those multilayer barrier structures that cannot be recycled with the currently available technologies.

Enoxite is a **water-soluble high barrier polymer**, which **can replace EVOH** as it presents equivalent OTR and processing conditions.

Multilayer high barrier packaging structures containing different plastics (PE, PA, PET, PP), including **Enoxite** between them are eligible to delaminate during the water bath step of the recycling stream.

SUSTAINABLE PERFORMANCE

BIO CONTENT SOLUTIONS

BIOBASED

PROMYDE® BF1540 & BF1340

Introducing our latest innovation **Promyde BF1540 & BF1340** a new line of **partially biobased polyamides** that can help reduce dependence on fossil resources. With a renewable content **from 30% up to 53%**. Despite being environmentally conscious, it still maintains exceptional mechanical performance similar to standard polyamides, with the added benefit of **superior tear resistance**.

Melting point (°C)

	PA6	PA6/66	BF1540	BF1340
Melting point (°C)	220	195	155	180

BIOCIRCULAR

PROMYDE® BIO-C

NUREL can now provide a full range of **100% biosourced PA** materials with **ISCC Plus certification**, thanks to the recent introduction of new bio-monomers sourced from cooking oils, vegetable oils, and other sub-materials utilized in the food industry. In addition, these materials will have a reduced carbon footprint, providing further **environmental advantages**.

PROCESS GUIDELINES

CAST EXTRUSION

Cast film extrusion is a continuous operation of **melting one or more polymers through a flat die** to form a film that will be conveyed to successive rollers with different functions (cooling, film finishing, etc.), and finally wound onto a roll.

Typical film thickness ranges are between **20-200 µm and width of 400-3,000 mm**. The film thickness is controlled by the die gap and the extrusion line speed.

Casting Rolls' Temperatures

In cast film the temperature of the casting roll has an important influence on the film properties.

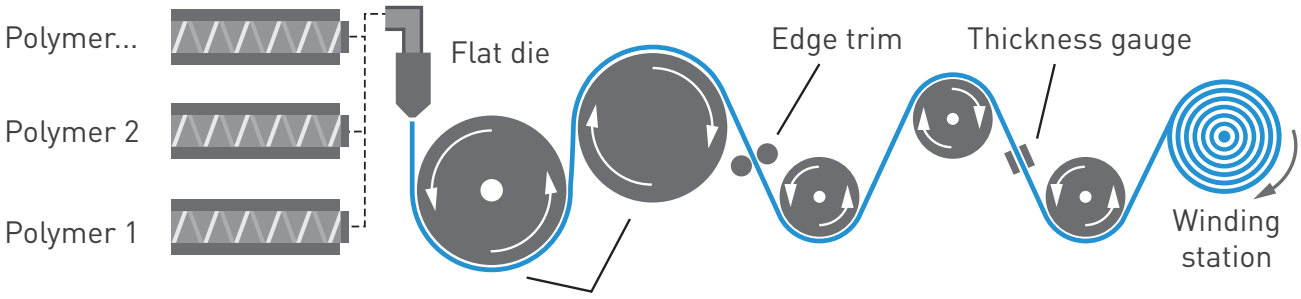
For **films requiring good dimensional stability** and strength, such as lidding films, temperature should be set to **80-120ºC**.

For good **thermoforming and high transparency**, setting to **20-40ºC** is recommended.

PROMYDE® Cast Extrusion Grades
BF33, BF36, BF38, BF40, BF933, BF940, BF640, BF642 BF740 & BF745

*All products can be lubricated (L) and/or nucleated (N).

Multi-layer extrusion



PROCESS GUIDELINES

BLOWN EXTRUSION

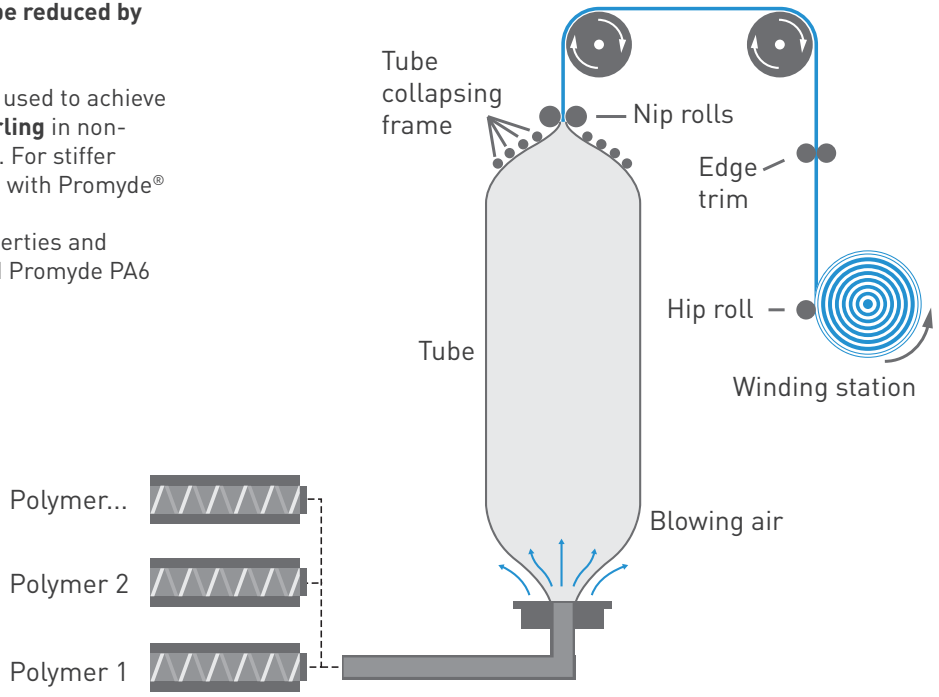
Blown film extrusion is a continuous operation of **melting one or more polymers through a circular die** to form a hollow tube. The tube is expanded with air, collapsed and finally rolled up.

PROMYDE® Blown Extrusion Grades
BF38, BF40, BF933, BF940, BF640, BF645, BF740 & BF745

*All products can be lubricated (L) and/or nucleated (N).

Processing Recommendations

- **Blown-up ratio**: 1.1-3.0
- In asymmetric structures, **curling may be reduced by wetting** the film in a warm water bath.
- Cooling:
  - **Air cooling**: copolyamides are mainly used to achieve **better optical properties and low curling** in non-symmetric structures, like PE/Tie/PA. For stiffer films, copolyamides can be combined with Promyde® PA6.
  - **Water cooling**: for better optical properties and thermoformability. Copolyamides and Promyde PA6 can be used.



PROCESS GUIDELINES

BOPA EXTRUSION

Biaxially Oriented Polyamide (BOPA) films are special structures with high **gas barrier and excellent mechanical properties** (tear and puncture resistance), also achieving thinner thicknesses. It is especially recommended for **frozen packaging, top fill for rigid trays or vacuum packaging applications**.

Processing Recommendations

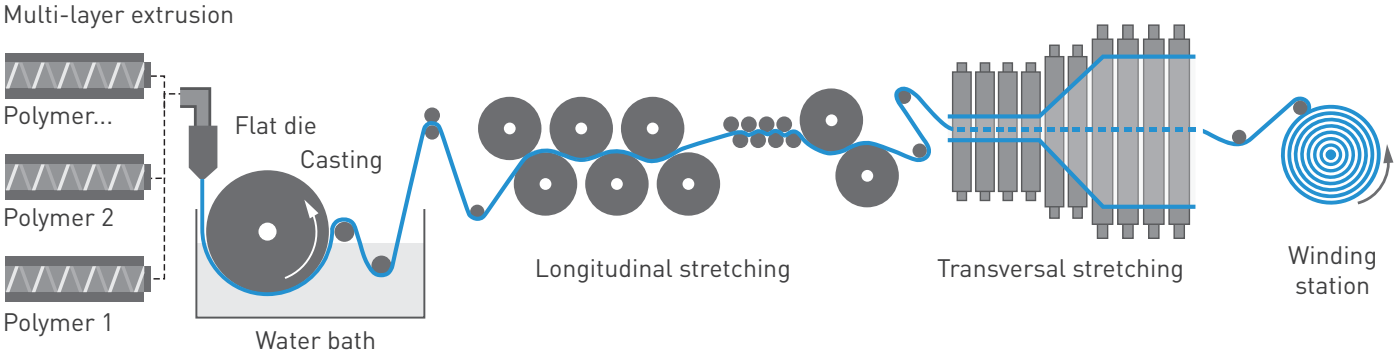
For simultaneous BOPA lines where MD and TD stretching is performed in one step, the use of lubricant is not required. For these applications we advise the use of **Promyde® BF33** or **BF33L**.

A temperature of **45-60ºC is recommended during MD stretching and 75-100ºC during TD stretching**.

BOPA sequential lines first stretch the film in MD and then, on a second step, stretch the film in a transversal direction.

In this case, during MD stretching hydrogen bonds are generated between PA chains. For this reason, we encourage the use of lubricating products to assist the TD stretching (Promyde BF33L).

PROMYDE® BOPA Extrusion Grades
BF33 & BF33L



PROCESS GUIDELINES

THREE BUBBLE EXTRUSION

The main purpose of using three-bubble technology is to get a **good controlled shrinkage** and **improve mechanical properties** of down gauging films. The use of polyamide is mainly recommended for **sausage casings and coextruded for high barrier packaging shrink film**.

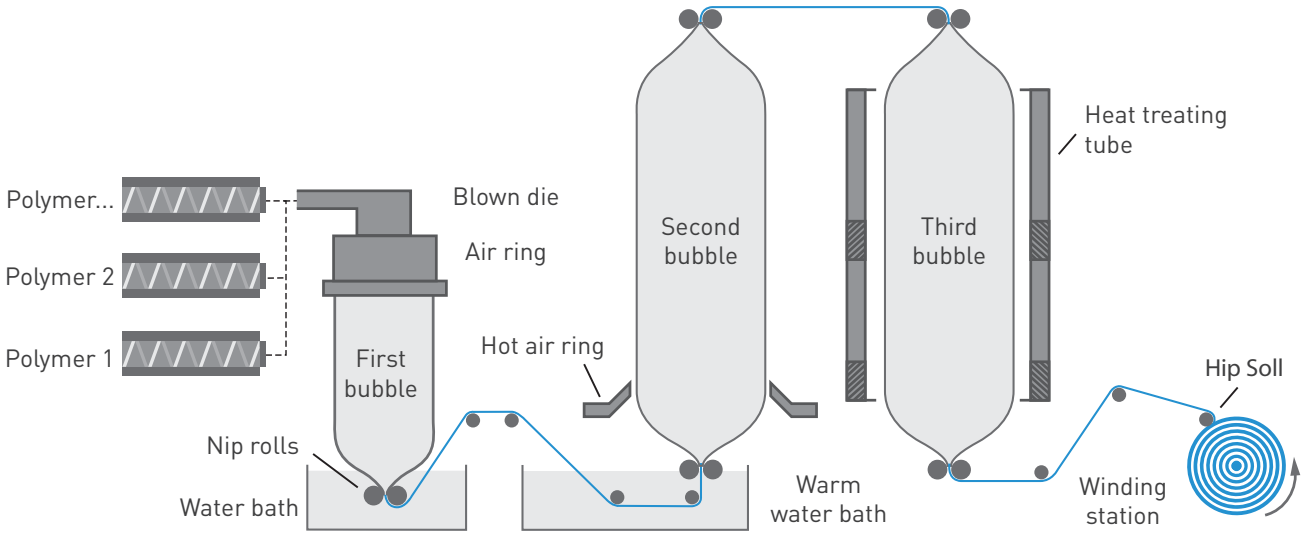
PROMYDE® Three Bubble Extrusion Grades

BF38, BF38L, BF40, BF40L, BF640, BF640L, BF642, BF642L, BF740, BF740L, BF940 & BF940L

Processing Recommendations

First bubble is collapsed and cooled down quickly in order to minimize the crystallization, then the film is warmed up in a hot water bath and then blown and oriented in a second bubble.

In this orientation step, MD: 2.0-3.3 and TD: 2.5-3.8 ratios are recommended. After the second bubble collapses, the annealing step takes place by a third bubble which is maintained at a certain temperature in order to control the % of shrinkage of the final product. **The use of all Promyde Copolyamides and PA6 is granted.**



EXTRUSION & POST-PROCESSING

PROCESSING CONDITIONS

The film extrusion industry demands the **highest quality** polyamide. **Promyde®** delivers the continuous reliability it requires.

Promyde polyamide can be processed either by CAST or BLOWN extrusion for **industrial manufacture of monolayer and multilayer film**, including both non-oriented and biaxially oriented (BOPA) film.

Promyde® is the material of choice for film production that delivers excellent mechanical and barrier properties.

Screw Recommendations

- Standard single-fligther, **three-section screws**.
- Better results can be obtained by using **high performance screws** equipped with shearing and mixing sections.
- The **screw length** should be **at least 24D**, and preferably 28-33D to guarantee optimum plasticizing and conveying with the high through-put rates of film extrusion (D: screw diameter).
- A three-section screw should have a **compression ratio** (ratio of flight depth in the feed section to flight depth in the metering section) **of 3:1 to 4:1**.
- **Screw length sections** (L: overall length of screw):
  - Feed section: 0.25 to 0.30 x L
  - Compression section: 0.15 to 0.25 x L
  - Metering section: 0.40 to 0.55 x L

Processing Temperatures (ºC)

	Extrusion Temperatures (ºC)								
PROPERTY	**BF40 (PA6)**	**BF540 (PA6/66)**	**BF940**	**BF745**	**BF740**	**BF642**	**BF640**	**BF1540**	**BF1340**
Feed section	210-240	210-235	210-235	210-235	170-205	150-190	150-190	150-190	210-235
Compression Section	240-255	240-250	235-245	235-245	200-210	200-220	200	200	235-245
Metering Section	250-260	240-250	245-250	245-250	200-210	200-220	200	200	235-245
Die	250-260	240-250	235-240	235-240	200-210	200-220	200	200	235-245
Melting Temperature	250-260	240-250	245-250	245-250	200-210	200-220	200	200	235-245

Conditioning

Before converting, cutting or laminating a PA film, it should be conditioned.

Polyamide is a hygroscopic polymer that absorbs humidity after being processed. A polyamide film reaches its equilibrium by **storing it in controlled moisture and temperature environment**. Active conditioning techniques such as in-line humidification or water quenching can also be used.

When conditioned, the film will **improve its elastic and thermoformability properties**, and achieves its final dimensions and properties.

Printing and Metallizing

PA films can be also **printed or metalized** without any special treatment. For better results **corona treatment** is recommended.

Life Cycle Assessments

NUREL currently undertakes life cycle analysis of all our products under SimaPro methodology, according to the most recognized international standards.

Handling and Storage

Material is supplied **pre-dried and ready to process**. Bags and containers should be stored in a dry place at room temperature not exceeding twelve months. Material from open or damaged containers should be dried at 75 to 80ºC.

Food Legislation

Promyde® fully complies with EU and FDA regulations related to plastic materials intended to come **into contact with foodstuffs**.

- **EU Regulations**: Regulation (EC) 1935/2004 and Commission Regulation (EU) 10/2011.
- **FDA Regulations**: Compliance with all specifications and limitations stated in USA FDA 21 CFR (B) §177.1500, (a) 6 and (b) 6.1 and 6.2 "Nylon Resins".

For further information, please **contact NUREL's team.**

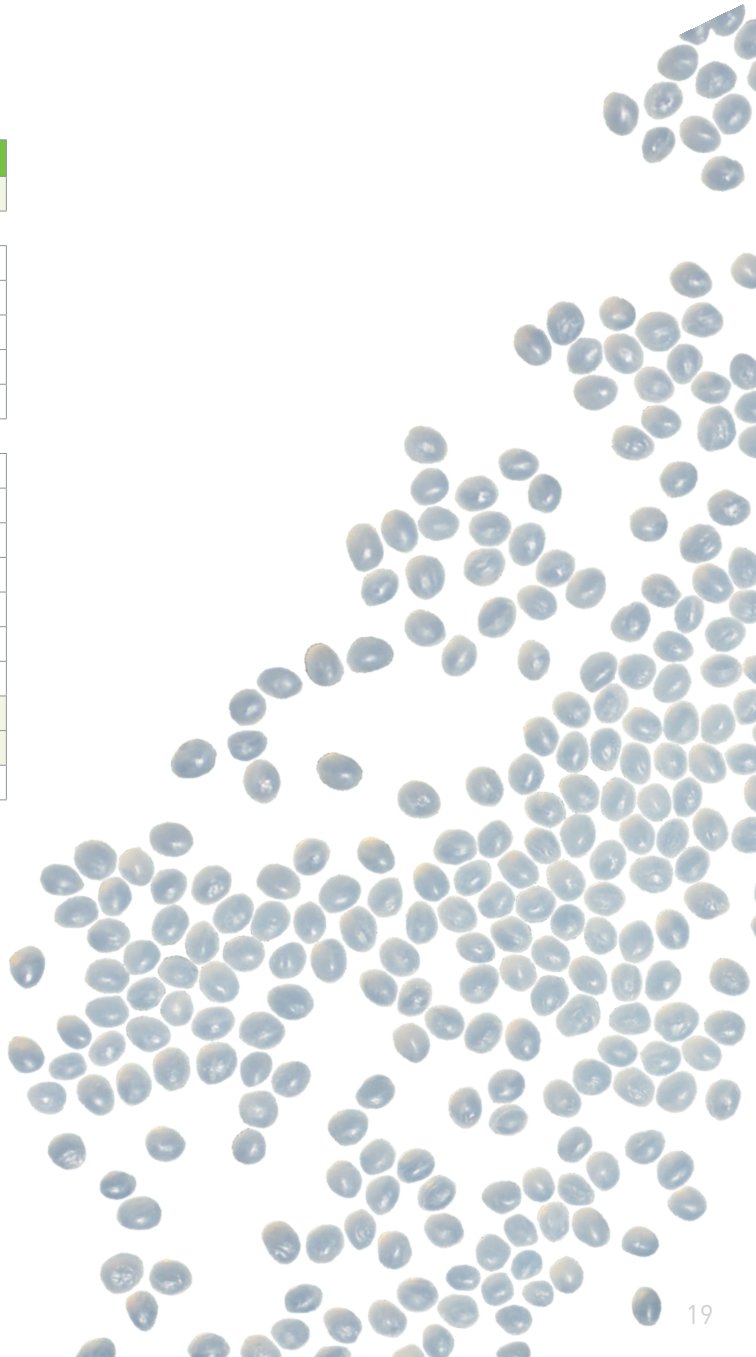
PROPERTIES

COMPARATIVE PROMYDE® POLYAMIDES & COPOLYAMIDES GRADES

	PA6	BF940	BF540	PA 6/66/12	BF642	BF740
Melting Point (°C)	220	210	195	190	185	180
Thickness, microns	50	50	50	50	50	50
Haze, %	11	0.8	2	2	0.7	1
Pasteurization Haze, %. 90°C/1h	13	1.2	4	2	0.8	5
Retort Haze, %. 121°C/20 min	20	1.3	5.4	3	1.7	3
OTR, 50%/23°C	12	14	19	33	35	7
OTR, 90%/23°C	39	32	55	74	73	20
WVTR, 85%/23°C	5	4	5	5	5	3
Module MD, MPa	1000	1700	740	760	600	1800
Stress at break MD, MPa	50	50	50	50	50	55
Strain at break MD, %	220	250	300	340	350	300
Tear streangth MD, N/mm	21	18	37	46	62	18
Tear streangth TD, N/mm	17	16	38	54	61	17
Puncture energy, mJ	10	13	12	12	13	11

[1] Promyde PA6 for Packaging. Also available other viscosities: BF33, BF36, BF38
[2] Promyde PA 6/66. Also available viscosity: BF533
[3] Promyde Copolyamide. Also available viscosity: BF933

BF740	BF745	BF1340	BF1540
180	190	180	155
50	50	50	50
1	2	2	2
5	3	2	-
3	5	5	-
7	9	25	30
20	29	-	50
3	3	4	4
1000	1700	1000	400
55	55	50	50
300	290	390	390
18	19	45	50
17	18	60	116
11	10	12	12



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