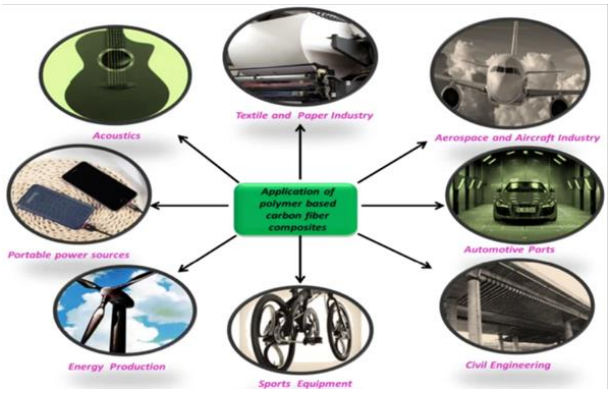
What are POLYMERS about?













Published in 2021

Table of **Contents**

Table of Contents

A) Few words about LIGHTHOUSE training program 2
B) Basic definition: what is a polymer? 3
C) Industrial process for production of polymers (polyethylene) 4
D) Top plastics and resins global producers 6

- Dow Chemical 6
- Lyondell Basell 6
- Exxon Mobil 6
- SABIC 6
- INEOS 7
- BASF 7
- ENI 7
- LG Chem 7
- Chevron Phillips 7
- Lanxess 7

E) As an example, BASF business segments 9
F) Petrochemical industry in the Middle-East 10

- Oman 10
- Saudi arabia 10
- Iran 11
- Qatar 11
- Kuwait 11
- Other petrochemical producer and consumer markets 12

G) Two main groups of polymers: natural and synthetic 13
H) Polymerization and polymer characterization 14

- Polymer classification 14

I) Heating polymers 15

- Thermoplastics: 15
- Thermosets: 16

J) Polymer uses: plastic characterization 17
K) Plastics' use and identification 18
L) Polymer uses: additives, compounds and masterbatches 20
M) Polymer market highlights 22
N) Global Packaging Materials Market 23
O) Pathwel products 25

- Pathwel products Technical datasheet: INNOSLIP O 26
- Pathwel products Technical datasheet: INNOSLIP E 28

P) Polymer technical glossary 30
Q) Interesting sources 33

A) Few words about LIGHTHOUSE training program

From its inception, First Maritime Company is committed to meet the highest professional standards. This hails from the strong belief that working habits and processes, based on mindful and demonstrated standards, generate corporate value and definitely help at reaching business targets.
The LIGHTHOUSE training program is a tool used by First Maritime staff members to enforce "stay on top" standard policy during their operations throughout their carrier path.
By delivering flexible and customized training packages, Lighthouse program is a multi-modal training platform ready to address training needs:

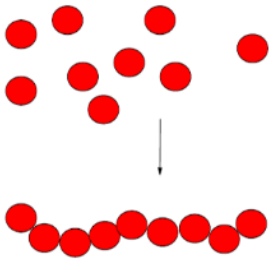
- By creating an online collaborative experience-based community through a permanent digital framework
- By supporting online training schemes including cloud shared space, social network groups, distance learning platforms (Moodle, etc.).
- By archiving and putting at disposal series of training contents and materials available online
- By making possible exchange of views and questions related to maritime business

After « A nutshell explanation of the shipping art » published in 2020, we are pleased today to introduce the second title of our specialized textbooks. Derived from the collection by First Maritime Chemicals team of open-source specialized materials, this textbook, entitled « What are Polymers about? », is an introduction to the fascinating world of polymer industry and business. No doubt it will strengthen our understanding of petrochemical and polymer industrial and commercial operations. To date, FM is the official agent of Pathwel company in Oman.
As the second publication resulting from LIGHTHOUSE program activities, we wish it will not only benefit First Maritime staff members but also prove helpful to a larger audience among its business community environment.

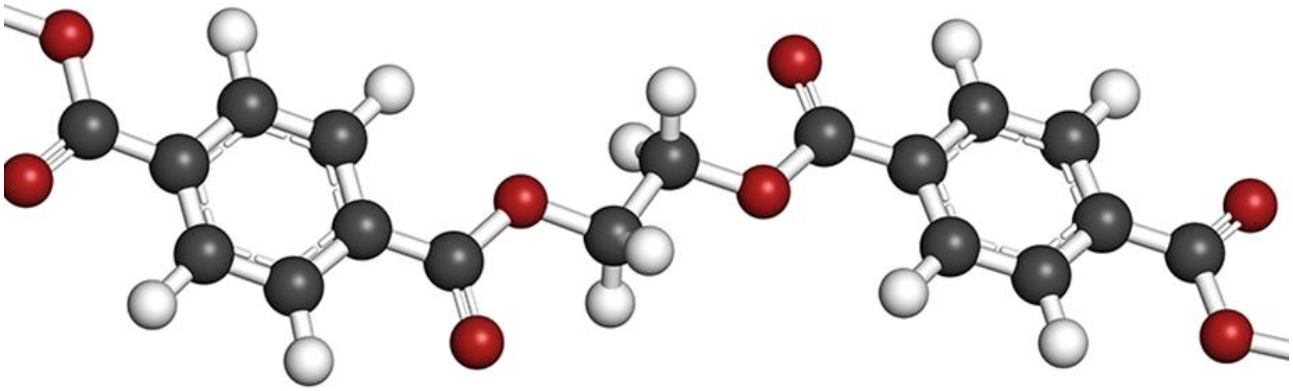
Julien PELISSIER,
CEO of First Maritime Company
First Maritime Lighthouse program team
July 2021

B) Basic definition: what is a polymer?

A polymer is a long molecule made up from lots of small molecules called monomers.
Polymers are created via polymerization of many small molecules, known as monomers.



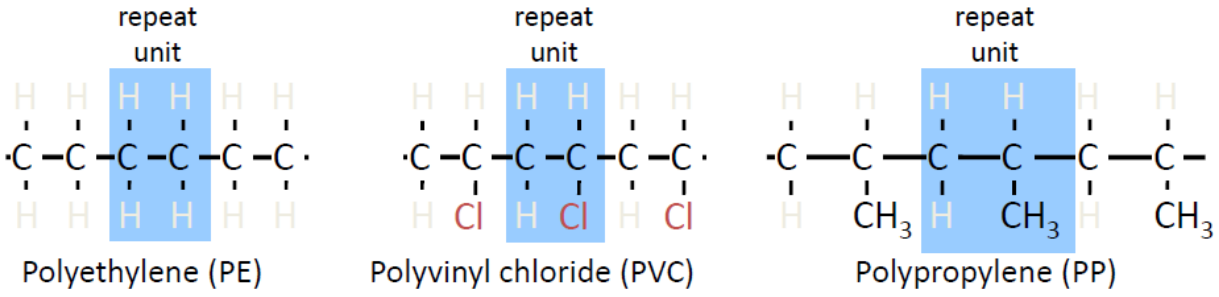
Due to their broad range of properties, price and flexible processing play essential and ubiquitous roles in everyday human life.



Very Large molecules structures chain-like in nature.

Poly mer

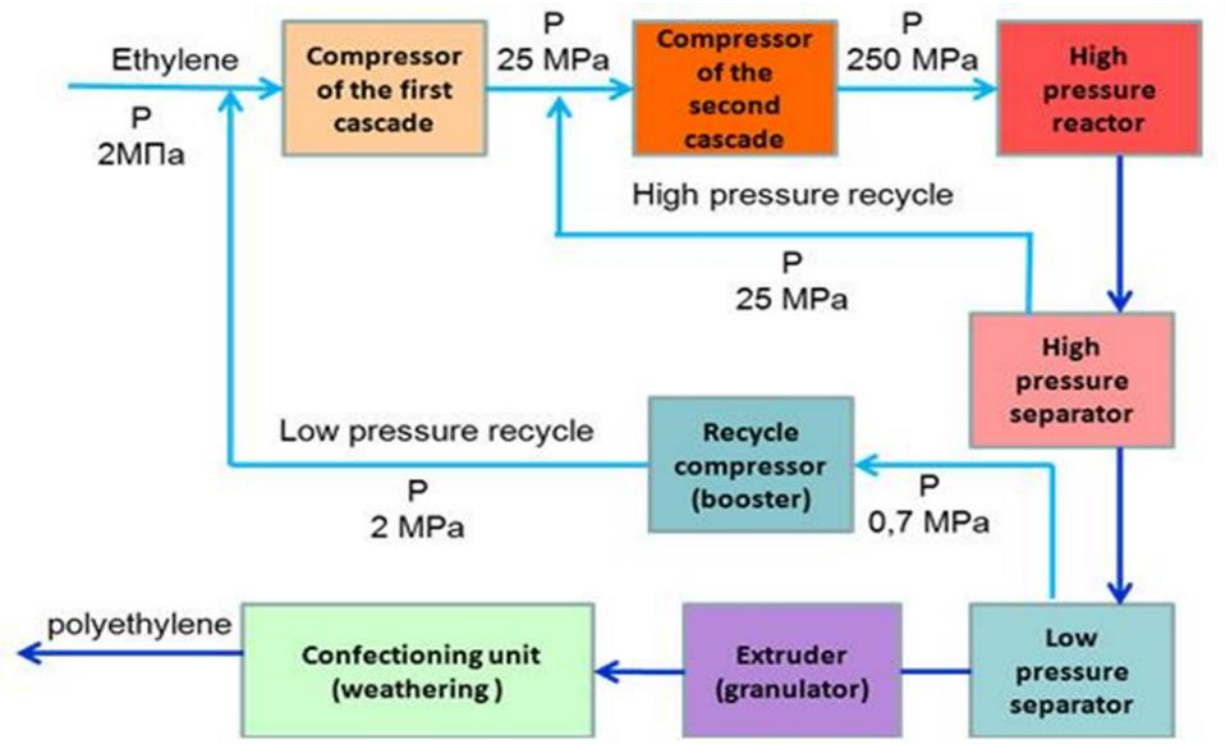
many repeat unit



Polyethylene (PE) Polyvinyl chloride (PVC) Polypropylene (PP)

Adapted from Fig. 14.2, *Callister 7e.*

C) Industrial process for production of polymers (polyethylene)



Production Flowchart of polyethylene

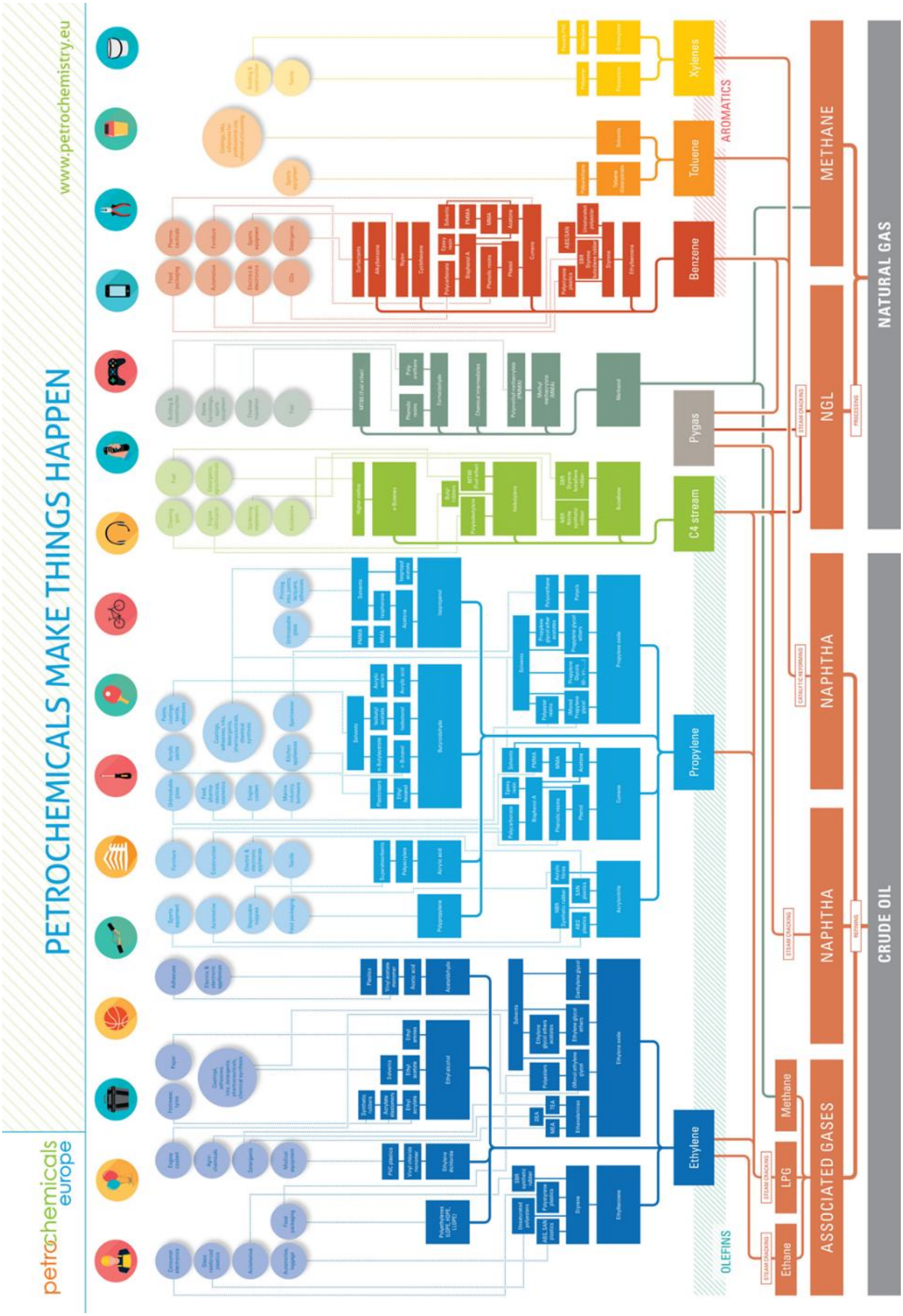


Recycle coolers of high pressure



Low pressure separator V=12 м3

Industrial process **for production of polymers (polyethylene)**



D) Top plastics and resins global producers

Dow Chemical

Global sales: $49 billion

Dow is an American multinational chemical company headquartered in Midland, Michigan. Dow provides chemicals, plastics, and agricultural products and operates in approximately 35 countries. It has more than 6,000 product groups that are manufactured at 179 sites across the globe. Dow is the leading global supplier of every major polyethylene (PE) resin worldwide (2016) and the world's largest producer of chlorine and polyalkylene glycols. It was ranked as the world's largest plastics manufacturer during 2008.

Dow's principal lines of business include agricultural sciences, consumer solutions, infrastructure solutions, performance materials & chemicals, and performance plastics. In 2015, the company had annual sales of nearly $49 billion and employed approximately 49,500 people worldwide.

Lyondell Basell

Global sales: $34.7 billion

Lyondell Basell is one of the world's largest plastics, chemicals and refining companies incorporated in the Netherlands, and with U.S. operations headquartered in Houston, Texas, and global operations in London, UK. The company was formed in December 2007 by the acquisition of Lyondell Chemical Company by Basell Polyolefins for $12.7 billion. It provides chemicals, plastics, petrochemical products, diesel, and gasoline among many other products which are produced in 17 countries at 55 sites. LyondellBasell is the world’s largest producer of polypropylene resins and polypropylene compounds and one of the top worldwide producers of polyethylene. It is also a major producer of high-value specialty polymers and resins. In 2019, the company had annual sales of about $34.7 billion and employed approximately 19,400 people worldwide.

Exxon Mobil

Global sales: $290 billion

Exxon Mobil Corp. (ExxonMobil) is an American multinational oil, gas and chemical company headquartered in Irving, Texas. It is a direct descendant of John D. Rockefeller's Standard Oil Company and was formed in 1999 by the merger of Exxon and Mobil (both formerly the Standard Oil Company). It is the world's 9th largest public company by revenue and was ranked no. 6 in sales and no. 17 in profit globally in Forbes Global 2016 list. ExxonMobil produces plastics, petrochemicals, diesel, and gasoline among many other products in all major countries of the world and explores for oil and natural gas in six continents. The company is one of the top worldwide producers of polyolefins and other polymers and resins. In 2016, the company had annual sales of nearly $290 billion and employed approximately 75,600 people worldwide.

SABIC

Global sales: $35.4 billion

SABIC (Saudi Arabia Basic Industries Corporation) is a public petrochemical company founded in 1976 and based in Riyadh, Saudi Arabia. It is active in chemicals and intermediates, industrial polymers, fertilizers, and metals. SABIC is the world’s third-largest producer of polyethylene and the fourth-largest producer of polypropylene and polyolefins in general. The company operates in more than 40 countries across the world, has 60 manufacturing sites and employes over 40,000 people. According to Forbes, SABIC generated about $35 billion sales in 2017.

Top plastics **and resins global producers**

INEOS

Global sales: $60 billion

Ineos Group Limited is a multinational chemicals company headquartered in Rolle, Switzerland. Ineos is an acronym for **IN**spec **E**thylene **O**xide**S**pecialities. The company produces plastics, resins and intermediates for all major markets including packaging, pharmaceuticals, agrochemicals, textiles, consumer goods, building & construction, and automotive & transportation. The company operates in 24 countries across the world, has 171 sites and employes over 19,000 people. The company generated about $60 billion sales in 2018.

BASF

Global sales: $65.4 billion

BASF is a German multinational chemical company founded in 1865 and headquartered in Ludwigshafen, Germany. The company is one of the largest plastics and resin supplier and has one of the most comprehensive plastics portfolios. It also provides a large number of chemicals, dyes, pharmaceutical ingredients and agricultural products. In 2019, BASF employed more than 117,000 people in over 200 countries with over 50,000 in Germany alone and 34,000 in the plastic and resin industry. The company generated sales of about US$ 65 billion in 2019.

ENI

Global sales: $89.4 billion

Eni S.p.A. (Ente Nazionale Idrocarburi) is an Italian multinational oil and gas company headquartered in Rome. It engages in the exploration, production, and refining of gas and oil, and is one of the major manufacturers of plastics and rubbers. The company operates in 73 countries across the world and employes over 31,000 people. According to Forbes, ENI generated more than $89 billion in sales in 2019.

LG Chem

Global sales: $25.5 billion

LG Chemical, is the largest Korean chemical company, headquartered in Seoul, South Korea. It is a major manufacturer of petrochemicals, polyolefins, polyvinyl chloride, polystyrene, synthetic rubbers and specialty polymers. The company is also a major producer of IT & electronic materials, and batteries. In 2019, the company had annual sales of about $25.5 billion and employed approximately 15,000 people worldwide.

Chevron Phillips

Global sales: $158.9 billion

Chevron Phillips Chemical is a petrochemical company headquartered in Woodlands, Texas. The company is jointly owned by Chevron Corporation and Phillips and was formed in 2000 by merging the chemicals operations of both companies. It is a major producer of petrochemicals, polyolefins, and specialty chemicals. Chevron Phillips has approximately 5,000 employees working in 31 production and research facilities located in the United States, Singapore, South Korea, Saudi Arabia, Qatar and Belgium. The company generated about $160 billion in sales in 2018.

Lanxess

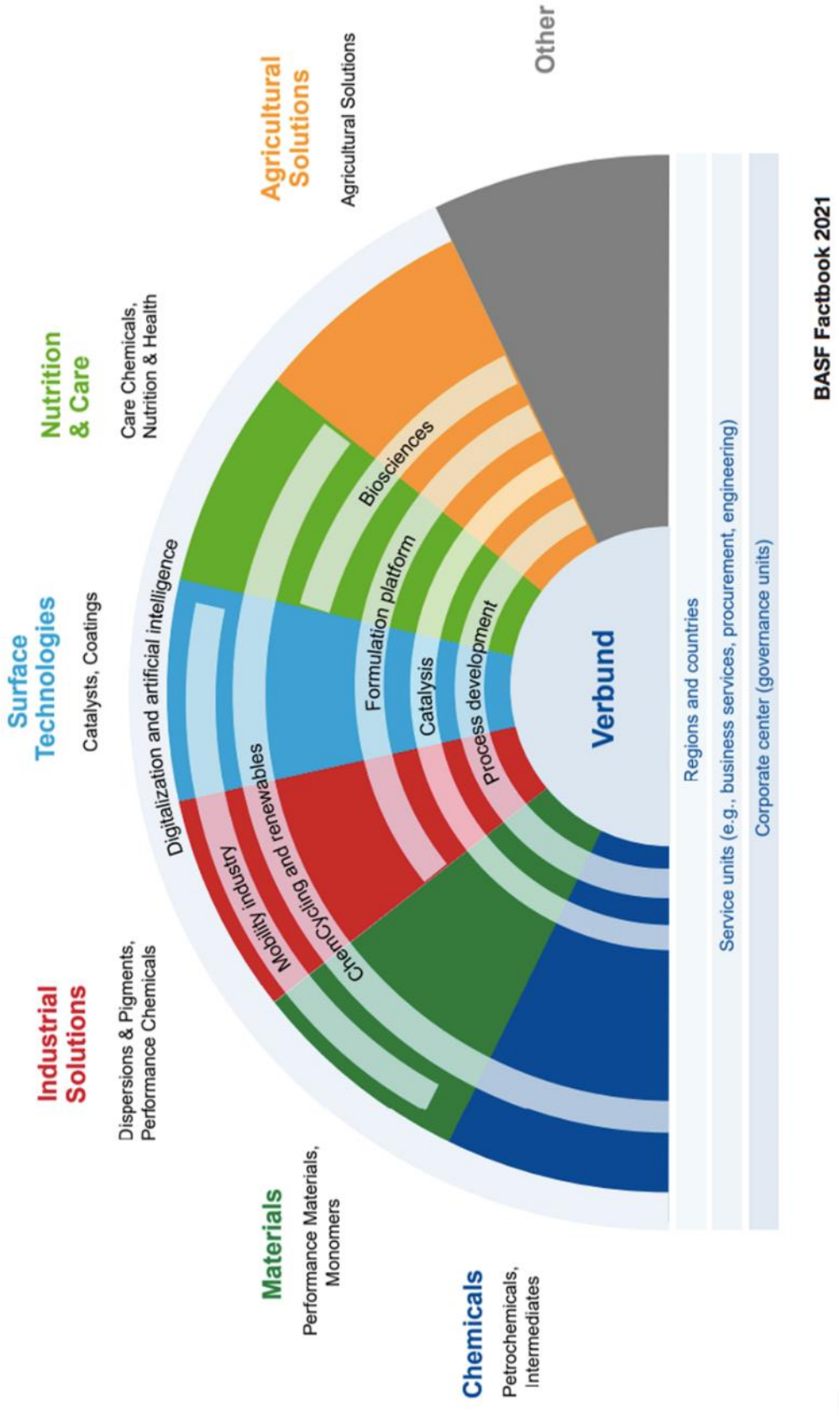
Global sales: $7.9 billion

Lanxess is a German specialty chemicals company based in Cologne, Germany. The company was founded in 2004 as a spin-off of the chemicals division and parts of the polymers segment of Bayer

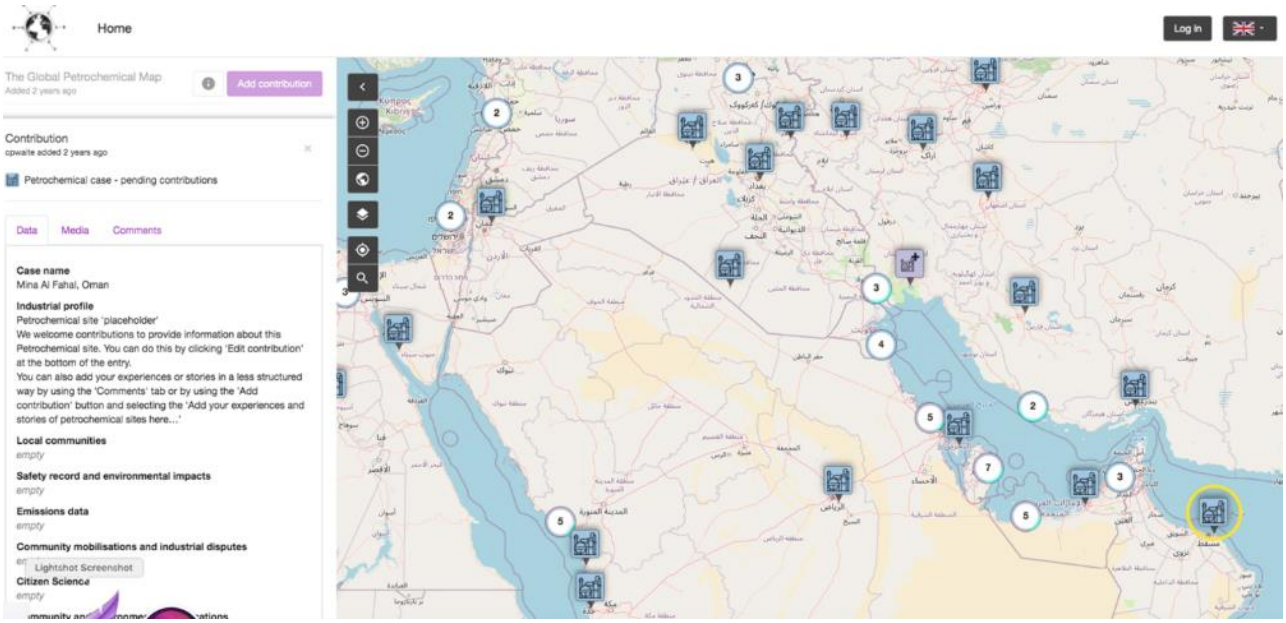
Top plastics **and resins global producers**

AG. The core business is the development, manufacturing and marketing of plastics, rubbers, intermediates and specialty chemicals. Through the joint venture with Saudi Aramco, Lanxess is also a leading supplier of synthetic rubber. The company created sales of EUR 7.9 billion in 2015 and has about 16,700 employees and 54 production sites worldwide in 29 countries.

E) As an example, BASF business segments



F) Petrochemical industry in the Middle-East



Source: https://globalpetrochemicalmap.communitymaps.org.uk/project/the-global-petrochemical-map/contribution/32894?categories=1418.0.0:20748.0,20749.0,20751.0,20752.0,20753.0,20755.0,20756.0,20757.0,20758.0,20759.0,20760.0,20761.0,20762.0,20763.0;1422.1.0;1423.0.0;1424.1.0;1427.0.0;1440.1.0&center=28.1592:47.0654:6&tab=1

Oman[1]

- Octal Petrochemicals Company -- Oman
- Oman Methanol Company (OMC) -- Oman
- Oman Oil Refineries and Petroleum Industries Company (ORPIC) -- Oman
- Oman Petrochemical Industries Company (OPIC) -- Oman
- Oman Refinery Company LLC -- Oman
- Oman Chemicals & Pharmaceuticals LLC -- Oman
- Oman International Petrochemical Industry Company (OMPET) -- Oman
- Salalah Methanol Company L.L.C (SFZ) -- Oman
- Shams Development Company -- Oman
- Sohar International Urea and Chemical Industries (SIUCI) -- Oman
- Takamul Investment Company SAOC -- Oman
- _ Liwa Petrochemical Company LLC -- Oman
- Oman Mechanical Services Co. Ltd LLC - OMSC -- Oman

Saudi arabia[2]

- SABIC
- Arabian Petrochemicals Company in Jubail

[1] Source: https://www.gulfoilandgas.com/webpro1/prod1/suplista.asp?id=608&yx1=OM

[2] https://oxfordbusinessgroup.com/overview/more-petrochemicals-heavy-industry-and-petrochemicals-dominate-while-other-segments-such--1
https://www.alawwalinvest.com/content/ksapetrochemicalsector(1).pdf

Petrochemical industry **in the Middle-East**

- Yanbu Petrochemical Company
- Saudi Kayan Petrochemical Company (Jubail)
- Saudi Arabia Fertilizers Co
- Saudi Industrial Investment Group
- National Industrialization Co
- National Petrochemical Company
- Rabigh Refining and Petrochemical Co
- Saudi International Petrochemical Co
- Sahara Petrochemical Co.
- Advanced Petrochemical Company
- Methanol Chemicals Company
- Alujain Corporation
- Nama Chemicals Co.

Iran[3]

- National Petrochemical Company (NPC)
- The Persian Gulf Petrochemical Company
- Kimia Pars Middle East Petrochemical Plant (Busher)
- Kaveh Petrochemical Plant
- Lorestan Petrochemical Catalyst Production Unit
- Tamin Petroleum & Petrochemical Investment Company
- Persian Gulf Petrochemical Industries Company
- Persian Oil & Gas
- Jam Petrochemical
- Kharg Petrochemical
- Ghadir Investment Company

Qatar[4]

- Qatar Petrochemical Company (QAPCO)

Kuwait[5]

- Petroleum Industries Company (PIC)
  - Fertiliser plants at Shuaiba Industrial Area
- Equate Petrochemicals Company
  - Kuwait Olefin Company

[3] https://oxfordbusinessgroup.com/overview/more-petrochemicals-heavy-industry-and-petrochemicals-dominate-while-other-segments-such--1

[4] Sources: https://oxfordbusinessgroup.com/analysis/rising-power-petrochemicals-segment-increases-its-contribution-gdp-despite-lower-oil-prices
https://www.gbreports.com/wp-content/uploads/2016/02/Qatar_Chemicals_2016_IE.pdf

[5] Sources: https://oxfordbusinessgroup.com/analysis/building-experience-efforts-are-under-way-widen-range-chemicals-produced-and-boost-output

Petrochemical industry **in the Middle-East**

- MEG lobal
- Boubyan Petrochemical Company
- Al Qurain Petrochemical Industries Company
- The Kuwait Aromatics Company (TKAC)
  - Kuwait Paraxylene Production Facility
  - Kuwait Styrene Company

Other petrochemical producer and consumer markets

- Egypt, Algeria, Tunisia, Morocco
- Iraq
- Turkey
- India

G) Two main groups of polymers: natural and synthetic

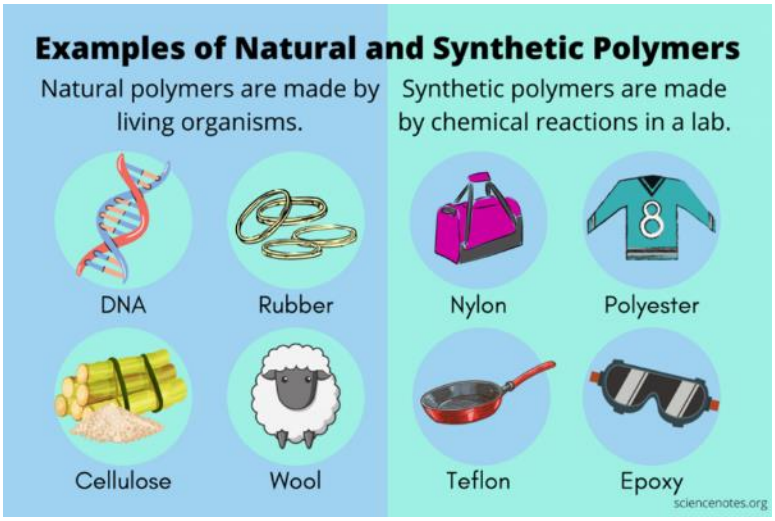
From view point of existence and occurrence, polymers are divided to two group:

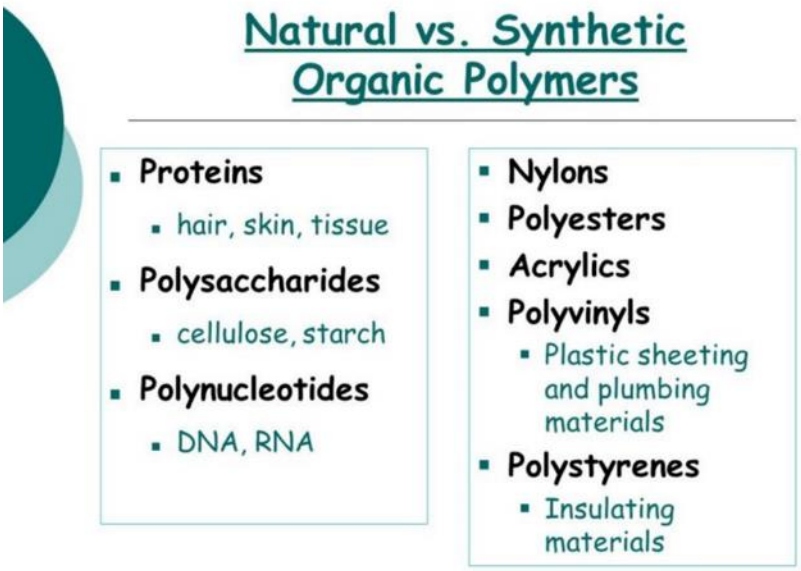
- Natural occurrence called Biopolymer like: Starch, Protein and DNA.

Biopolymers are naturally occurring materials formed during the life cycles of green plants, animals, bacteria and fungi. Biopolymers include animal protein- based biopolymers such as wool, silk, gelatin and collagen and polysaccharides such as cellulose, starch, carbohydrate polymers produced by bacteria and fungi.

- Synthetic polymers like: polyolefin, polystyrene, resin and rubber

Synthetic polymers are human-made polymers, often derived from petroleum oil.
Middle east, especially Persian Gulf according to huge resource of crude oil and natural gas is the main hub of synthetic polymer producing.



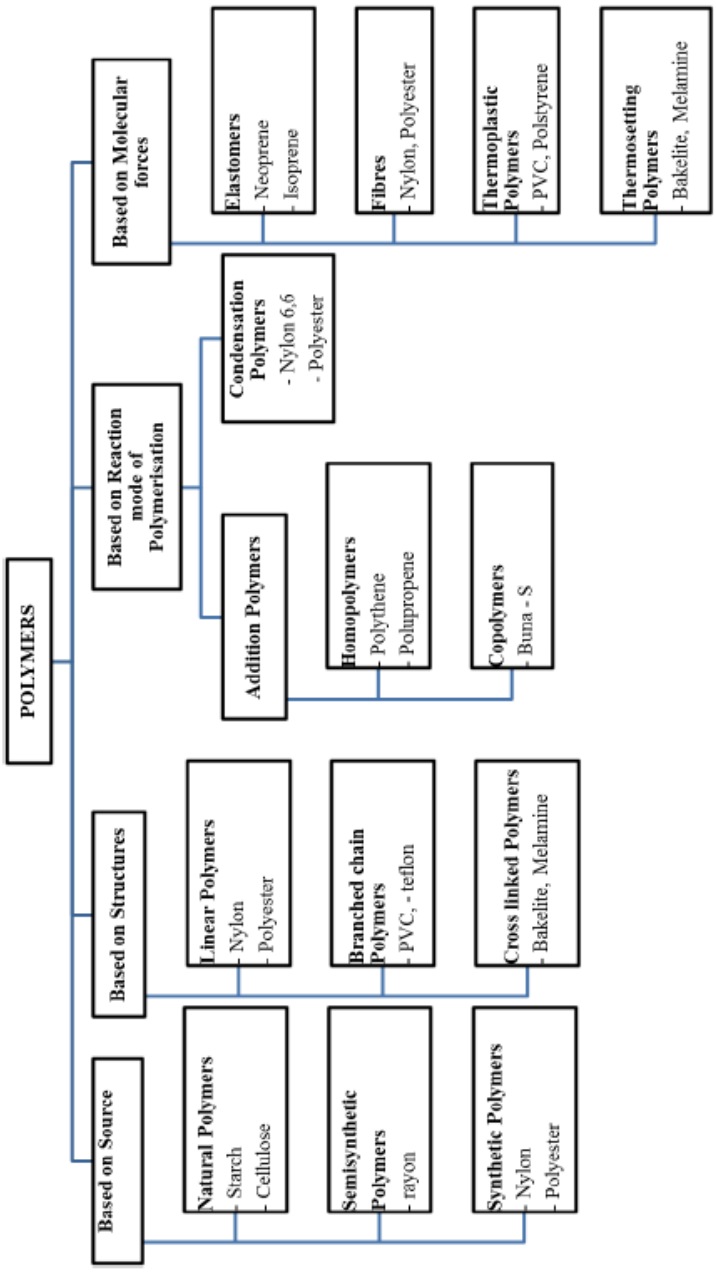


H) Polymerization and polymer characterization

In polymer chemistry, polymerization is a process of reacting monomer molecules together in a chemical reaction to form polymer chains or three-dimensional networks

Polymer characterization is the analytical branch of polymer science. The discipline is concerned with the characterization of polymeric materials on a variety of levels. The characterization typically has as a goal to improve the performance of the material. As such, many characterization techniques should ideally be linked to the desirable properties of the material such as strength, impermeability, thermal stability, and optical properties. Characterization techniques are typically used to determine molecular mass, molecular structure, morphology, thermal properties, and mechanical properties

Polymer classification



I) Heating polymers

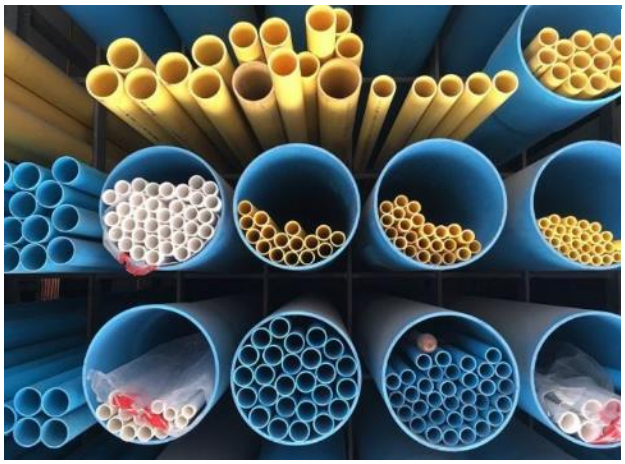
Based upon the physical property related to heating polymers are divided to two group: The thermoplastics are melting polymers, while thermosetting is a polymer that does not melt due to heat, but is irreversibly degraded at high temperatures

Thermoplastics:

Plastics that soften when heated and become solid again when cooled. This is the more popular type of polymer because the heating and cooling may be repeated.





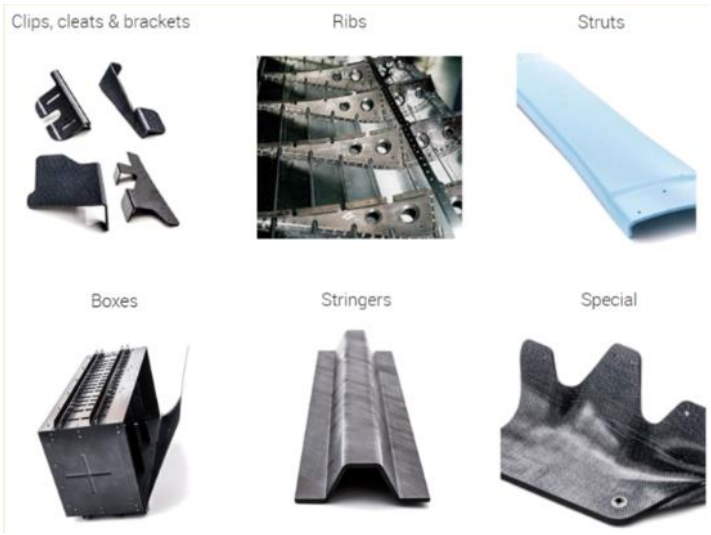




Heating polymers

Thermosets:

Polymer that soften when heated and can be molded, but harden permanently. They will decompose when reheated. An example is Bakelite, which is used in toasters, handles for pots and pans, dishes, electrical outlets and billiard balls.









J) Polymer uses: plastic characterization

Plastic is a moldable substance composed of synthetic (human-made) materials, made from polymers, which are long molecules built around chains of carbon atoms. It was a real game-changer for many industries and now there are many types of plastic used in everyday life. Different compositions produce different types of plastic, each with unique characteristics. While there are hundreds of different types of plastic, the following are the 6 most common types of plastic used in America today.

PET or PETE – Polyethylene terephthalate, or polyester, is most commonly used as for thermoformed sheets in manufacturing, clothing fiber, strapping and soft drinking bottles. This plastic is very durable and resistant to many chemicals. It also has a high tensile strength so it is strong, while still being lightweight. PET is clear in appearance and maintains it shape well.

HDPE – High-density polyethylene is a thicker plastic which is used to make milk jugs, laundry detergent bottles, playground equipment, plastic lumber and recycling bins. This plastic is known for its strength, durability, and weather and chemical resistance.

PVC or V – Polyvinyl chloride is most often seen in piping, fencing, shower curtains and non-food bottles. This material is very dense and rigid and has a high tensile strength.

LDPE – Low-density polyethylene is a lighterweight and more flexible plastic that is used to make plastic bags, tubing, laboratory equipment and various containers. LDPE is quite flexible and strong and has a high resilience towards environmental factors like moisture, extreme heat and cold.

PP – Polypropylene is commonly used for auto parts, industrial fibers, food containers and dishware. Polypropylene is often transparent in appearance, has a high heat resistance and is very stiff. It is also more stretchable when heated than other plastic materials.

PS – Polystyrene can be a hard plastic used for desk accessories, food trays, utensils, toys and insulation boards, as well as a rigid foam material form. The hard plastic is very stiff and strong, and the foam material is often used for packing material and is soft and moldable.
What else do these plastics have in common? All of these types of plastics are recyclable and can be produced from recycled plastic. But what are the sources of recycled plastic?

K) Plastics' use and identification

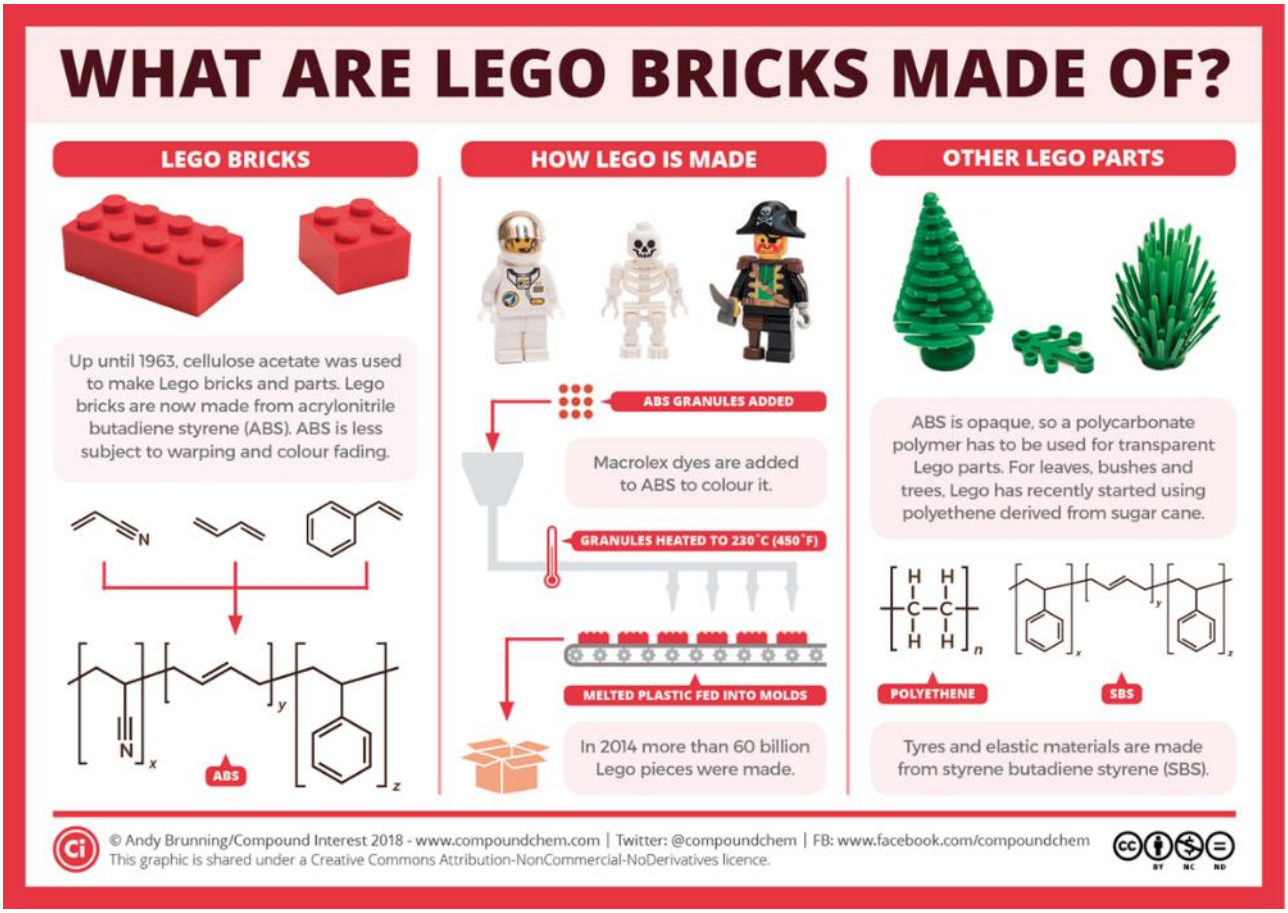
Plastics are identified by numbers 1 through 7. Usually located on the bottom of the package, this number is code for the specific type of plastic you're holding. Here are a couple of examples of the identification numbers and their corresponding products: Identification Key: Recycling Codes and Application Examples for Polymeric Materials in the USA

- PET (Polyethylene terephthalate) – Fizzy drink bottles, oven-ready meal trays and water bottles
- HDPE (High-density polyethylene) – Milk bottles, detergent bottles, yogurt and margarine tubs, cereal box liners and grocery, trash and retail bags
- PVC (Polyvinyl chloride) – Cling film (plastic food wrap), vegetable oil bottles, loose-leaf binders and construction products such as plastic pipes
- LDPE (Low-density polyethylene) – Dry cleaning bags, produce bags, trash can liners, bread bags, frozen food bags and squeezable bottles, such as mustard and honey
- PP (Polypropylene) – Ketchup bottles, medicine bottles, aerosol caps and drinking straws
- PS (Polystyrene) – Compact disc jackets, grocery store meat trays, egg cartons, aspirin bottles, foam packaging peanuts and plastic tableware
- Other - Three- and five-gallon reusable water bottles, certain kinds of food containers and Tupperware



Plastics' use **and identification**





L) Polymer uses: additives, compounds and masterbatches

Industrial solutions raw materials (additives, pigments) are used to formulate products in coatings, construction, paper, printing and packaging, adhesives and electronics industries

Additives:

- Antiblock additives
- Slip additives
- Antistatic additives
- Flame retardant additives

Compounds:

- Polyethylene (PE) Compound : Irrigation water and gas pipe, Silent pipes and fittings
- Black polyethylene compound for geo-membrane sheet
- Wood plastic compound (Polyethylene/ Polypropylene)
- Polypropylene reinforced with glass fiber

Masterbatches:

The colorful masterbatch is made of PE and PP as carriers, inorganic pigments and organic dyes with high-performance additives. The particles are uniform and beautiful in appearance, cylindrical or flat-round in shape, uniform in color, good dispersibility, stability and heat resistance. It is widely used in packaging film, pots, bottles, caps, pipes, containers, toys, household appliances, office supplies, automotive accessories and all kinds of construction. It is suitable for all kinds of blow molding, extrusion, injection molding, casting, wire drawing, chemical fiber and other processing fields.

Polymer uses**: additives, compounds and masterbatches**

ADDITIVE MASTERBATCHES

Function	Product Series	Description	Application
Polymer Processing Aid	PA	Prevent melt fracture, Improve process ability, Remove die build-up, Decrease die pressure, Increase output, Reduce energy consumption, Improve mechanical & optical properties	Polyolefin (PE&PP) extrusion like PE & PP film, pipe, sheet, coating,...
Anti Static	AS	Reduce surface resistivity & dust contamination	All polyolefin processing included of Injection & extrusion.
Anti Block	AB	Prevent blocking of plastic layer, Improve unwinding & slitting	Specially in polyolefin film, also for deep injected products.
Slip/Anti Block	SA	Prevent blocking & stickiness, Increase packaging line speed, Improve unwinding & slitting	Specially in polyolefin film, also for deep injected products.
Anti Fusion	AF	Prevent fusion of plastic layer & damage	Specially in polyethylene shrink film.
Optical Brightener	OB	Increase whiteness, Eliminate yellowish effect & Improve appearance	All polyolefin products, all plastic processing included injection & extrusion.
Clarifier	CA	Increase transparency of PP, Improve mechanical properties & decrease cycle time	All polypropylene products such as: Cup, sheet,... included both of injection & extrusion.
Anti Slip	ASL	Increase COF, Prevent slipping & Increase surface roughness	Specially in polyethylene film.
Slip	SL	Decrease COF & stickiness, Increase packing line speed & Enhance mold releasing	Extrusion of polyolefin film as slip agent. Injection of polyolefin products as mold release agent.
Fast Slip	FSL	Decrease COF & stickiness immediately and fast , Increase packing line speed & Enhance mold releasing	Extrusion of polyolefin film as slip agent. Injection of polyolefin products as mold release agent.
Anti Oxidant	AO	Prevent thermal degradation, Inhibit oxidation, Decrease discoloration & prevent gel & carbonized particle formation	All polyolefin products, all plastic processing, included of injection & extrusion.
Cleaner (Polymric)	PU	Clean the injection & extruder machine without harmful effect & decrease scrap	Injection of polyolefin, ABS, PS,...
Shut Down	SD	Eliminate black specks, Reduce scrap & Facilitate start up	Specially in polyolefin film extruders.
Irrigation Pipe	IP	LDPE compound for producing irrigation pipe	Irrigation pipe extrusions.
Silicone Masterbatch	SI	Highly efficient lubricants, Modify flow ability, Reduces the COF permanently, Scratch-resistant	All polyolefin products, all plastic processing, included of injection & extrusion.

M) Polymer market highlights

Global Polymers Market size is forecast to reach around $ 750 billion by 2025, after growing at a CAGR of 5.1% during 2020-2025 to reach $838.5 billion by 2030.

Polymer is one of the widely used chemical products in almost all the sectors such a medical, aerospace, packaging, automotive, construction, electrical appliances, and medical sector, and consequently, the global polymers market is thriving. Polymers are used widely as a substitute of metal and mineral based products due to its high performance, cost-effectiveness, and low weight. Increase in the retail sector and prospering e-commerce industry is demanding for more packaging material that is influencing the significance of the polymers market. Whereas, the growing interest in renewable feedstock and biopolymers among the consumers have led to the development of several alternatives to traditional plastics that in turn drives the demand for Polymer during the forecast period. Furthermore, growing demand for polymer in the electronic industry for the manufacturing of different electrical parts such as switches and sockets are driving the Polymers Market.

The COVID-19 impact has been witnessed by every industry all over the globe. During the pandemic, the polymer industry has been impacted due to the reduction in demand and production of light vehicles, where polymer-based products are highly needed. Besides, other industrial sectors, such as packaging, food processing, personal care, and pharmaceutical, have continued to be in operation, which has generated the demand for polymers

Packaging is the largest category under the application segment of the polymer industry.
The major polymer market drivers are increased replacement of conventional materials in automotive sector and rising use of smart polymers in healthcare industry
Asia-Pacific is the largest and fastest-growing polymer market. China market by 2030: $273 bn.

N) Global Packaging Materials Market

Global Packaging Materials Market size was estimated over USD 900 billion in 2016 and will exhibit growth by a CAGR of over 3% up to 2024 and value 1.3 Trillion USD
Food is the largest end-user segment and was valued at more than USD 300 billion in 2016
High growth in the global food & beverage industry will propel packaging materials demand during the forecast years. These products are extensively used in the packaging of raw & processed food items. They are also increasingly used in packaging bulk food products such as grains, cereals, etc. Rising consumption of frozen meat products, canned sea-foods, and ready-to-eat meals across the globe will augment the packing materials market growth. High consumption of alcoholic and non-alcoholic beverages will also be a major growth enabler for the market.
Alcoholic drinks such as beer, whiskey, wine, etc. are packed in glass, metal as well as rigid plastic bottles. Glass and rigid plastic bottles are also widely used in packaging non-alcoholic beverages such as soft drinks, energy drinks, juices, etc. The global food & beverage industry size exceeded USD 4.8 trillion in 2016 and will grow by a CAGR of around 4% in the next five years. This enormous size of the global food & beverage industry coupled with a steady growth rate in the next few years will be the major factor behind the packaging materials market growth during the forecast period.
According to product, the global packaging materials market is segmented into bottles & cans, containers & jars, bags, pouches, & wraps, closures & lids, boxes & crates, drums & intermediate bulk containers (IBCs), and other packaging structures such as bins, trays, etc. Bottles & cans are a major product segment accounting for close to 20% of the overall market in 2016. They are employed in packaging a broad range of products including beverages, chemicals, household products, personal care products, pharmaceuticals, etc. Increasing demand for beverages across the globe will drive this segments market during the forecast period.

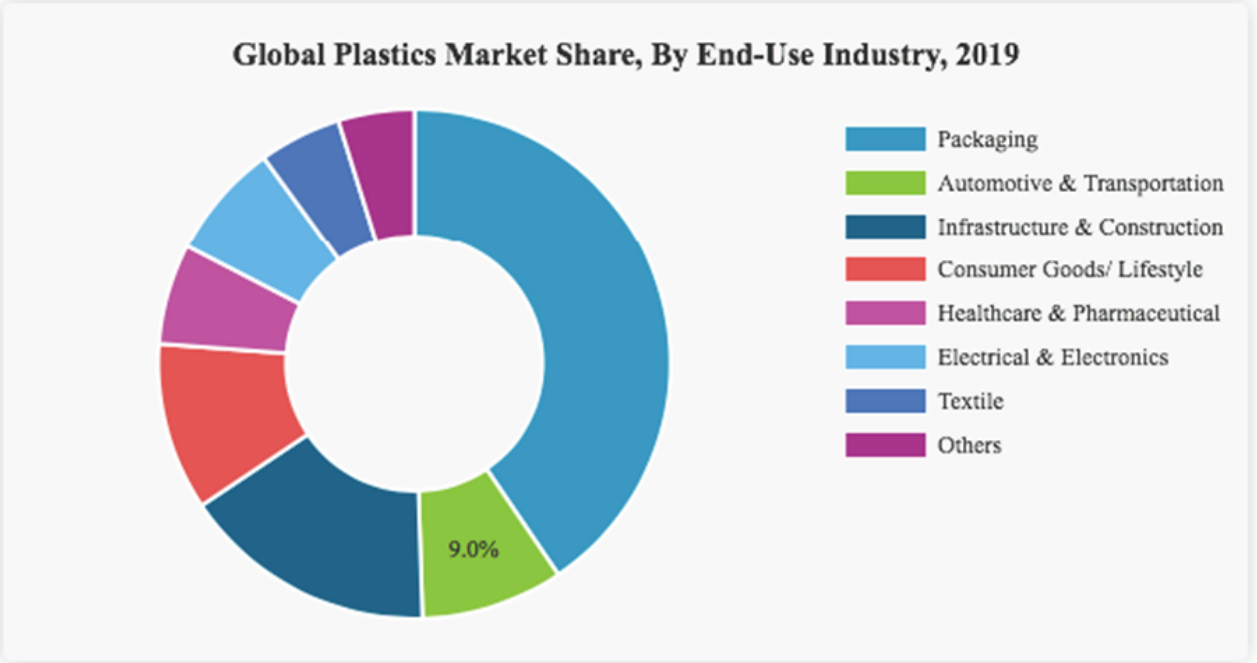
GLOBAL PACKAGING MARKET

- Global industry size: around 900bn$
- Fairly fragmented market with many players
- 41% of the growth with APAC region
- One of key drivers increase in demand for digitally printed packaging
- Top pricing models: spot base pricing, volume base pricing, value base pricing,

GLOBAL BIOPACKAGING MARKET

- CAGR of 18%
- Incremental growth of 5bn$/year
- Market fragmented
- 32% of growth from Europe

Global Packaging **Materials Market**





O) Pathwel products PATHWEL

First Maritime is the agent of Pathwel company in Oman.

Polymers are used to make our everyday products including food packaging, water bottle caps, and plastic films. However, these polymers inherently exhibit high friction and mutual adhesion. Our range of products is used to improve polymer processing efficiency and end-product quality. They are suitable for use in a range of applications and in multiple polymer types. Most importantly, our products are made only from vegetable-derived natural raw materials.
Pathwel products are additives used to reduce the coefficient of friction between the surfaces of poly olefins (polyethylene and polypropylene). They belong to the family of organic materials though not polymers but as small molecules.

The competitive advantages of Pathwel products:

- Competitive pricing with a very good quality/price ratio: despite being cheaper than competitors ‘products, their quality is satisfying
- These products (lubricants) are not hydrocarbon polymers but are biodegradable and have FDA (Food & Drug Administration) certification for use in food contact product & industries.

Main target markets for Pathwel products are upstream and downstream players

- Upstream: petrochemical industries such as OQ Liwa Petrochemical company in Oman (Sohar)
- Downstream:
  - masterbatches producers (greenhouse films, shopping bags, FFS)
  - Plastic colored masterbatches: white masterbatches

Pathwel products Technical datasheet: INNOSLIP O

CHEMICAL DESCRIPTION

Product Name	**INNOSLIP – O**
Chemical Name	(Z)-9-Octadecenamide *(IUPAC Nomenclature)*, Oleamide
Molecular Formula	$C_{18}H_{35}NO$
CAS Number	301-02-0
EC Number	931-801-1

PRODUCT DESCRIPTION & APPLICATIONS

INNOSLIP – O is an unsaturated fatty amide, used as a high performing slip and medium anti-block agent. Unlike traditional oleamides, INNOSLIP products are entirely derived from a vegetable source. It can be applied to a wide range of polymer resins and applications, but it is most often used in LDPE, LLDPE and PP films. Given its limited anti-blocking characteristic, INNOSLIP – S or INNOSLIP – B can be used together for improved the anti-blocking property.

Polyolefin Films

INNOSLIP – O is commonly added to LDPE, LLDPE and PP films as a good slip agent. It migrates to the surface and forms a layer that reduces the coefficient of friction (CoF). In comparison to the INNOSLIP – E Series, it has lower thermal stability but it is a faster migrating or "blooming" slip agent due to its shorter carbon chain. It is recommended for applications requiring a fast slip development after product extrusion.

Mold Release

INNOSLIP – O can be used as a mold release agent in injection molding applications. It forms a lubricating layer on the product surface to facilitate mold release. It is suitable for most polymers, including synthetic rubber.

SPECIFICATION

Parameter	Unit	Lower Limit	Upper Limit
Amide Purity	%	98.5	-
Acid Value	mg KOH/g	0.0	0.5
Iodine Value	gI2/100g	81.0	87.0
Moisture	%	0.00	0.50
Melting Point	°C	72.0	76.0
Color	Gardner	0.0	2.0

Product Form	*Bead, Microbead*
Raw Material Origin	*Vegetable. The product does not contain any animal based products.*

USAGE

For polymer applications, INNOSLIP – O can be added to the resin directly or via a masterbatch. Although this substance has a migrative property, thoroughly disperse for best performance. A dosage of 500 – 3,000 ppm is recommended but the actual usage should depend on the polymer type, the application and the required outcome of the final product by the user. A higher dosage may be required for formulas containing large amounts of pigments and fillers with absorptive properties.

CHEMICAL INVENTORY

Australia (AICS)	*Listed*	**Korea (KECL)**	*Listed*
Canada (DSL)	*Listed*	**New Zealand (NZIoC)**	*Listed*
China (IECS)	*Listed*	**Philippines (PICCS)**	*Listed*
European Union (EINECS)	*Listed*	**Taiwan (TSCI)**	*Listed*
Japan (ENCS)	*Listed*	**United States (TSCA)**	*Listed*

FOOD CONTACT APPROVAL

United States

This substance is in compliance with the *FDA Code of Federal Regulations (Title 21 Food and Drugs, Chapter 1)*. It is approved for various uses as an indirect additive used in food contact materials.

European Union

This substance is not listed as a hazardous substance that requires harmonized classification and labelling according to *EC Regulation 1272/2008 (on classification, labelling and packaging of substances and mixtures)*. It is also authorized to be used as additive or polymer production aid without a Specific Migration Limit (SML) according to *EU Commission Regulation 10/2011 (on plastic materials and articles intended to come into contact with food)* under *Reference Number 68960* and *FCM Substance Number 335*.

China

This substance is a permitted food contact additive in compliance with *GB 9685-2016 Hygienic Standard for Use of Additives in Food Containers and Packaging Materials*. It is on the positive list under *FCA Number 0017* without Specific Migration Limit (SML) and/or allowed Maximum Quantity (QM) of residual monomer.

Please contact us for additional food contact approvals and regulatory information.

PACKAGING

Standard packing unit is 25kg for the product in bead form and 20kg for the product in microbead form. Standard packaging is a PE bag but customized packaging are also available. Please contact us at *info@pathwelglobal.com* for more information.

STORAGE

Store in a cool, dry, and well-ventilated indoor location at a temperature below 30°C. Keep the product in its original packaging and away from moisture. Avoid exposure to direct sunlight and do not store with incompatible substances including oxidizing agents.

SHELF LIFE

When stored under the recommended conditions, the product has a shelf life of twelve months from manufacturing.

SAFETY AND HANDLING

INNOSLIP – O is non-corrosive, non-toxic and non-hazardous. However, we recommend that handlers follow all standard procedures required for the safe handling of chemical products, including the use of appropriate personal protective gears. These products are not dangerous goods according to all international transport regulations and therefore, can be transported in a standard dry container without any restriction. For detailed safety and handling information, please refer to the safety data sheet or contact us at *stewardship@pathwelglobal.com*.

Pathwel products Technical datasheet: INNOSLIP E

CHEMICAL DESCRIPTION	
Product Name	**INNOSLIP – E**
Chemical Name	(Z)-13-Docosenamide *(IUPAC Nomenclature)*, Erucamide
Molecular Formula	$C_{22}H_{43}NO$
CAS Number	112-84-5
EC Number	204-009-2

PRODUCT DESCRIPTION & APPLICATIONS

INNOSLIP – E is an unsaturated fatty amide used as an excellent slip agent and good anti-block agent in a wide range of polymer applications using LDPE, LLDPE, PP, PVC, and EVA. INNOSLIP – E reduces problems caused by polymers' inherent tendency to adhere to other surfaces such as processing machines (e.g., extruders) and also in their end uses. It is characterized by its good heat stability and low volatility, making it suitable for applications requiring high processing temperatures.

Polyolefin Films

INNOSLIP – E is the most commonly used slip agent, particularly in LDPE, LLDPE and PP films to reduce the coefficient of friction (CoF) without compromising important optical properties such as clarity. When incorporated, erucamide molecules migrate to the film surface to form a thin lubricative layer. It has a slower migration speed than oleamide, making it preferable for films that require printing, sealing or other surface treatments after extrusion (i.e., treatment can be done before erucamide layer develops on the surface).

Injection Molding

INNOSLIP – E can be used in molding applications as a release agent. As it migrates to the surface and forms a layer, erucamide facilitates mold release and in the due process reduce scratch and scuff on the product.

Printing Ink

INNOSLIP – E can be used in printing ink as a dispersant and it also adds slip and anti-block properties to the ink.

SPECIFICATION

Parameter	Unit	Lower Limit	Upper Limit
Amide Purity	%	98.5	-
Acid Value	mg KOH/g	0.0	0.5
Iodine Value	gI2/100g	74.0	79.0
Moisture	%	0.00	0.50
Melting Point	°C	80.0	84.0
Color	Gardner	0.0	2.0
Product Form	*Bead, Microbead*		
Raw Material Origin	*Vegetable. The product does not contain any animal based products.*		

USAGE

For polymer applications, INNOSLIP – E can be added to the resin directly or via a masterbatch. Although this substance has a migrative property, thoroughly disperse for best performance. A dosage of 500 – 3,000 ppm is recommended but the actual usage should depend on the polymer type, the application and the required outcome of the final product by the user. A higher dosage may be required for formulas containing large amounts of pigments and fillers with absorptive properties.

CHEMICAL INVENTORY

Australia (AICS)	*Listed*	**Korea (KECL)**	*Listed*
Canada (DSL)	*Listed*	**New Zealand (NZIoC)**	*Listed*
China (IECS)	*Listed*	**Philippines (PICCS)**	*Listed*
European Union (EINECS)	*Listed*	**Taiwan (TSCI)**	*Listed*

Japan (ENCS)	*Lisied*	**United States (TSCA)**	*Listed*

FOOD CONTACT APPROVAL

United States

This substance is in compliance with the *FDA Code of Federal Regulations (Title 21 Food and Drugs, Chapter 1).* It is approved for various uses as an indirect additive used in food contact materials.

European Union

This substance is not listed as a hazardous substance that requires harmonized classification and labelling according to *EC Regulation 1272/2008 (on classification, labelling and packaging of substances and mixtures).* It is also authorized to be used as additive or polymer production aid without a Specific Migration Limit (SML) according to *EU Commission Regulation 10/2011 (on plastic materials and articles intended to come into contact with food)* under *Reference Number 52720* and *FCM Substance Number 271*.

China

This substance is a permitted food contact additive in compliance with *GB 9685-2016 Hygienic Standard for Use of Additives in Food Containers and Packaging Materials.* It is on the positive list under *FCA Number 0910* without Specific Migration Limit (SML) and/or allowed Maximum Quantity (QM) of residual monomer.

Please contact us for additional food contact approvals and regulatory information.

PACKAGING

Standard packing unit is 25kg for the product in bead form and 20kg for the product in microbead form. Standard packaging is a PE bag but customized packaging are also available. Please contact us at *info@pathwelglobal.com* for more information.

STORAGE

Store in a cool, dry, and well-ventilated indoor location at a temperature below 30°C. Keep the product in its original packaging and away from moisture. Avoid exposure to direct sunlight and do not store with incompatible substances including oxidizing agents.

SHELF LIFE

When stored under the recommended conditions, the product has a shelf life of twelve months from manufacturing.

SAFETY AND HANDLING

INNOSLIP – E is non-corrosive, non-toxic and non-hazardous. However, we recommend that handlers follow all standard procedures required for the safe handling of chemical products, including the use of appropriate personal protective gears. These products are not dangerous goods according to all international transport regulations and therefore, can be transported in a standard dry container without any restriction. For detailed safety and handling information, please refer to the safety data sheet or contact us at *stewardship@pathwelglobal.com.*

P) Polymer technical glossary

- **amino acids** Simple molecules that occur naturally in plant and animal tissues and that are the basic building blocks of proteins.
- **anatomy**:(adj. anatomical) The study of the organs and tissues of animals. Or the characterization of the body or parts of the body on the basis of its structure and tissues. Scientists who work in this field are known as anatomists.
- **atom**: The basic unit of a chemical element. Atoms are made up of a dense nucleus that contains positively charged protons and uncharged neutrons. The nucleus is orbited by a cloud of negatively charged electrons.
- **bond**: (in chemistry) A semi-permanent attachment between atoms — or groups of atoms — in a molecule. It's formed by an attractive force between the participating atoms. Once bonded, the atoms will work as a unit. To separate the component atoms, energy must be supplied to the molecule as heat or some other type of radiation.
- **carbon**: The chemical element having the atomic number 6. It is the physical basis of all life on Earth. Carbon exists freely as graphite and diamond. It is an important part of coal, limestone and petroleum, and is capable of self-bonding, chemically, to form an enormous number of chemically, biologically and commercially important molecules.
- **cell**: The smallest structural and functional unit of an organism. Typically too small to see with the unaided eye, it consists of a watery fluid surrounded by a membrane or wall. Depending on their size, animals are made of anywhere from thousands to trillions of cells. Most organisms, such as yeasts, molds, bacteria and some algae, are composed of only one cell.
- **cellulose**: A type of fiber found in plant cell walls. It is formed by chains of glucose molecules.
- **chemical**: A substance formed from two or more atoms that unite (bond) in a fixed proportion and structure. For example, water is a chemical made when two hydrogen atoms bond to one oxygen atom. Its chemical formula is H_2O. Chemical also can be an adjective to describe properties of materials that are the result of various reactions between different compounds.
- **CAS number:** CAS Number, is a unique numerical identifier assigned by the Chemical Abstracts Service , a division of the American Chemical Society, to every chemical substance
- **chemical bonds**: Attractive forces between atoms that are strong enough to make the linked elements function as a single unit. Some of the attractive forces are weak, some are very strong. All bonds appear to link atoms through a sharing of — or an attempt to share — electrons.
- **component**: Something that is part of something else (such as pieces that go on an electronic circuit board or ingredients that go into a cookie recipe).
- **compound**: (often used as a synonym for chemical) A compound is a substance formed when two or more chemical elements unite (bond) in fixed proportions. For example, water is a compound made of two hydrogen atoms bonded to one oxygen atom. Its chemical symbol is H_2O.
- **crystal**: (adj. crystalline) A solid consisting of a symmetrical, ordered, three-dimensional arrangement of atoms or molecules. It's the organized structure taken by most minerals. Apatite, for example, forms six-sided crystals. The mineral crystals that make up rock are usually too small to be seen with the unaided eye.
- **dissolve**: To turn a solid into a liquid and disperse it into that starting liquid. (For instance, sugar or salt crystals, which are solids, will dissolve into water. Now the crystals are gone and the solution is a fully dispersed mix of the liquid form of the sugar or salt in water.)
- **DNA**: (short for deoxyribonucleic acid) A long, double-stranded and spiral-shaped molecule inside most living cells that carries genetic instructions. It is built on a backbone of phosphorus, oxygen,

and carbon atoms. In all living things, from plants and animals to microbes, these instructions tell cells which molecules to make.

- **element**: (in chemistry) Each of more than one hundred substances for which the smallest unit of each is a single atom. Examples include hydrogen, oxygen, carbon, lithium and uranium.
- **glucose**: A simple sugar that is an important energy source in living organisms. As an energy source moving through the bloodstream, it is known as "blood sugar." It is half of the molecule that makes up table sugar (also known as sucrose).
- **keratin**: A protein that makes up your hair, nails and skin.
- **lubricant**: A substance used to cut friction between surfaces that are in contact with one another.
- **macromolecule**: A molecule that contains a large number of atoms. (The prefix *macro* comes from the Greek and means "large" or "long.") Polymers, including natural proteins (such as DNA) and artificial materials (such as nylon and polyester), are examples of macromolecules.
- **materials scientist**:Someone who studies the ways in which the atomic and molecular structure of a material relates to its overall properties. Materials scientists can design new materials or analyze existing ones. Their analyses of a material's overall properties (such as density, strength and melting point) can help engineers and other researchers select materials that are best suited to a new application.
- **molecule**: An electrically neutral group of atoms that represents the smallest possible amount of a chemical compound. Molecules can be made of single types of atoms or of different types. For example, the oxygen in the air is made of two oxygen atoms (O_2), but water is made of two hydrogen atoms and one oxygen atom (H_2O).
- **monomer**:A molecule that is used as the basic building block of some larger molecule, known as polymers. From the Greek language, monomer means "one part." (Polymer, also from Greek, means "many parts.")
- **network**: A group of interconnected people or things.
- **nitrogen**: A colorless, odorless and nonreactive gaseous element that forms about 78 percent of Earth's atmosphere. Its scientific symbol is N. Nitrogen is released in the form of nitrogen oxides as fossil fuels burn.
- **nylon**: A silky material that is made from long, manufactured molecules called polymers. These are long chains of atoms linked together.
- **oxygen**: A gas that makes up about 21 percent of Earth's atmosphere. All animals and many microorganisms need oxygen to fuel their growth (and metabolism).
- **pendant group**:(in chemistry) A group of atoms that dangle from the main links of a polymer (a type of chain-like molecule). Such pendant groups of atoms (as well as any single atoms that might be attached to a polymer) often determine how the polymer interacts with other substances in its environment.
- **plastic**: Any of a series of materials that are easily deformable; or synthetic materials that have been made from polymers (long strings of some building-block molecule) that tend to be lightweight, inexpensive and resistant to degradation.
- **plasticizer**: Any of several chemicals added to certain synthetic materials to make them soft and/or pliable.
- **polyester**: A synthetic material used chiefly to make fabrics. The actual chemical name for the material used is polyethylene terephthalate.
- **polymer**: A substance made from long chains of repeating groups of atoms. Manufactured polymers include nylon, polyvinyl chloride (better known as PVC) and many types of plastics.

Natural polymers include rubber, silk and cellulose (found in plants and used to make paper, for example).

- **polyvinyl chloride** (PVC): A plastic formed by using heat to turn a liquid resin into a solid. The plastic can be soft and flexible or rigid and hard. The raw ingredients consist primarily of chlorine and carbon.
- **protein**: A compound made from one or more long chains of amino acids. Proteins are an essential part of all living organisms. They form the basis of living cells, muscle and tissues; they also do the work inside of cells. Among the better-known, stand-alone proteins are the hemoglobin (in blood) and the antibodies (also in blood) that attempt to fight infections. Medicines frequently work by latching onto proteins.
- **resistance**:(in physics) Something that keeps a physical material (such as a block of wood, flow of water or air) from moving freely, usually because it provides friction to impede its motion.
- **silicon**: A nonmetal, semiconducting element used in making electronic circuits. Pure silicon exists in a shiny, dark-gray crystalline form and as a shapeless powder.
- **silicone**: Heat-resistant substances that can be used in many different ways, including the rubber-like materials that provide a waterproof seal around windows and in aquariums. Some silicones serve as grease-like lubricants in cars and trucks. Most silicones, a type of molecule known as a polymer, are built around long chains of silicon and oxygen atoms.
- **starch**: A soft white chemical made by all green plants. It's a relatively long molecule made from linking together a lot of smaller, identical building blocks — all of them glucose, a simple sugar. Plants and animals use glucose as an energy source. Plants store that glucose, in the form of starch, as a reserve supply of energy. Animals that consume starch can break down the starch into glucose molecules to extract the useful energy.
- **viscosity**: The measure of a fluid's resistance to stress. Viscosity corresponds to the idea of how "thick" a liquid is. Honey is very viscous, for instance, while water has relatively low viscosity.

Q) Interesting sources

- https://polymerdatabase.com/
- Open sources