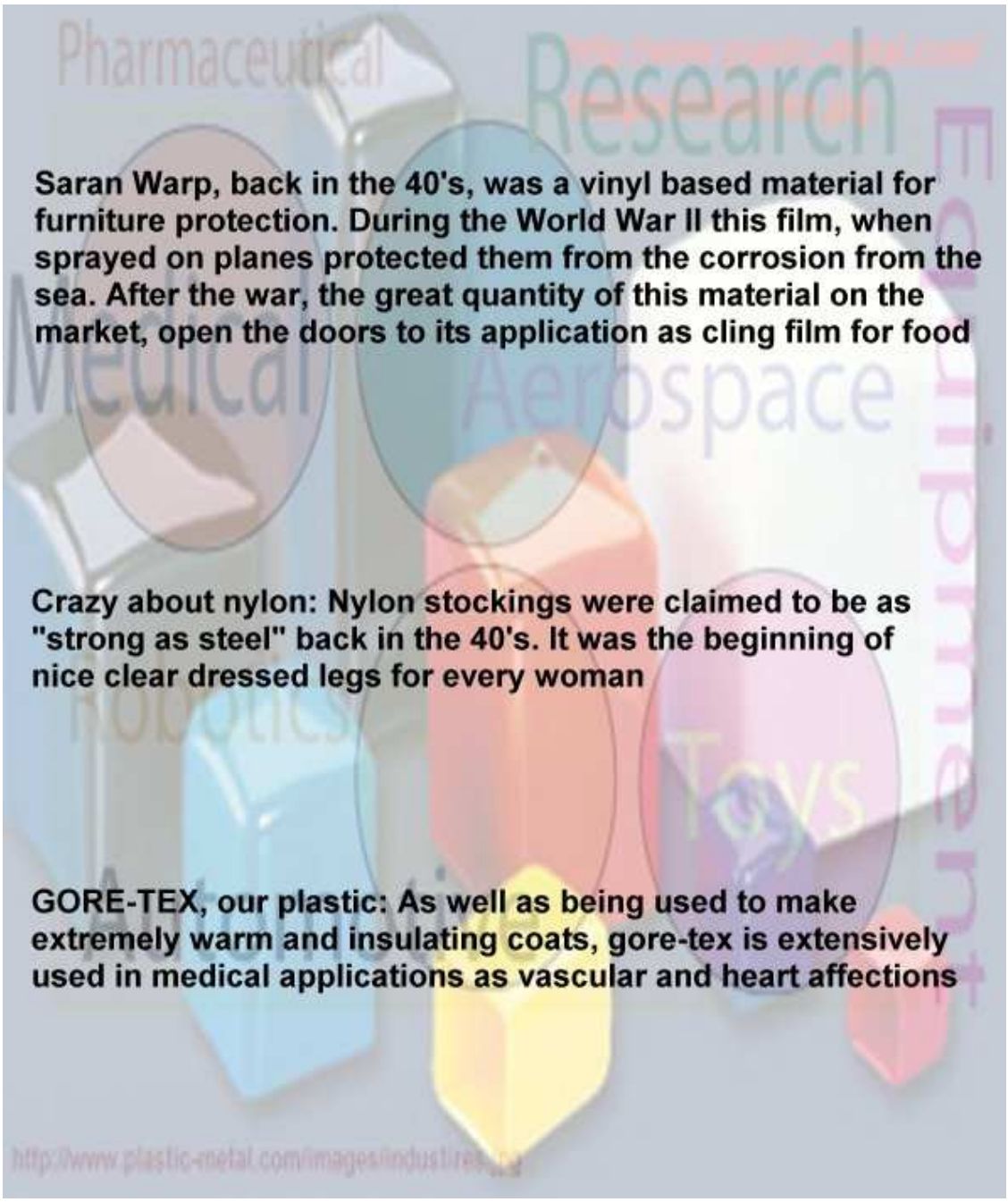
Polymers


Saran Warp, back in the 40's, was a vinyl based material for furniture protection. During the World War II this film, when sprayed on planes protected them from the corrosion from the sea. After the war, the great quantity of this material on the market, open the doors to its application as cling film for food
Crazy about nylon: Nylon stockings were claimed to be as "strong as steel" back in the 40's. It was the beginning of nice clear dressed legs for every woman
GORE-TEX, our plastic: As well as being used to make extremely warm and insulating coats, gore-tex is extensively used in medical applications as vascular and heart affections

Polymers

Activity number 14: The newest polymer (project, homework)

Polymer classification

Activity number 15: Classifying objects (project, homework)

Activity number 16: Modelling a polymer (project, homework)

Evaluation activities

All activities will be evaluated but you can also choose some on-going assessment (1/2 hour to 1 hour) such as:

- **Card game**
- **Project: recycling poster**
- **Fill in the blank and multiple choice test**
- **Rational question test**

Activity number 1: LET'S BURN POLYMERS!

Objective: A way to identify polymers by burning them

- Copy the questions your teacher has written on the board.

- Search 24 words related to polymers and to the application of polymers in the word search below.
- If you need help, ask your teacher

Polymers word search

S	H	A	N	E	E	N	O	I	T	A	S	N	E	D	N	O	C
F	A	T	E	K	Z	D	B	U	R	N	T	L	I	M	E	D	A
R	N	C	C	O	N	T	A	I	N	E	R	E	M	Y	L	O	P
Y	D	O	E	M	N	P	O	L	Y	E	T	H	Y	L	E	N	E
I	L	L	N	S	T	I	N	K	E	R	E	A	D	E	T	I	O
N	E	U	M	Y	O	G	U	R	T	N	B	A	L	E	A	C	G
G	A	E	T	A	X	T	E	P	K	O	H	E	M	A	L	F	E
L	L	A	T	D	E	T	E	X	T	U	R	E	P	A	Y	U	P
L	O	L	I	D	E	S	R	T	E	L	E	S	A	V	R	C	A
M	E	D	A	I	L	E	L	A	T	H	W	G	I	N	C	A	N
M	C	A	D	T	O	E	A	N	O	I	T	I	D	D	A	U	D
X	A	E	K	I	Z	B	E	E	N	C	Y	A	R	D	H	S	A
Q	U	E	K	V	X	F	Z	D	R	E	T	S	E	Y	T	O	O
N	I	C	E	E	P	O	L	Y	S	T	Y	R	E	N	E	W	R
E	N	I	S	E	R	N	S	R	R	E	M	O	N	O	M	T	A

- Pay attention to the correction
- Score a point for every correct word.
- Write your score ……. points out of 24.

- Prepare the identification activity by following your teacher's instructions.
- Work in pairs
- Your teacher will provide you with: a plate, a lighter, wooden test tube holders, universal pH paper and water.
- Five pieces of different types of plastic will be tested.
- Read the first grid

First grid

Object	Type of Polymer
Detergent bottle	
Yoghurt container	
Water bottle (different types)	
Decoration	
Frying pan handle	

- Look at the handout ***Classifying Polymers*** and follow your teacher's instructions to burn the pieces one by one. Do not allow them to burn completely.
- With wooden test tube holders hold the piece of detergent bottle on top of the plate and light it.
- Observe the flame and complete the first line on the grid.
- Do the same for each of the five pieces given.
- Take two other plastic pieces handed to you by your teacher.
- Burn each one and identify the polymer.
- Write what you have observed and complete the second grid.

Second grid

Object (piece)	FLAME	ASPECT	SMELL	Polymer
Protection for fruit				
Clear plastic glass (soft)				
Clear plastic glass (hard)				
Hamburger container				
Water bottle (PET)				
Water pipe				
Decoration (other colour)				

- Complete the rest of the grid using the results of other students.

Classifying polymers

Polyethylene

· Translucid or opaque

Very stable, flexible, it can be painted:
plastic bags, flexible bottles, insulate protections, packages

· Flexible, semi rigid

· Can be cut, but does not break

· Low density

· Does not react with acids and bases

· Does not react with solvents

· Thermoplastic

· **FLAME: brilliant, yellow or blue. It melts and leaks. Wax smell**

Polystyrene

· Transparent or opaque

Easy to mould, cheap, breakable:
boxes and non returnable containers (yogurts)

· Rigid or semirigid

· It can be cut, it breaks

· High density

· Does not react with acids and bases

· It will react with solvents mainly

· Thermoplastic

· **FLAME: easy to maintain. Yellow with black smoke and unpleasant smell**

PVC

· Transparent or opaque

Diverse aspect:

pipes, window blinds, plastic curtains, water bottles

· Flexible, semi-rigid

· It can be cut, does not break

· High density

· Does not react with acids and bases

· It will react with some solvents

· Thermoplastic

· **FLAME: difficult to maintain. Yellow with almost no smoke and acid vapors**

Methacrylate

· Transparent, very brilliant

Security crystals, decoration, optics

· Rigid, crystalline

· It breaks

· High density

· Does not react with polar solvents

· Thermoplastic

· **FLAME: stable, it burns without smoke. It melts and leaks. Characteristic crepitating sound. Fruity smell**

Resins PF/MF

· Brilliant or mat. PF is dark

PF: obscure (bakelite)
MF: electric material
dishware, telephone
(melamine)

· Rigid and hard

· It breaks

· High density

· PF will react with strong acids and bases

· MF will react with weak acids and bases.

· Thermostable

· **FLAME: No flame. PF smells like burnt wood and MF like ammonia.**

Activity number 2: POLYMERS FOR CONTAINERS,

POLYMERS FOR EVERYTHING

Objectives: Recognize the major polymer in everyday objects
Be aware of the diverse aspect that polymers can have

- Copy the questions your teacher has written on the board.

- Work individually.
- Answer **Polymer: true or false**

Polymer: true or false
Tick the correct option

	TRUE	FALSE
Polymers are substances formed by a large number of units, monomers		
A monomer is a complex structural unit		
There are only natural polymers		
All polymers are vegetal		
Man can modify natural polymers		
Polymers are widely used due to their properties		
A covalent bond joins simple structural units		

- Check the correct answer on the board.

- Take notes about your teacher explanation of polymers

Polymers: introduction

.....

.....

.....

.....

.....

.....

.....

Classify polymer images

- Work in pairs.
- Take the box your teacher hands you with images of plastic objects.
- Classify different images / objects according to the polymer present in the highest proportion. Remember:

Code							
Polymer Name	**Polyethylene Terephthalate (PET or PETE)**	**High density Polyethylene (HDPE)**	**Polyvinyl Chloride or Vinyl (PVC-V)**	**Low density Polyethylene (LDPE)**	**Polypropylene (PP)**	**Polystyrene (PS)**	**Other**

- Talk with your partner about the uses of different objects and their compositions, polymer wise.
- Use the English frames hung on the wall.
- Your teacher will help you.
- Evaluate from 1 to 10 (maximum) your success: …… points
- Working in pairs, complete the grid below.
- Use five different objects from the pictures given or any other.

Object	Main polymer	Advantages	Disadvantages

Are you aware that the same polymer can be used for different purposes and their aspect can differ in colour, texture, transparency, resistance, etc?

Polymers and their uses (Helping guide)

Code	Polymer Name	Uses
	**Polyethylene Terephthalate (PET or PETE)**	**Soft drink bottles, salad dressing bottles, mouth wash jars** **Recycled Products: Liquid soap bottles, fibrefill for winter coats, surfboards, paint brushes, fuzz on tennis balls, soft drink bottles, film**
	**High density Polyethylene (HDPE)**	**Milk, water, and juice containers, grocery bags, toys, liquid detergent bottles** **Recycled Products: Soft drink based cups, flower pots, drain pipes, signs, stadium seats, trash cans, re-cycling bins, traffic barrier cones, toys**
	**Polyvinyl Chloride or Vinyl (PVC-V)**	**Clear food packaging, shampoo bottles** **Recycled Products: Floor mats, pipes, hoses**
	**Low density Polyethylene (LDPE)**	**Bread bags, frozen food bags, grocery bags** **Recycled Products: Garbage can liners, grocery bags, multi purpose bags**
	**Polypropylene (PP)**	**Ketchup bottles, tubs, medicine bottles** **Recycled Products: Videocassette storage cases, ice scrapers, fast food trays, lawn mower wheels, automobile battery parts**
	**Polystyrene (PS)**	**Video cassette cases, compact disk jackets, coffee cups, cutlery, cafeteria trays, grocery store meat trays, fast-food sandwich container, yogurt and margarine** **Recycled Products: License plate holders, desk top accessories, hanging files, food service trays, flower pots, trash cans**

and  for the rest of polymers.

Activity number 3: CHECKING AT HOME (homework)

Objective: Remember what you have learnt about polymers

Gemma and her family will help you to work through the unit

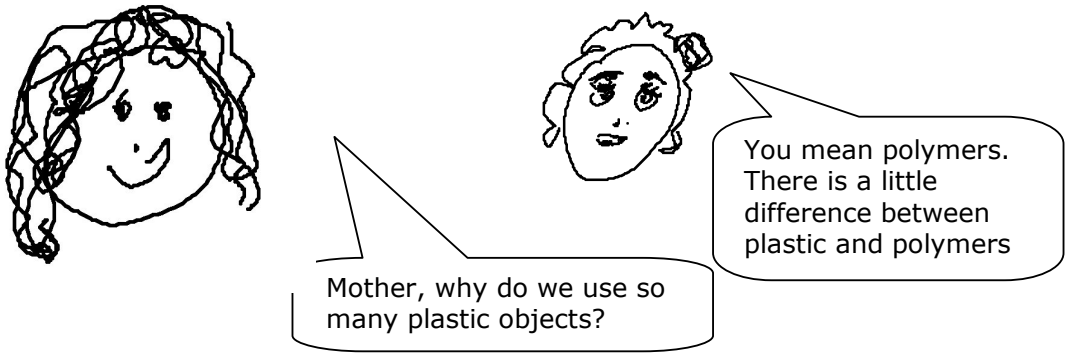
Gemma's family and friend

Name	Tecla, the mother	Timothy, the father	Gemma, the daughter	Joan, the son	Caroline, the friend
Picture					
Job / Age	Chemist scientist	Journalist	16 years old	13 years old	15 years old
Job	Catalan Research Center	TV3	4t ESO in a state school in Barcelona	2n ESO in a state school in Barcelona	4t ESO in a public school in Sant Cugat
Hobbies	Photography, classical music, and reading	Sculpture among others	Chemistry and physics, swimming and tennis, music…….	Physics and art, reading, history, swimming……..	Chemistry and biology, art and dance, photography, athletics

Homework instructions

- Read the introduction: **Arriving home, mother explains and mother inquires**
- Fill in the blanks
- Construct a linear and a cross-linked polymer with paper clip
- Draw a linear and a cross-linked polymer
- Finally as Gemma's mother asks, prepare short explanations about polymers for the class (half a page)
- You can do the homework in pairs.

Arriving home:



Mother explains:

Remember that it is impossible for us to get through a day without using dozen or more synthetic organic polymers. The word polymer means "many parts" (Greek ***poly***, meaning "many", and ***meros***, meaning "parts"). Polymers are giant molecules with molar masses ranging from thousands to millions. Our clothes are polymers; our food is packed in polymers; our appliances and cars contain a large number of polymer components.

A ..... is a substance that will melt and flow under heat and pressure and hence is capable of being moulded into various shapes. All ..... are polymers, but not all ..... are plastics. (Note: Use the words plastic and polymer)

Mother inquires:

Here Gemma, take these paper clips, make a linear polymer with them and draw it down. Now do the same for a cross – linked polymer.

LINEAR POLYMER	CROSS-LINKED POLYMER

Gemma: Does it look all right, mother?

Mother: Yes, that's good. Now prepare the explanations for your class, tomorrow. Isn't that you homework? Your teacher said half a page, right?

Activity number 4: POLYMERS IN USE (homework)

Objective: Be aware of the wide use of polymers

Homework / Project instructions:

- Look at the grid below, and note some of the fields where polymers are used.
- Follow your teacher's instructions to work in groups or individually.
- Search through the internet, and give real examples of polymer applications in these fields.
- Choose one of the fields and write you own comment about polymer application in the chosen field.
- Use frames to help you with the language.
- Ask your teacher for help to search through the internet.
- Hand the grid back to your teacher.

Agriculture	Medicine	Transport	Industry	Construction	Housing	Clothing	Packaging	Sports

Example:

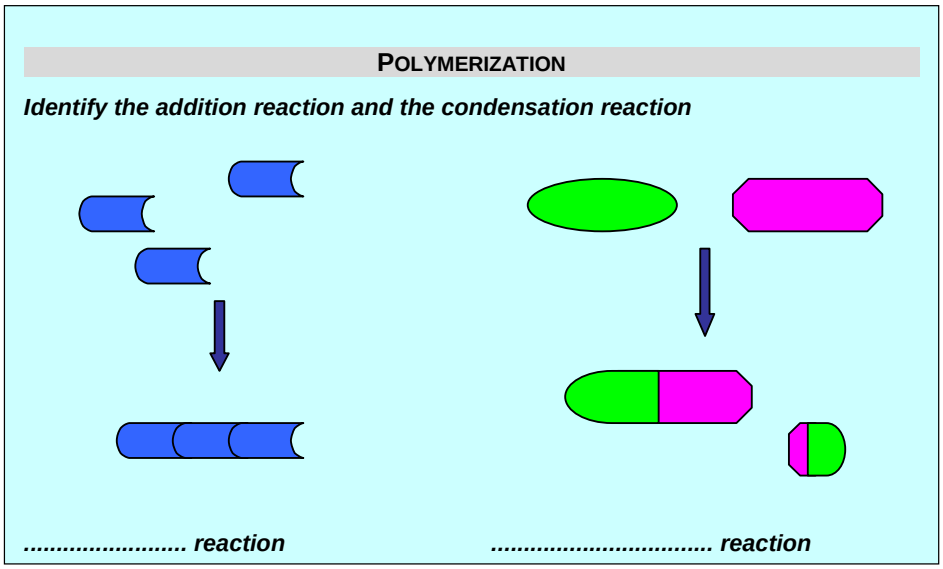
Polymer medical applications

In medicine polymers are widely used to …….

Polymer synthesis

Addition polymerization / condensation polymerization

- After your teacher's explanation, name each image: addition or condensation.



Activity number 5: BASIC IDEAS ABOUT POLYMERS

Objective: Summarize knowledge about polymers

- Copy and complete the phrases dictated by your teacher.

1.- .....

.....

2.- .....

.....

3.- .....

.....

4.- .....

.....

5.- .....

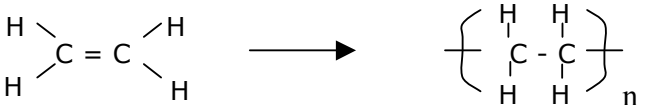
.....

Addition Polymerization

- Listen to your teacher's explanation and highlight the most important points in the text.

Gemma, Joan, pay attention

A monomer molecule in addition polymers contains one or more double bonds.
Take ethylene, the first alkene $CH_2=CH_2$.
Heated to 100 to 250ºC at 1000 to 3000 atm.with a catalyst, polyethylene is formed.

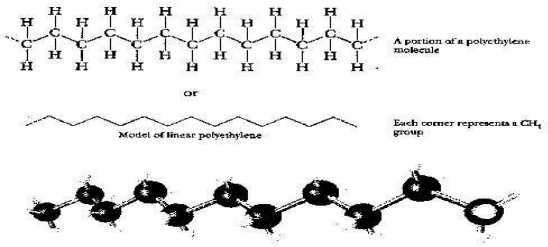


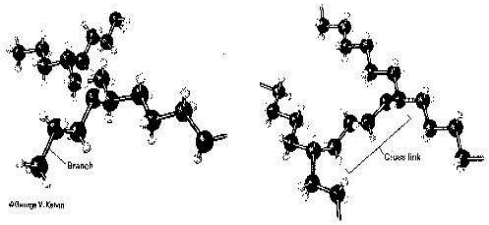
Mother is polyethylene the only polymer we use? And, what do we use it for?

Is polyethylene always the same?

Let me explain it to you:
Polyethylene is the simplest example of an addition polymer, chain-reaction polymerization. In the process, the unsaturated hydrocarbon monomer, ethylene, is changed into a long chain saturated hydrocarbon polymer, polyethylene.

Linear chains of polyethylene could be long and packed closely: high-density polyethylene (HDPE), a polymer with high density and high molar mass, is hard, tough, and with certain rigidity. Plastic bottles, like milk and soap bottles, are examples of uses of HDPE





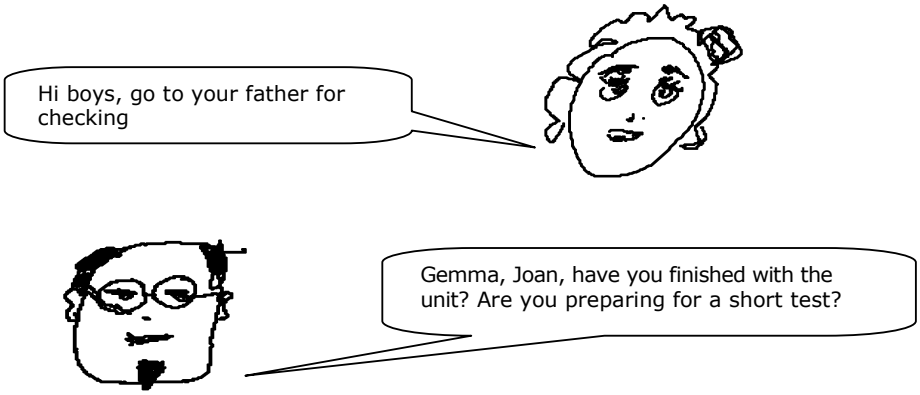
If during the polymerization we allow some lateral chains to grow; instead of linear chain polyethylene, we end up with a branched chain of polyethylene.
Branched chains of polyethylene cannot get so close together and the low-density polyethylene (LDPE), is a material with lower density, soft and flexible, ideal for plastic bags and some plastic films.

I'll look at the table of addition polymers that the teacher gave us and try to find some objects made of these polymers

Mother:

Summarizing: different monomers, differences in length, branching, and cross-linking produce different polymers with special properties for each addition polymer. Chemists try to find the right polymer with the desired properties by linking monomers through chemical polymerization.

Many of the addition polymers are copolymers. That means polymers obtained by the polymerization of two or more monomers. Styrene with butadiene is the most important synthetic rubber produced.



Activity number 6: CONSOLIDATING NEW KNOWLEDGE

- Work in threes: one student will be the father and the others, Gemma and Joan.
- Complete the sentences in the handout below.
- One of you will be "the father": reformulate the sentences as questions and ask them to "Gemma and Joan"
- The other two students will be students will "Gemma and Joan", and they answers "the father'''s questions.

1.- The individual molecules from which polymers are made are called .....

2.- Monomers must have a ..... bond in their structure if they are to participate in an addition reaction.

3.- The double bond in ethylene is converted to a ..... bond during an addition reaction.

4.- PVC is polyvinyl chloride. It is built from the monomer.....

5.- Stereoregulation catalysts are used to prepare synthetic .....

6.- Two different types of polyethylene are LDPE and HDPE

a) LDPE stands for.....

b) HDPE stands for.....

7.- Thermoplastic polymers can be affected by ..... and permit to ..... them.

8.- Thermostable polymers cannot ..... at high temperature, thus they will be used in ..... accessories.

9.- Copolymers are obtained by .....

10.- Addition polymerization usually needs high ..... and ....., and the presence of a catalyst.

- Evaluate the use of English language during the activity on a scale of 1 to 10 (maximum)

Additional activity: Article

- Write an article focussing on one addition polymer of your choice.
- Explain and write polymer addition reaction, formulas and uses of the polymer.
- You can use one or two little images.
- Write it by hand in the given space.

Polystyrene, the star of polymer addition

Activity number 7: METHYL ACRYLATE, THE MONOMER. POLYMETHYLACRYLATE, THE POLYMER

Objectives: Introduce laboratory work and laboratory language
Analyze the chemicals used and be aware of their potential danger
Consolidate knowledge about addition polymerization

- Copy the questions your teacher writes on the board.

- Listen to your teacher's explanation about addition polymerization and write a summary

Addition polymerization .....

First of all read the safety notes carefully, afterwards read the experiment and begin the laboratory work

- Work under the laboratory hood under the supervision of the teacher
- Use protection gloves and laboratory glasses and apron
- The monomer, Methyl acrylate, has an acrid odour and irritates eyes, skin, and mucous membranes; it is a lachrymator. Do not inhale the vapour.
- Both, methyl acrylate and acetone are extremely flammable; perform the experiment away from flames or other sources of heat.

1.

What to observe?

Change of temperature	
Change of visual aspect	
Velocity of this change	
Change of aspect as NaCl is added	
Physical characteristics of the product	
Solubility in acetone	

What to conclude?

Type of reaction	
Polymerization	
Reaction kinetics	
Terminate the reaction	
Polymer uses	
Type of bounding	

- Listen to your teacher's explanation about condensation polymerization and write a summary

Condensation polymerization .....

Activity number 8: FIRST REPORT

Objective: Assess new knowledge

- Copy the questions that your teacher writes on the board.

- Remember the different types of questions you can formulate:
  - recall and knowledge questions (to remember previous information)
  - comprehension questions (to express the main ideas of the new knowledge), and
  - application and analysis questions (to apply new knowledge to a everyday or hypothetic situation).
- Work in pairs.
- First, fill in the blanks.
- Afterwards, summarize the main concepts on condensation polymerization.
- Write two recall questions, two comprehension questions and two application / analysis questions about your own text.

1.- Nylon is an example of a **.....** polymer.

2.- Polyesters are formed by a **.....** reaction, called **.....**.

3.- A molecule with **.....** groups, and another molecule with two alcohol groups, can react with each other at **.....** ends.

4.- The reaction of terephthalic acid with **.....** gives a **.....** with the elimination of **.....**

5.- Dacron is an excellent substitute for **.....** in heart bypass operations, and Dacron sheets are used as a **.....** in ulcers and burn victims.

6.- Amines can be considered derivatives of **.....** and they are **.....**, similar to ammonia in strength.

7.- One well known polyamide, **.....**, has introduced a new era in the **.....** industry.

8.- The name polycarbonate comes from the linkage similarity to an

..... ion, with the formula .....

9.- Polycarbonates are tough, ... and can substitute glass due to

their capacity to .....

10.- The ..... bonding explains why nylons make such good fibers. If

the chains are linked together with ..... bonds, the strength of the

linkage does not allow nylon to stretch.

Activity number 9: TO STRETCH IS WONDERFUL

(fourth period)

Objectives: Evaluate the potential of the properties of synthetic fibres
Differentiate addition polymerization from condensation polymerization

- Review the social event that allowed every woman to wear clear stockings to show off her legs.
- Find out about the origins of nylon (you can use information handed to you by your teacher)
- Express your opinion to the rest of the class.

First of all read the safety notes carefully, afterwards read the experiment and begin the laboratory work

- Work in the laboratory hood under the supervision of the teacher
- Use protection gloves , laboratory glasses and apron
- Hexamethylenediamine and adipoyl chloride (caustic) irritates the skin, eyes, and respiratory system and sodium hydroxide is extremely caustic. The solvent, hexane is extremely flammable.

Objective

Obtain a condensation polymer from its monomers

Observe nylon proprieties

Materials and supplies:

- 10 ml of 1,6-hexanediamina, 5% solution (water soluble)
- 10 drops of sodium hydroxide, 20% solution
- 10 mL of adipoyl chloride, 5% solution in hexane
- 10 mL graduated cylinders and droppers. 100 mL beaker
- 1 metallic paper clip and glass stirring rod

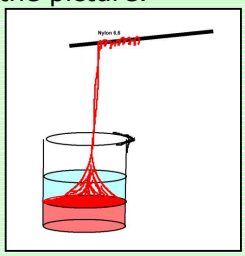
Procedure:

1. Wearing gloves, place 10 mL of 1,6-hexanediamina, 5% solution, in a 100mL or smaller beaker.
2. Add 10 drops of sodium hydroxide, 20% solution, and mix.
3. Slowly add 10 mL of adipoyl chloride (it can be used instead of adipic acid), 5% solution in hexane, to the first solution. ***Take care, both solutions should stay separate, and you should see two layers***.
4. Open a paper clip and with one end take a little bit of the substance formed between the two layers.
5. Pull it up and roll up around a glass stick as shown in the picture.
6. Look at the picture and write on it:

   a) What is in each part, top and bottom?

   b) Where does the reaction take place?

   c) What is the name of the substance produced?



7. Clean the substance you have obtained with enough water. Try to unroll and dry it with a paper towel.
8. Observe and write the name and the properties of the new product.
9. Finally, with the glass stick mix the substances in the beaker and write down what you observe.

What to observe

Change of temperature	
Change of visual aspect	
Velocity of this change	
Layers	
Where the reaction takes place	

What to conclude

Type of reaction	
Polymerization	
Reaction kinetics	
Products solubility Possible bonds	
Affection to kinetics	
Polymer uses	

▪ to learn about the origin of the name *NYLON* and to think about the urban myth search in: http://www.snopes.com/business/names/nylon.htm
▪ to carry out a short investigation about the stretching capacityof nylon, you can buy a cheap pair of stockings and stretch them as much as possible. You can work in a qualitative or quantitative way.

Chemical structure and physical properties of polymers

Chemical structure of the polymers will refer to the arrangement of the monomers in the polymer.

- Listen to your teacher's explanations about chemical structure and physical properties of polymers and take notes.
- Complete:

Chemical structure

Homopolymers .....

Copolymers .....

.....

The copolymer can lead to different configurations depending on the relative situation of the monomer:
a)

b)

c)

d)

But monomers can join forming linear chains, branched or cross-linked ones:

Linear polymers → .....

Branched polymers → .....

.....

Cross-linking polymers → .....

.....

Physical properties of polymers

Molecular weight **.....**	Melting or softening temperature **.....**
Molecular shape **.....**	Elastic properties **.....**
Chains structure **.....**	Strength / thermal stability **.....**

Elasticity (stress-strain) → .....

.....

.....

Fracture → .....

.....

.....

Hardness → .....

.....

Polymer crystalline structure

.....

.....

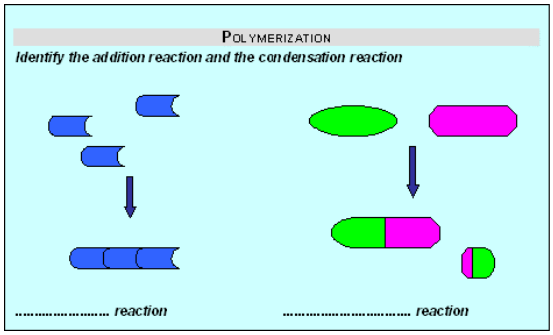
.....

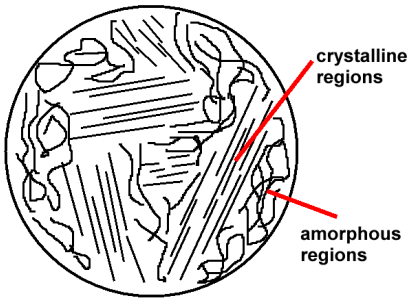
.....

Activity number 10: PAPER CLIPS TO MODEL

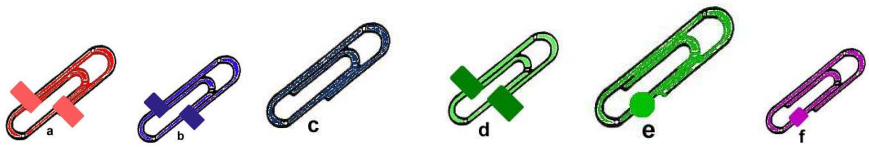
Objectives: To model addition polymers and condensation polymers
To visualise crystalline and amorphous structure
To analyse different properties

- To review addition polymerization and condensation polymerization, homopolymers and copolymers; and crystalline and amorphous structure the teacher will hang these two images on the wall.





- Work in pairs.
- Take the boxes distributed by your teacher with different colour paperclips and use them as monomer units.



- Some clips can be chained together easily to form the polymer, but for some others the two pieces of paper have to be removed. Some are simple and some have a little object attached to them.
- First you will decide which are suitable to model addition polymerization, and which condensation polymerization, and which will be monomers of branched polymers.
- According to this information decide which colour and size of paper clips will be used to model different polymers. Complete the grid: **We can form .....**

Addition polymers with	
Condensation polymers with	
Branched addition polymers with	

- Use these clips:
  - to model three addition polymers: a) a single chain polymer, b) a branched polymer, c) a cross-linked polymer, and also d) a condensation polymer.
  - draw the models on the grid or glue a photo of it.
- Now, explain to your partner the characteristics of each type of polymer.

- Finally, using linear polymers, model an amorphous region and a crystalline one, and discuss the characteristics of the two polymer structures.

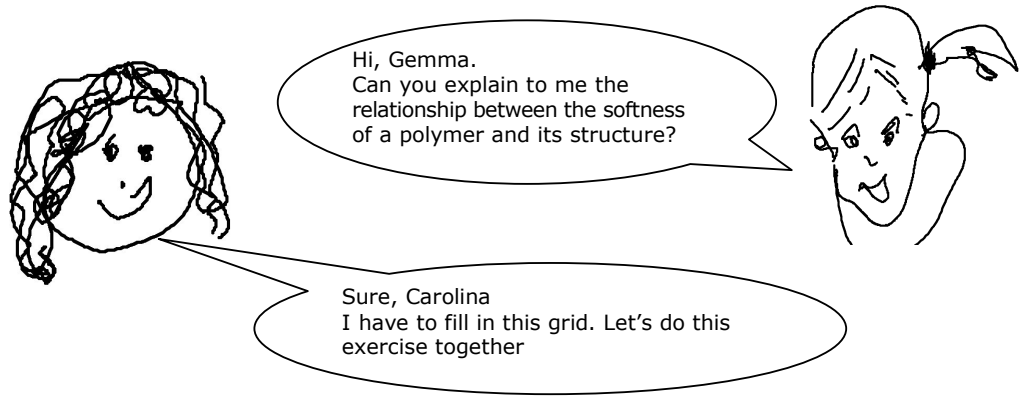
Draw the polymers proposed on this grid

Linear polymer	**Branched polymer**
Cross-linked polymer	**Condensation polymer**
Polymer structure: amorphous crystalline zones	

- Answer the following questions:
  1) Explain the difference between linear, branched and cross-linking polymers.
  2) Relate elasticity, hardness and fracture to the chemical structure of a polymer.
  3) Explain the dependence of the degree of crystalline structure in a polymer on the cooling rate.

To remember:

Read the conversation between the two friends and fill in the grid with the physical properties of polymers (second column) related to the structure of polymers (first column)
After filling the grid you can perform a conversation between the two friends. They can explain to each other the relation between the chemical structural and its characteristics and the physical proprieties of the polymers.



How to predict the strength and flexibility of polymers

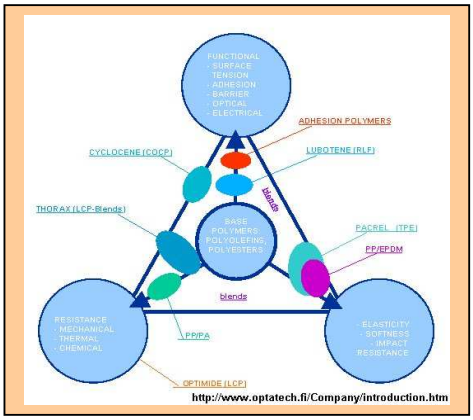
Molecular weight	Melting or softening temperature **rises**
Molecular shape	Elastic properties **increase**
Chains structure	Strength / thermal stability **rises**
Chain structure	Fracture **rises**
Chain structure	Flexibility/fluidity **decreases**

Activity number 11: PHYSICAL PROPERTIES

Objective: To analyse the effect of the oriented chains in linear polymers both in strength and their behaviour to light

- Look at the image on the wall.
- What does it mean?
  - ➢ Base Polymers

  If you analyze the situations on the image:
  - ➢ Which type of polymer is LUBUTENE®? What are the properties that make it useful?
  - ➢ Which type of polymer is OPTIMIDE ®? What are the properties that make it useful?



Pay attention to your teacher's explanation about the image and the balance between the properties represented in the three blue spheres.

Now begin the experimental activity.
Work in pairs, 10 minutes maximum.
Your teacher will give you the following materials: newspaper, cellophane tape, plastic film, and plastic bags.
The experiment with polarized light will be performed as a demonstration by the teacher.

Objective

To observe the relationship between the strenght of the polymer and the chain orientation
To visualize the relationship with polymeric chains and optical properties

Materials and supplies:

- newspaper, cellophane tape, plastic film, plastic bags
- iridescent plastic film
- polarizing lenses, and flashlight

Procedure

1. Take a sheet of newspaper and tear it, first longways and afterwards widthways. Observe the torn border. In which case it is more regular?

2. Polymers always break easily in the direction of the chain. Decide which is the direction of the natural polymer cellulose in the newspaper.

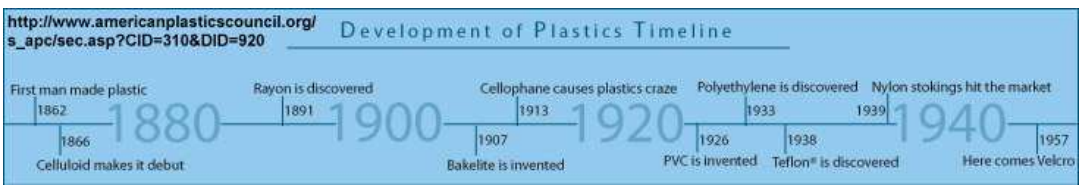
3. Do the same with a piece of cellophane tape, to observe the direction of the polymer chain.
4. Use an inexpensive 1 layer plastic bag. Try to penetrate the bag, with a pointed instrument, and tear it, first longways and afterwards widthways.
5. Write your comments in the grid below.
6. Look at the flash light through one polarizing lens. Use the second polarising lens, crossed (90 degrees to the other), to see that no light is coming through.
7. Use now pieces of plastic to show that they rotate the polarized light due to the presence of the polymer chains.
8. Place diverse strips of cellophane tape crossed randomly over a overhead transparency. See the colour appear as they rotate: polarised light.

TEAR	
Along the chain direction	**Across the chain direction**
Newspaper	
Cellophane tape	
Plastic bag	

A step to the future

The history of polymers: Polymers have always been found in nature and chemical research is carried out to improve its material properties for a wide range of uses. Remember that chemistry improvements are not only due to good luck.

See the polymer timeline proposed by ***The American Plastics Council***



Read and discuss the most important facts in the history of polymers described in the table below: **Polymer timeline**

1000 BC	Lacquer work in China
800	Records from a tree natural resin Gutta percha (Malayan)
1550	Valdes describes First reference to natural rubber: Valdes expeditions to Central America
1731	Charles Marie de la Condamine reports the use of rubber in the Amazon
1839	Charles Goodyear (USA) discovers 'vulcanisation'.
1863	Phelan and Collander, a billiard ball manufacturer, offers prize of $10,000 to find a substitute for ivory in billiard balls
1869	Hyatt brothers (USA) develop 'Celluloid'
1880	Shellac (Germany) used to produce phonograph
1884	Louis Bernigaud discover Rayon
1903	Stern and Charles Topham develop production of viscose (artificial silk).
1905	J. Edwin Brandenberger invents 'Cellophane'.
1909	Leo Baekeland (USA) patents Bakelite (thermoset)
1910	Herbert Faber and Daniel O'Conor (USA) first produced 'Formica'
1922	Hermann Staudinger (Germany) synthesizes rubber.
1926	PVC is discover Hermann Staudinger (Germany) starts its works on 'macromolecules'
1929	Dunlop Rubber Co. (Britain) produces the first foam rubber.
1930	BASF / I.G.Farben (Germany) develops polystyrene and Dow Chemical Co. (USA) polystyrene.
1931	Carothers develops Neoprene. Imperial Chemical Industries - ICI (Britain) develops polyethylene.
1933	ICI workers (R.Hill and J.W.C. Crawford) start synthesis of poly(methyl methacrylate) or PMMA
1934	Wallace Hume Carothers at Du Pont (USA) develops nylon
1938	Roy Plunkett (Du Pont) accidentally discovers PTFE (polytetrafluoroethylene).
1941	I.G.Farbenindustrie (Germany) starts polyurethanes production Announcement of first commercial PET polymer
1942	'Super Glue' (methyl cyanoacrylate) discovered by Dr Harry Coover (Kodak)
1949	'Lycra' is invented by Joe Shivers (DuPont).
1952	PVC appear - replacing shellacs and phenolic polymers in records.
1953	First production of high density polyethylene (Du Pont). Karl Ziegler (Germany) and Giulio Natta (Italy) develop metal ion catalysts for regular polymerization Hermann Staudinger wins Nobel Prize for Chemistry for the study of polymers. Herman Schnell at Bayer first synthesizes polycarbonate
1963	Ziegler and Natta share Nobel Prize for Chemistry for the synthesis of polymers.
1974	Oil crisis: 300% increase in price of crude oil prices increase.
1983	ICI and Bayer launch PEEK, PES and PPS (thermoplastics)
1990	Warner Lambert develops Novon and ICI launches Biopol (bio-degradeable plastics)

2000	New polymers emphasis is now on composites to improve polymer properties.

Now a Power Point presentation (*Polymer_History.ppt)* can be use as a basic presentation, complete it with images and text to create your own.

Activity number 12: EXPLAINING THE HISTORY OF POLYMERS

Objectives: To realise the importance of polymers in our world
To know some of the greatest steps in chemical synthesis

A 2nd presentation will be made to make students aware of the importance of polymers.
Project instructions:

- Make a Power Point presentation about some important fact or a relevant scientist in the history of polymers. For exemple:
  - One polymer, natural or man made: Natural Rubber, Shellac, Polystyrene, Cellulose Nitrate or Celluloid, Polytetrafluoroethylene or Teflon, Nylon, Neoprene, or Saran Wrap
  - Or one of the scientists that has worked on polymers: Leo Hendrick Baekeland, Wallace Hume Carothers, Charles Goodyear, John Wesley Hyatt, Giulio Natta, Hermann Staudinger, or Karl Ziegler.
- Work in threes.
- Power Point presentation: between 12 to 16 slides, images, schema, chemical clues, and short text.
- The project will be done in groups of three and last one week. At the end of the project you will evaluate your own work using the following grid.

Project Evaluation		**Student 1**	**Student 2**	**Student 3**
No more that 16 slides	1 point			
Title name and introduction	1 point			
Uniform clear style	1 point			
Reference and bibliography	1 point			
Chose of representative facts	2 points			
Relevance of images	2 points			
Personal explanations	2 points			
Student own proposed park (orientative)				
Increase of 10 % due to global evaluation	max. 1 point			
Final mark (maximum)	11 points			

Activity number 13: MAKE THE RIGHT DECISION

Objectives: To design some research to be done at home
To decide the most sustainable option, using scientific knowledge

Instructions for an optional project to be done at home in groups of three.
Which will be the most sustainable option?
The use of paper or plastic bags
The use of disposal or cotton diapers

Remember that your research has to include:

- A reasonable and argued hypothesis.
- Materials used and experimental process.
- Observation notes followed during the research.
- Conclusions (led by these observations) and discussion.
- Final recommendations.

- The project will be done in groups of three and last one week. At the end of the project you will evaluate your own work using the following grid.

Project Evaluation		**Student 1**	**Student 2**	**Student 3**
Complete explanation	1 point			
Title name and presentation	1 point			
Scientific methods applied	2 point			
Argued hypothesis	2 point			
Reliance between observation and conclusions	2 points			
Final discussion and recommendations	2 points			
Student own proposed park (orientative)				
Increase of 10 % due to global evaluation	max. 1 point			
Final mark (maximum)	11 points			

Activity number 14: THE NEWEST POLYMER (optional project)

Objective: To analyse the future of polymers

- Copy the questions on the board.

Polymers, the future

Polymers proprieties can be changed by using polymers derivatives of composites. Therefore, a large number of materials are developed for food processing and packaging, health, housing, transportation and construction. In addition to polymer uses and due to its particular modified properties, they have an important role as structural materials, well-known in orthopedics, trauma and, in general, in medical applications.

- Work in pairs. Using the text above write: 2 comprehension questions, 2 analysis questions and 2 synthesis questions.
- Answer the questions.

Comprehension

Question 1: .....

.....

Answer: .....

.....

Question 2: .....

.....

Answer: .....

.....

Analysis

Question 3: .....

.....

Answer: .....

.....

Question 4: .....

.....

Answer: .....

.....

Synthesis

Question 5: .....

.....

Answer: .....

.....

Question 6: .....

.....

Answer: .....

.....

Skin Substitutes

First read the text:

Skin is the largest organ in the body and its loss is an important medical problem that occurs, yearly, to millions of people.
In case of skin loss there are two important medical points:

Solve the problem and replace the skin

In minor affections skin from the patient is used to replace the damaged zone, but larger surfaces need donors. In this situation, skin from a human donor or other species is being used with limited success, due to rejection problems or the short supply of human donors.
Useful skin and skin substitute, as well, have to meet the following requirements:

Be bacterially balanced
Allow nutrition and hydration
Keep the zone vascularized

In addition, it needs a suitable cosmetic and functional effect.
Skin substitute research is a new field. Nowadays, there are some skin substitutes that provide temporary coverage for tissue: protection and stimulation. Furthermore, these substitutes minimize the rejection problems and transmission of diseases from the donor.
Approaches to the use of skin substitutes consist of synthetic polymers or collagen products that act as a matrix to human cell culture. Therefore, these are the cells that secrete the growth factors that allow the tissue to be repaired.

Two current products[1] on the market are:

Dermograf®, Smith and Nephew Inc.
Fibroblasts culture on a synthetic absorbable matrix.

Transcyte®, Smith and Nephew Inc.
A two layer semi-permeable product that allows fluid and gas exchange. The inner layer presents a high adherence to human tissue.

Integra®, Integra Life Sciences (Allied with Johnson and Johnson)
Bilayer, biodegradable matrix, made of a porous matrix of fibers of cross-linked fibers with a controlled porosity and degradation rate. The temporary epidermal substitute layer is made of synthetic polysiloxane polymer (silicone) with a moisturizing function.

Write a short article about one new polymer or new research on polymers.
First you can search the internet for two or more articles about a new polymer of your choice. The article should include the answer to the following questions:

- What do they tell us about the use of plastic in the article?
- Who is explaining it?
- What are the properties that determine the use of a plastic?
- What is improved by using a plastic?

…….., a step to the future

[1] Information base on http://woundhealer.com/Sknsub/Skin%20Sub%201.htm

Polymer classification

Take notes about the teacher explanation to complete the following text.

Types of Polymers

Plastics .....

.....

All plastics are polymers but not all polymers are plastics

Fibres .....

Elastomers .....

.....

Thermoplasts .....

.....

.....

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Thermosets .....

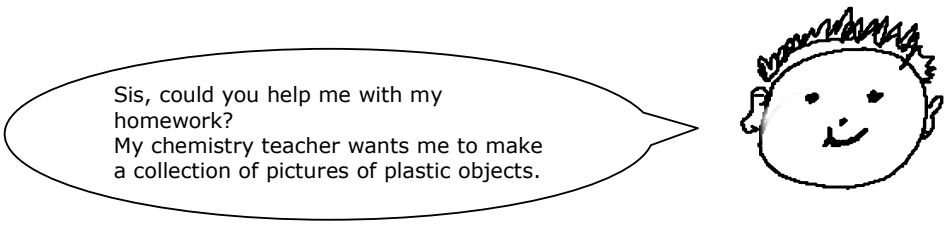
.....

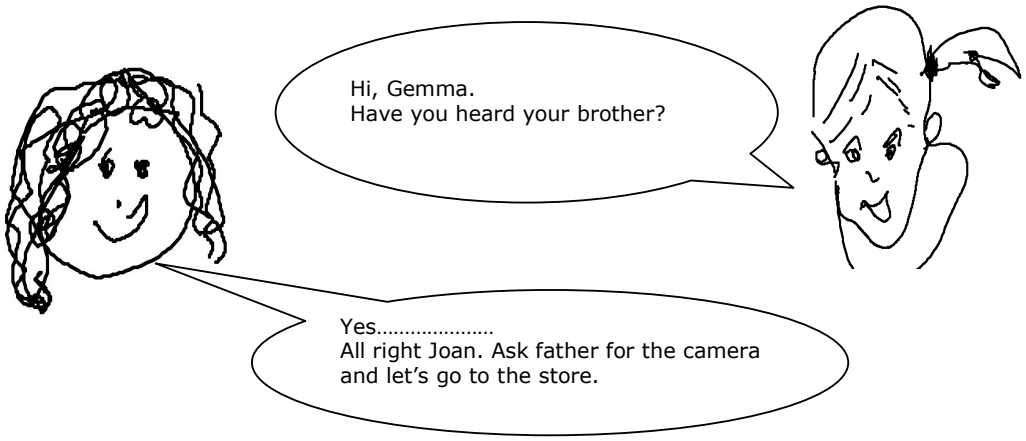
.....

.....

Activity number 15: IN THE STORE NEXT DOOR (homework, optional)

Objective: To revise knowledge and identification of polymers





- Do you homework individually.
- Look around at some grocer's or discount store for some plastic objects and what are they used for. (Remember that a plastic object does not have to look like it is made of plastic)
- With a digital camera take photos of the objects chosen.
- In a text document copy the grid below as many times as objects chosen.
- In the grid use: a) big space for the photo and the name of the object, b) small space for the polymer symbol and polymer name on the spaces besides, and finally, in the last space, the use of the object.
- If you can not use a digital camera you can draw the object to describe it.

Note: Plastic could be painted, like some decorative figure, or even can look metallaized. Remember that most paint, glues, etc are polymers, and that nature is full of polymeric structures.

Grid

Activity number 16: MODELLING A POLYMER

Objectives: To observe properties of thermoplastic polymers
To analyse processing of thermoplastic polymers

- Review the difference between thermoplastic and thermoset polymers. Write on the board
- Copy the questions on the board.

- Answer these two questions:
  - Can a thermoplastic polymer be used in electrical accessories? Why? Why not?

.....

.....

  - Which ones, thermoplastics or thermosets can be easily recycled?

.....

.....

- Explain the difference between thermoplastic and thermoset polymers to you partner.

Now you will do some easy laboratory work with your partner. A thermoplastic polymer that can be moulded at low temperature will be used. It only needs hot water to soften and, therefore, it can be moulded by hand.

- The teacher will distribute the materials, including a small amount of Shapelock[2] polymer. With this polymer you will mould a little object.

Objective

Apply thermoplastic polymer proprieties

Observe processing and recycling possibilities of a thermoplastic polymer

Materials and supplies:

- Kettle to heat water
- 250 mL beaker, forceps and thermometer

[2] Shapelock polymer can be ordered through the URL http://www.shapelock.com/

Procedure

1. Design a little figure about 1 cm^3 to mould.
2. Pour some hot water in the beaker and control the cooling temperature.
3. At 60ºC introduce the thermoplastic polymer into the hot water to soften it.
5. Once soft enough take it out of the hot water using forceps and mould the figure with your hands.

Discussion

Discus with your partner which polymer properties allow us to work in this way, and what would be the uses of such a polymer. Focus on two questions:

- Can every thermoplastic polymer be moulded by hand?
- Why can this polymer be moulded so easily?