

Non Mettalic Engineering Materials

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"I just want to say one word to you -- just one word -- 'plastics.'"

Advice to Dustin Hoffman's character in *The Graduate*

INTRODUCTION

❖ A WORD POLYMER IS A COMBINATION OF TWO GREEK WORDS, "POLY" MEANS "MANY" AND "MEROS" MEANING "PARTS OR UNITS".

A POLYMER IS A LARGE MOLECULE OF WHICH IS FORMED BY REPEATED LINKING OF THE SMALL MOLECULES CALLED "MONOMERS".

MORE MONOMER MOLECULES JOINED IN UNITS OF LONG POLYMER.

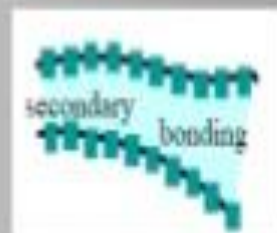


CLASSIFICATION BASED ON SOURCE

- 1. NATURAL POLYMERS:** THE DEFINITION OF A NATURAL POLYMER IS A POLYMER THAT RESULTS FROM ONLY RAW MATERIALS THAT ARE FOUND IN NATURE. EXAMPLE:- PROTEINS, CELLULOSE, STARCH, RUBBER.
- 2. SEMI-SYNTHESIS POLYMERS:** CELLULOSE DERIVATIVES - CELLULOSE ACETATE (RAYON).
- 3. SYNTHESIS POLYMERS:** BUNA-S, BUNA-R, NYLON, POLYTHENE, POLYESTER.

CLASSIFICATION BASED ON STRUCTURE

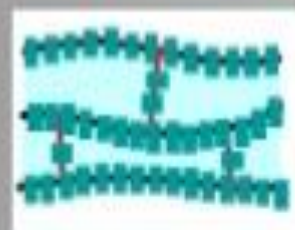
- 1. LINEAR POLYMERS:-** CONSIST OF LONG AND STRAIGHT CHAINS. EXAMPLE:- PVC
- 2. BRANCHED CHAIN POLYMERS:-** CONTAIN LINEAR CHAINS HAVING SOME BRANCHES, E.G., LOW DENSITY POLYMER.
- 3. CROSS LINKED CHAIN POLYMERS:-** FORMED FROM BI-FUNCTIONAL AND TRI-FUNCTIONAL MONOMERS AND CONTAIN STRONG COVALENT BONDS E.G. BAKELITE, MELAMINE.



LINEAR



BRANCHED



CROSS-LINKED

CLASSIFICATION BASED ON MOLECULAR FORCE

1. **NYLON**:- NYLON IS USED AS GENERAL NAME FOR ALL SYNTHETIC FIBER FORMING POLYAMIDES, I.E., HAVING A PROTEIN LIKE STRUCTURE. THESE ARE THE CONDENSATION POLYMERS OF DIAMINES AND DIBASIC ACIDS A NUMBER IS USUALLY SUFFIXED WITH THE NYLON WHICH REFERS TO THE NUMBER OF CARBON ATOMS PRESENT IN THE DIAMINE AND THE DIBASIC ACIDS RESPECTIVELY.

EXAMPLE: **NYLON 6,6**

NYLON-6,6: NYLON-6,6 IS OBTAINED BY THE POLYMERISATION OF ADIPIC ACID WITH HEXAMETHYLENE DIAMINE.



2. THERMOPLASTIC POLYMERS:-

THESE ARE LINEAR OR SLIGHTLY BRANCHED LONG CHAIN POLYMERS, WHICH CAN BE SOFTENED ON HEATING & REVERSIBLY HARDENED ON COOLING REPEATEDLY. THEIR HARDNESS IS A TEMPORARY PROPERTY & VARIES WITH TEMPERATURE.

EXAMPLE:- POLYVINYL CHLORIDE.

POLYVINYL CHLORIDE:- IT IS A VINYL POLYMER CONSTRUCTED OF REPEATING VINYL GROUPS (ETHENYLS) HAVING ONE OF THEIR HYDROGENS REPLACED WITH A CHLORIDE GROUP.

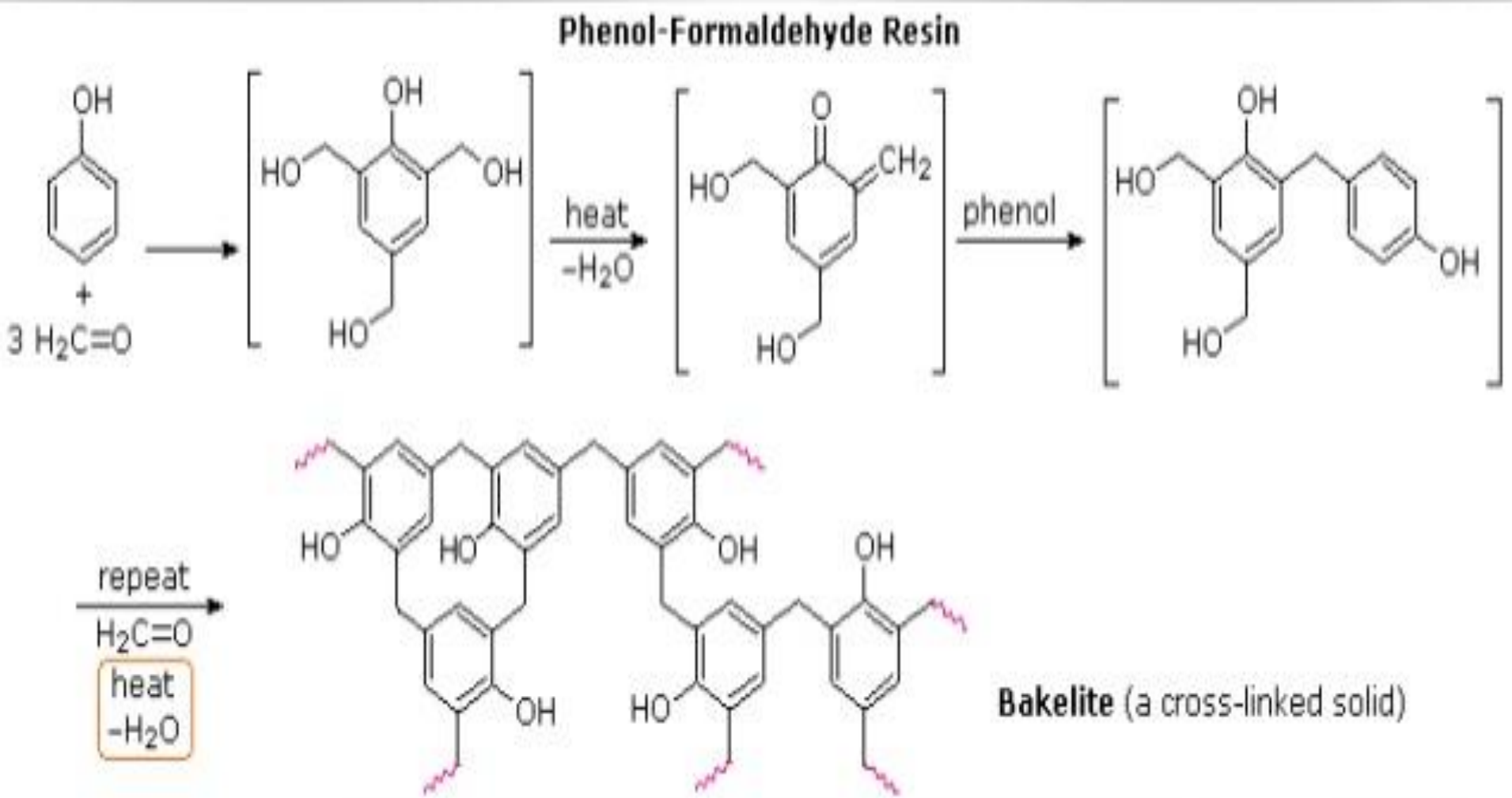


3. THERMOSETTING POLYMERS:-

INITIAL MIXTURE OF REACTIVE, LOW MOLAR MASS COMPOUNDS REACTS UPON HEATING IN THE MOLD TO FORM AN INSOLUBLE, INFUSIBLE NETWORK.

EXAMPLE: BAKELITE

BAKELITE: BAKELITE IS FORMED OF PHENOL AND FORM-ALDEHYDE POLYMERIZATION.



TYPES OF POLYMERIZATION

1. ADDITION POLYMERIZATION

2. CONDENSATION POLYMERIZATION

3. ADDITION POLYMERIZATION:-

- ❑ THE POLYMER IS FORMED FROM THE MONOMER, WITHOUT THE LOSS OF ANY MATERIAL, AND THE PRODUCT IS THE EXACT MULTIPLE OF THE ORIGINAL MONOMERIC MOLECULE.
- ❑ ADDITION POLYMERIZATION PROCEEDS BY THE INITIAL FORMATION OF SOME REACTIVE SPECIES SUCH AS FREE RADICALS OR IONS AND BY THE ADDITION OF THE REACTIVE SPECIES TO THE OTHER MOLECULE, WITH THE REGENERATION OF THE REACTIVE FEATURE.

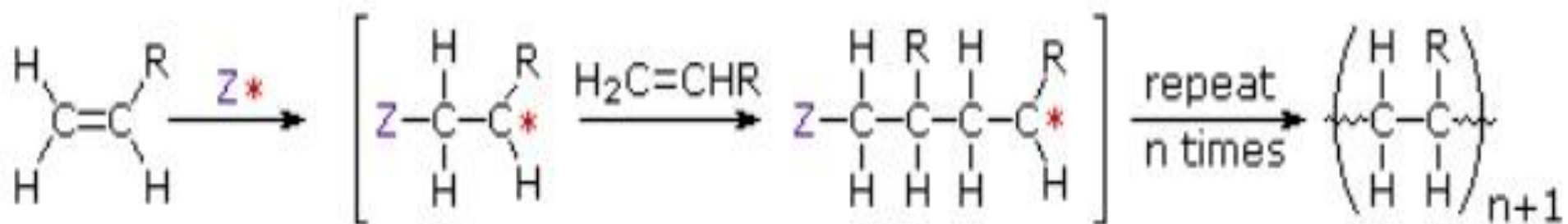
1. FREE RADICAL MECHANISM: ALKENES OR DIENES AND THEIR DERIVATIVES ARE POLYMERIZED IN THE PRESENCE OF A FREE RADICAL GENERATING INITIATOR (CATALYST) LIKE BENZOYL PEROXIDE, ACETYL PEROXIDE, T-BU PEROXIDE, ETC.

THIS PROCESS INVOLVES THREE STEPS:-

A) CHAIN INITIATION STEP - ADDITION OF PHENYL FREE RADICAL FORMED BY THE PEROXIDE TO THE ETHENE DOUBLE BOND, THEREBY FORMING A LARGER RADICAL.

B) CHAIN PROPAGATION STEP - REPETITION OF THIS SEQUENCE WITH NEW AND BIGGER RADICALS.

C) CHAIN TERMINATING STEP - THE PRODUCT RADICAL THUS FORMED REACTS WITH ANOTHER RADICAL TO FORM THE POLYMERIZED PRODUCT.



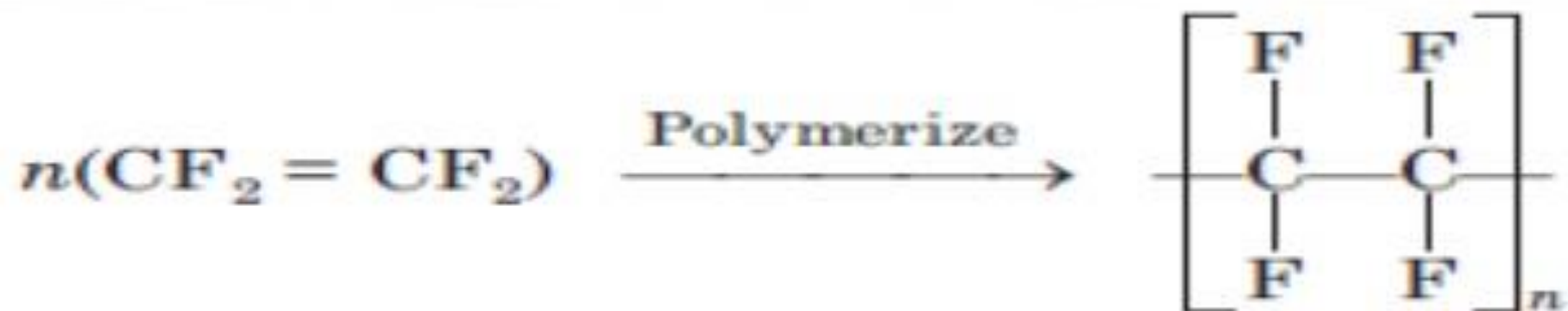
Z* is an initiating species

* may be a radical, a cation or an anion

EXAMPLE: POLYTETRAFLUOROETHYLENE (TEFLON)

TEFLON:-

IT IS OBTAINED BY POLYMERIZATION OF WATER-EMULSION OF TETRAFLUORO ETHYLENE, UNDER PRESSURE AND IN THE PRESENCE OF BENZOYL PEROXIDE AS A CATALYST.



2. CONDENSATION POLYMERIZATION:-

PROCESS IN WHICH TWO MONOMERS REACT TO FORM A LARGER MOLECULE AND **ELIMINATE A SMALLER MOLECULE** (USUALLY WATER, AMMONIA, METHANOL OR HYDROGEN CHLORIDE).

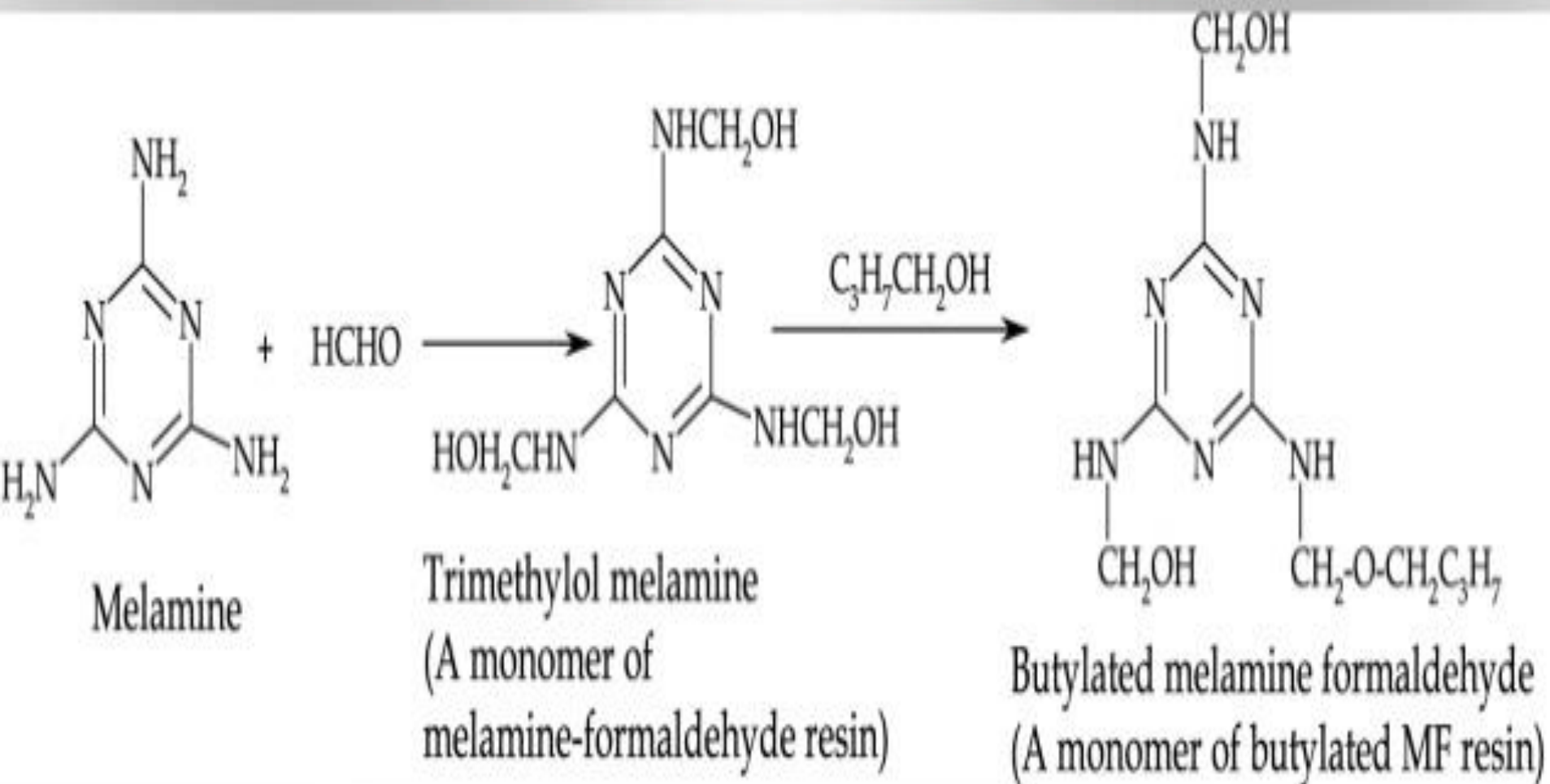
IT ALSO CALLED AS **STEP-GROWTH** POLYMERIZATION.

EXAMPLE:-

1. POLYAMIDE:- NYLON 6-6, NYLON 6.
2. POLYESTER:- TERILIN
3. BAKELITE POLYMER
4. MALEIN POLYMER

MELAMINE POLYMER

THE RESIN IS FORMED BY CONDENSATION CO-POLYMERISATION OF MELAMINE AND FORMALDEHYDE.



CHARACTERISTICS OF POLYMER

- LOW DENSITY.
- LOW COEFFICIENT OF FRICTION.
- GOOD CORROSION RESISTANCE.
- GOOD MOULD ABILITY.
- EXCELLENT SURFACE FINISH CAN BE OBTAINED.
- CAN BE PRODUCED WITH CLOSE DIMENSIONAL TOLERANCES.
- ECONOMICAL.
- POOR TENSILE STRENGTH.
- LOW MECHANICAL PROPERTIES.
- POOR TEMPERATURE RESISTANCE.
- CAN BE PRODUCED TRANSPARENT OR IN DIFFERENT COLOURS

APPLICATION OF POLYMERS

- 1. MEDICINE:-** MANY BIOMATERIALS, ESPECIALLY HEART VALVE REPLACEMENTS AND BLOOD VESSELS, ARE MADE OF POLYMERS LIKE DACRON, TEFLON AND POLYURETHANE.
- 2. CONSUMER SCIENCE :-** PLASTIC CONTAINERS OF ALL SHAPES AND SIZES ARE LIGHT WEIGHT AND ECONOMICALLY LESS EXPENSIVE THAN THE MORE TRADITIONAL CONTAINERS. CLOTHING, FLOOR COVERINGS, GARBAGE DISPOSAL BAGS, AND PACKAGING ARE OTHER POLYMER APPLICATIONS.
- 3. INDUSTRY -** AUTOMOBILE PARTS, WINDSHIELDS FOR FIGHTER PLANES, PIPES, TANKS, PACKING MATERIALS, INSULATION, WOOD SUBSTITUTES, ADHESIVES, MATRIX FOR COMPOSITES, AND ELASTOMERS ARE ALL POLYMER APPLICATIONS USED IN THE INDUSTRIAL MARKET.
- 4. SPORTS:-** PLAYGROUND EQUIPMENT, VARIOUS BALLS, GOLF CLUBS, SWIMMING POOLS AND PROTECTIVE HELMETS ARE OFTEN PRODUCED FROM POLYMERS.

THANK YOU

