

Ultrahigh Molecular Weight Polyethylene (UHMWPE)

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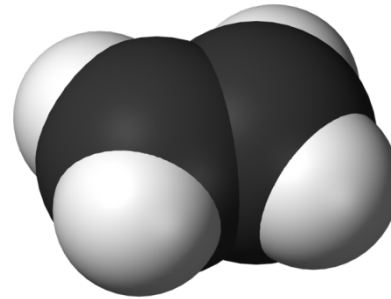
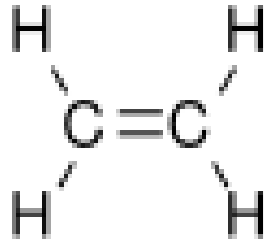


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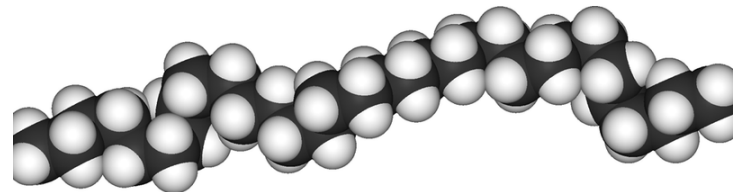
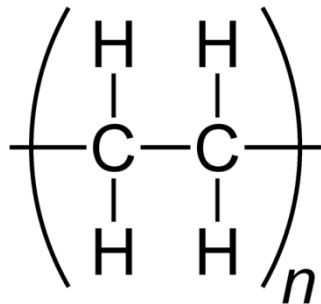


Polyethylene: Introduction

- Polyethylene is a thermoplastic polymer.
- Monomer is Ethene (C_2H_4 or $CH_2=CH_2$).
- Ethene:



- Polyethylene:



Polyethylene: Classification

On the basis of branching, crystal structure, density and the molecular weight, polyethylene is classified as:

- Ultra high molecular weight polyethylene (UHMWPE)
- Ultra low molecular weight polyethylene (ULMWPE)
- High molecular weight polyethylene (HMWPE)
- High density polyethylene (HDPE)
- High density cross-linked polyethylene (HDXLPE)
- Cross-linked polyethylene (PEX or XLPE)
- Medium density polyethylene (MDPE)
- Linear low density polyethylene (LLDPE)
- Low density polyethylene (LDPE)
- Very low density polyethylene (VLDPE)

Contd...



Polyethylene: Classification

Types	Mol. Weight (g/mol)
Common Linear Polyethylene	1,00,000 - 2,00,000
High-Molecular Weight Polyethylene	3,00,000 - 5,00,000
Ultra High-Molecular Weight Polyethylene	20,00,000 - 60,00,000



Ultrahigh Molecular Weight Polyethylene

- Chain can consist of as many as 2,00,000 ethylene repeat units
- Molecular weight up to 20,00,000 – 60,00,000 g/mol
- Melting temperature is low (132-138 °C)
- Specific gravity = 0.925–0.945
- Commercially available in form of powders, fibres and sheets; commonly under tradenames Spectra and Dyneema

Carbon

Hydrogen



Synthesis:

UHMWPE is processed in following steps:

- I. **Polymerization:** From Ethylene Gas to UHMWPE Powder
- II. **Conversion:** From UHMWPE Powder to Consolidated Form
- III. **Machining**



Synthesis: Polymerisation

Ziegler process:

- using Ziegler-Natta catalyst i.e. titanium chloride, (TiCl_4) and triethylaluminium, $\text{Al}(\text{C}_2\text{H}_5)_3$
- lower temperatures (about 60°C) and pressures (about 1 atm.)
- long straight-chain molecules is formed in powder form



Synthesis: Conversion

UHMWPE is processed from powder using the following methods:

- compression molding
 - ram extrusion
 - gel spinning
 - sintering
- ❖ Due to its high mol. weight, it doesn't flow or melt in normal manner. So, fabrication is based on *compression molding technique*.

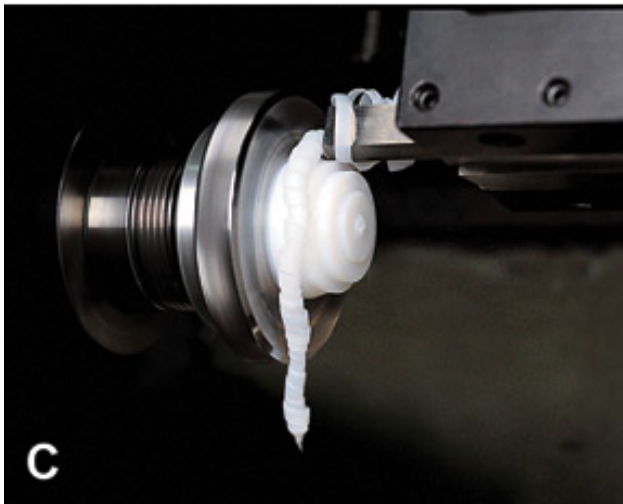


Synthesis: Overview

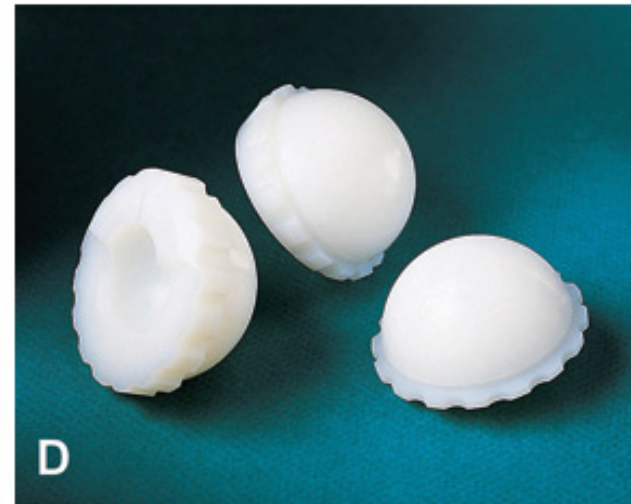
Powder form



Semi-finished rod



Machining of rods on a lathe



UHMWPE components
after machining



Characteristics:

- **High impact strength:** the long chain transfer load more effectively
- **Highly resistant to corrosive chemicals** with exception of oxidizing acids
- **Low moisture absorption**
- **Low coefficient of friction:** lower than that of nylon and acetal
- **Self-lubricating and nonstick surface**

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Characteristics:

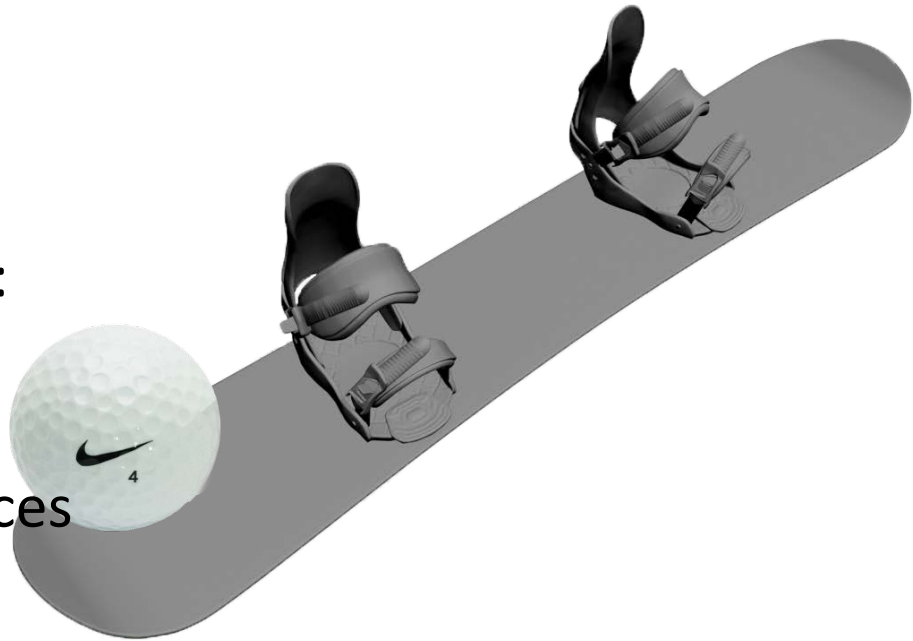
- **Highly resistant to abrasion:** 15 times more resistant to abrasion than steel
- **Electrically insulating**
- **Excellent dielectric properties**
- **Odorless, tasteless and non-toxic**
- **Excellent low-temperature properties**
- **High sound damping and energy absorption**



Applications:

In sports industries:

- Golf ball cores
- Ski-bottom surfaces
- Fishing lines
- Snowboards
- Bow strings
- Climbing equipment
- Spear guns



Contd...



Applications:

In defence industries:

- Bullet proof vests
- Military helmets
- Suspension lines on parachutes and paragliders
- Cut resistant gloves



Contd...



Applications:

In **medical industries:**

- Total joint replacement
- Spine implant
- Hip replacement
- Blood filters



References:

1. <http://science.jrank.org/pages/20795/Ziegler-process.html>
2. http://plastics.inwiki.org/Liquid_Crystal_Polymer
3. http://en.wikipedia.org/wiki/Ultra_high_molecular_weight_polyethylene
4. <http://www.mitsuichemicals.com/mipelon.htm>
5. 'Material Science' By S.L. Kakani, Page-579



THANK YOU 😊

