KMM6111 Polimer Yapı ve Özellikleri

Güz -2020

- Gün/Saat Salı 09:00 – 12:00
- Sınıf : Online

Ofis saatleri :

Değerlendirme : Geçme notunuz aşağıdaki şekilde belirlenecektir.

Ödev …….. % 15
Quiz……. %15
Ara Sınav …… % 30
Final……% 40

Dersler : Ekim : 6, 13, 20,27 Kasım : 3, 10, 17, 24 Aralık :1, 8, 15, 22, 29

Ara Sınavlar : 17 Kasım ve 22 Aralık

Final : Daha sonra ilan edilecek

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Kapsam

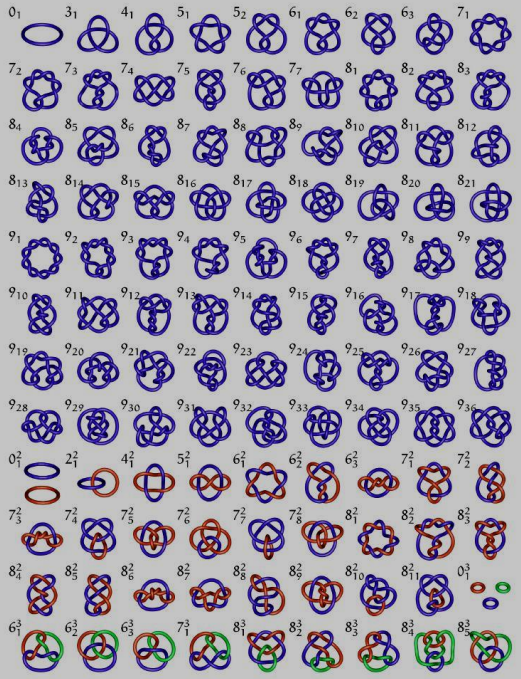
- Polimerlerin fiziksel özelliklerine dair temel kavramlar,
- polimer zincirlerinin konfigurasyonu ve konformasyonu,
- polimer çözeltilerinin termodinamiği, çözelti karakterizasyonu,
- polimerlerin amorf ve kristal halleri,
- polimer reolojisi
- polimerlerin mekanin özellikleri

Molekül Ağırlığı

Kimyasal Yapı ve polimer morfolojisi

Değerlendirme, karakterizasyon, polimerlerin analizi

POLİMERLERİN YAPI VE ÖZELLİKLERİ



- Principle of Polymer Systems
  Ferdinand Rodriguez, 2015

- Introduction to Polymers
  R.J.Young, P.A.Lovell, 1992

Tanım

- Tekrar eden birime göre

  Monomer : tek birim
  Oligomer : bir kaç birim
  Polimer : pek çok birim (poli : çok, mer : kısım)

  Makromer : (Makro monomer : monomerlerden oluşan uzun zincirler

Telechelic Polimer : reaktif uç grup içeren polimerler (tele : uzak, chelic : pence)

Telechelic oligomer : reaktif uç grup içeren oligmer

- 1833 : Berzelius, the first use of terminology, polymer
- 1839 : Synthesis of polystyrene
- 1860s : Poly(ethylene glycol), Poly(ethylene succinate)
- 1900s : Leo Baekeland, synthesis of phenol formaldehyde resin
- 1920s : Hermann staudinger

  Structure of polymer(long-chain molecules), Novel Prize(1953)
- 1939 : W.H. Carothers, Nylon synthesis (Du Pont)
- 1963 : Ziegler-Natta, stereoregular polymerization
- 1974 : Paul Flory, polymer solution property
- 1984 : Bruce Merrifield, solid-phase protein process

Selected Chronology of Polymer Science and Technology

1770	Priestley is said to have given rubber its name because it can erase pencil marks
1806	Gough (England) experiments with elasticity of natural rubber
1838	Regnault (France) polymerizes vinylidene chloride via sunlight
1839	Goodyear (the United States), Macintosh and Hancock (England), vulcanization (cross-linking) of natural rubber
1859	Joule (England) demonstrates thermodynamic principles of elasticity of rubber
1860s	Molding of natural plastics such as shellac and gutta-percha
1868	Hyatt (the United States), celluloid (cellulose nitrate-molded articles)
1891	Chardonnet (France), regenerated cellulose via nitrate
1893–1899	Cross, Bevan, Beadle, and Stearn (England), viscose rayon fbers
1907	Baekeland (the United States), phenol–formaldehyde resins
1910	First rayon plant in the United States
World War I	Cellulose acetate solutions (*dope*) for aircraft
	Laminated plywood and fabric construction for aircraft fuselages
1884–1919	Emil Fischer (Germany) establishes formulas of many sugars and proteins
1920	Staudinger (Germany) advances macromolecular hypothesis
1928	Meyer and Mark (Germany) measure crystallite sizes in cellulose and rubber
1929	Carothers (the United States) synthesizes and characterizes condensation polymers
1920s	Cellulose nitrate lacquers for autos
1924	Cellulose acetate fbers
1926	Alkyd resins from drying oils for coatings

1926	Alkyd resins from drying oils for coatings
1927	Poly(vinyl chloride)
	Cellulose acetate plastics
1929	Polysulfde (thiokol) rubber
	Urea–formaldehyde resins
1930–1934	Kuhn, Guth, and Mark (Germany) derive mathematical models for polymer confgurations; theory of rubber elasticity
1931	Poly(methyl methacrylate) plastics
	Neoprene (Duprene) synthetic rubber
1936	Poly(vinyl acetate) and poly(vinyl butyral) for laminated safety glass
1937	Polystyrene
	Styrene–butadiene (Buna 5) and acrylonitrile–butadiene (Buna N) rubbers (Germany)
1938	Nylon 6,6 fbers
1939	Melamine–formaldehyde resins
	Poly(vinylidene chloride)
1940	Butyl rubber (the United States)
1941	Polyethylene production (England)
1942	Unsaturated polyesters for laminates
World War II	Debye, light scattering of polymer solutions
	Flory, viscosity of polymer solutions
	Harkins, theory of emulsion polymerization
	Weissenberg, normal stresses in polymer fow
	Silicones
	Fluorocarbon resins
	Polyurethanes (Germany)
	Styrene–butadiene rubber (the United States)
	Latex-based paints
1944	Carboxymethyl cellulose
	Filament winding
1945	Cellulose propionate
	Dielectric heating of polymers
	Fiber-reinforced boats
1946	Screw-injection molding
	Automatic transfer molding
1947	Epoxy resins
1948	ABS polymers
1950	Polyester fbers

1948–1950	Acrylic fbers
1949	Blow-molded bottles
1950	Poly(vinyl chloride) pipe
1950s	Ziegler, coordination complex polymerization
	Natta, tacticity in polymers
	Szwarc, living polymers; interfacial polycondensation
	Hogan and Banks, crystalline polypropylene; fuidized bed coating
1953	Staudinger receives the Nobel prize
1954	Polyurethane foams (the United States)
	Styrene–acrylonitrile copolymers
1955	Williams–Landel–Ferry equation for time–temperature superposition of mechanical properties
1956	Linear polyethylene
	Acetals [poly(oxymethylene)]
1957	Polypropylene
	Polycarbonates
1957	Keller and Till, single crystals of polyethylene characterized
1958	Rotational molding
1959	Chlorinated polyether
	Synthetic *cis*-polyisoprene and *cis*-polybutadiene rubbers
1960	T. Smith, the failure envelope
1960	Ethylene–propylene rubber
	Spandex fbers
1962	Phenoxy resins
	Polyimide resins

1965	Poly(phenylene oxide)
	Polysulfones
	Styrene–butadiene block copolymers
1960s	Cyanoacrylate adhesives
	Aromatic polyamides
	Polyimides
	Silane coupling agents
	Thermoplastic elastomers (block styrene–butadiene copolymers)
	NMR applied to polymer structure analysis
	Maxwell, orthogonal rheometer
	Moore, Gel permeation chromatography (GPC) analysis for molecular weight distribution
	Differential scanning calorimetry
	Marvel, polybenzimidazoles
	Gilham, torsional braid analysis
	Ethylene–vinyl acetate copolymers
	Ionomers
	Natta and Ziegler share the Nobel prize (1963)
	Polysulfone
	Parylene coatings
	HDPE fuel tanks

1970s	Polybutene (isotactic)
	Poly(butyl terephthalate)
	Thermoplastic elastomers based on copolyesters
	Poly(phenylene sulfde)
	Polynorbornene (rubber)
	Polyarylates
	Polyphosphazenes
	Soft contact lenses
	Reaction injection molding
	Interpenetrating networks
	High-performance liquid chromatography
	Submicrometer lithography for integrated circuits
	Polyester beverage bottles
	Structural foams
	Kevlar aromatic polyamide
	Poly(ethersulfone)
	Reaction injection molding for auto fascia
	Unipol gas-phase polymerization
	Linear low-density polyethylene
	Polyarylates
	High-density polyethylene grocery bags
	Flory receives the Nobel prize (1974)

1980s	Polysilanes
	Liquid crystal polymers
	High-modulus fbers
	Poly(etheretherketone)
	Conducting polymers
	Polyetherimide
	Poly(methylpentene)
	Pultrusion
	Replacement of fuorocarbon blowing agents
	Group transfer polymerization
	Differential viscometry
1990s	Metallocene catalysts
	Large-scale recycling of polyester and HDPE bottles
	Poly(ethylene-2,6-naphthalene dicarboxylate)
	Living cationic polymerization (Kennedy)
	Syndiotactic polystyrene commercialized
	Styrene–ethylene copolymers
	Nanocomposites
	de Gennes receives the Nobel prize (1991)
2000	Heeger, MacDiarmid, and Shirakawa share the Nobel prize

ABS, acrylonitrile butadiene styrene; HDPE, high-density polyethylene; NMR, nuclear magnetic resonance.

polimer endüstrisini etkilemeye devam edecek faktörler???

Büyük hacimli plastikler otomobillerde, mobilyalarda ve konutlarda giderek daha fazla kullanım alanı bulacak

Elektronik, ilaç ve diğer alanlarda özel uygulamalar için polimerler geliştirimeye devam edecek

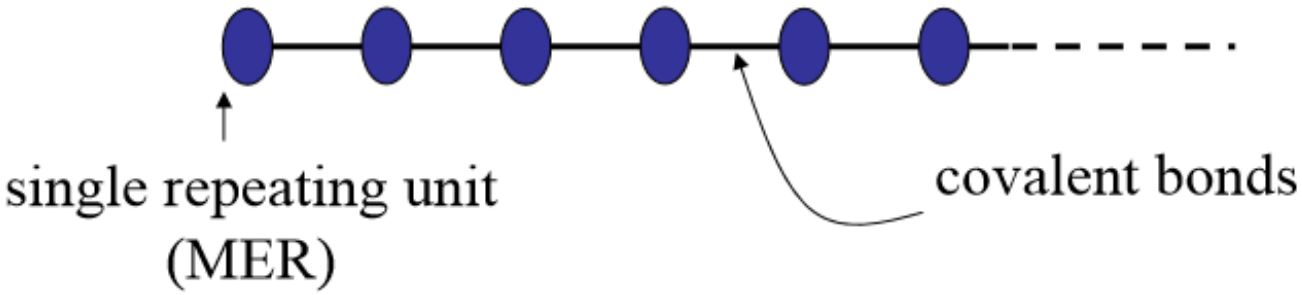
Üretim teknikleri daha verimli ve daha çevre dostu hale gelecek

Hammaddelere erişim, polimer endüstrisi oluşturma

Gelişmekte olan ülkelerdeki polimer tüketimi, dünyadaki polimerlerin ortalama tüketimi sanayileşmiş ülkelerdeki kullanımın çok gerisindedir.

H. Staudinger (1920's) colloidal ass'y vs. molecule

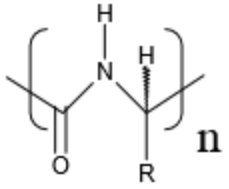
"MACROMOLECULAR HYPOTHESIS"



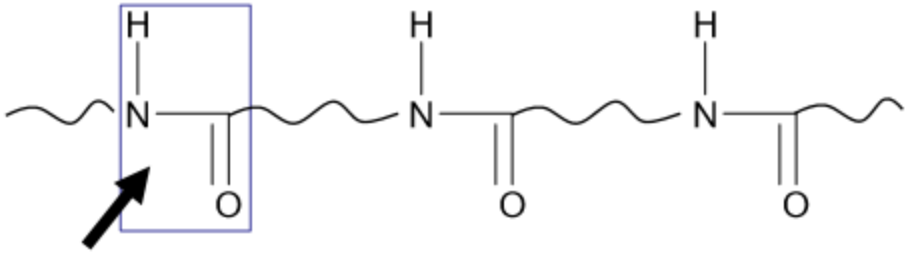
A SINGLE REPEAT UNIT → MONOMER (M)
MANY REPEAT UNITS → POLYMER $(M)_n$

"Macromolecule" - more general term than polymer

Proteins are "decorated nylon 2"

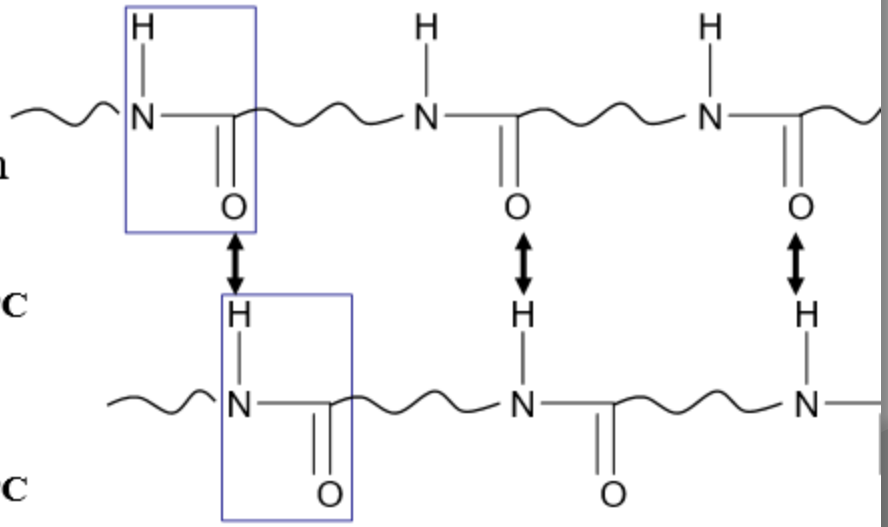


R = various side groups
(20 possible amino acids)
R = H → glycine
R = CH_3 → alanine, etc.



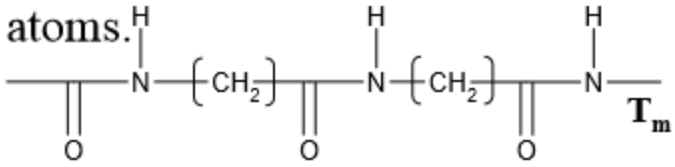
amide linkage

- Members of the nylon family are named by counting the number of carbon atoms in the backbone between nitrogen atoms.



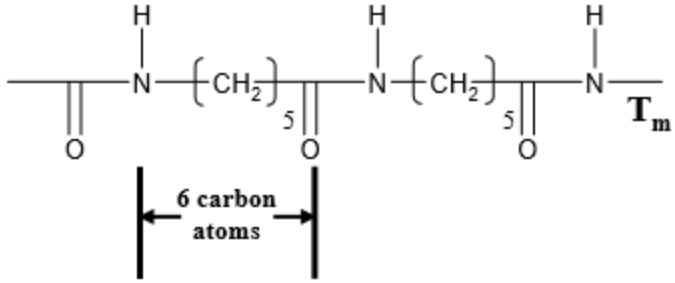
Hydrogen bonds

nylon 2



$T_m > 300°C$

nylon 6



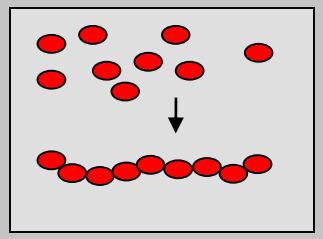
$T_m = 215°C$

note nylon n=∞ = polyethylene (!)

$T_m \sim 140°C$

Monomer ve Polimer

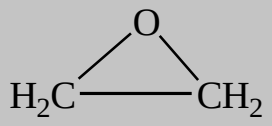
Monomer



Polimer

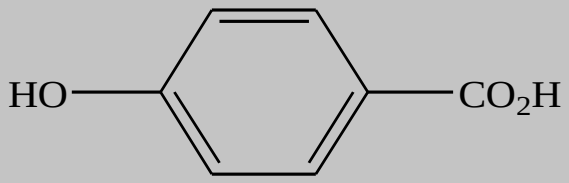
$CH_2=CH_2$ $\quad$ $-[CH_2CH_2]-$

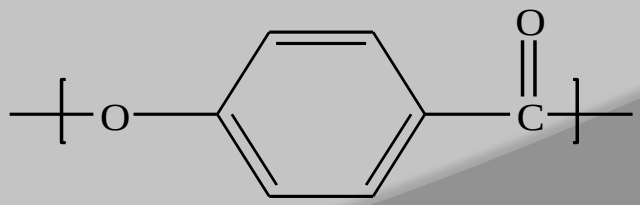
$CH_2=CHCl$ $\quad$ $-[CH_2CH_2]-$ (Cl)



$-[CH_2CH_2O]-$

$HOCH_2CH_2OH$ $\quad$ $-[CH_2CH_2O]-$



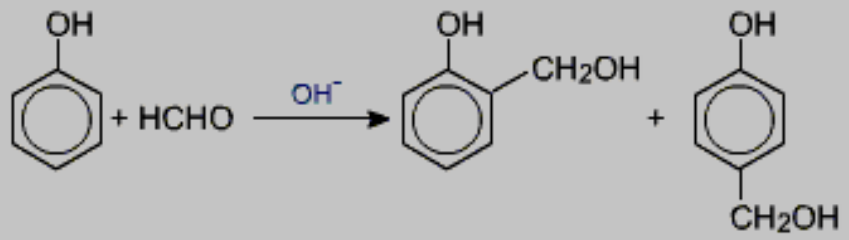


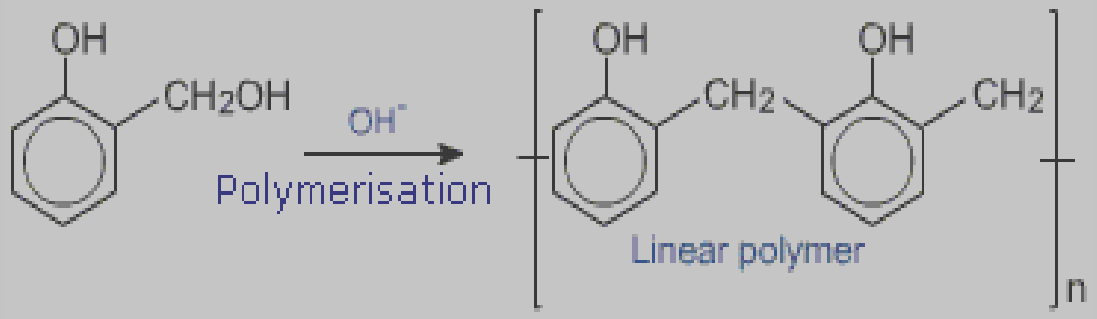
Polimer : monomer olarak adlandırılan pek çok küçük molekülden oluşmuş uzun bir zincir molekül

Makromolekül /1920 Staudinger

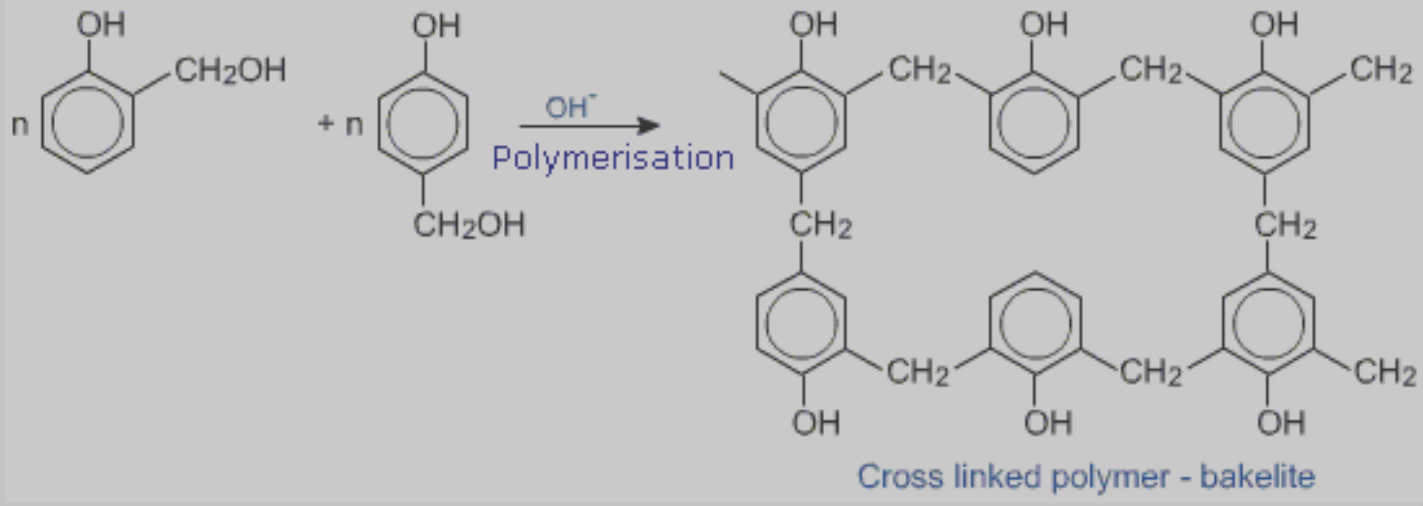
1907 /fenol + formaldehit

- Bakalit (1910 Leo Hendrik Baekeland)

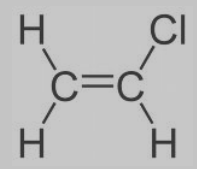


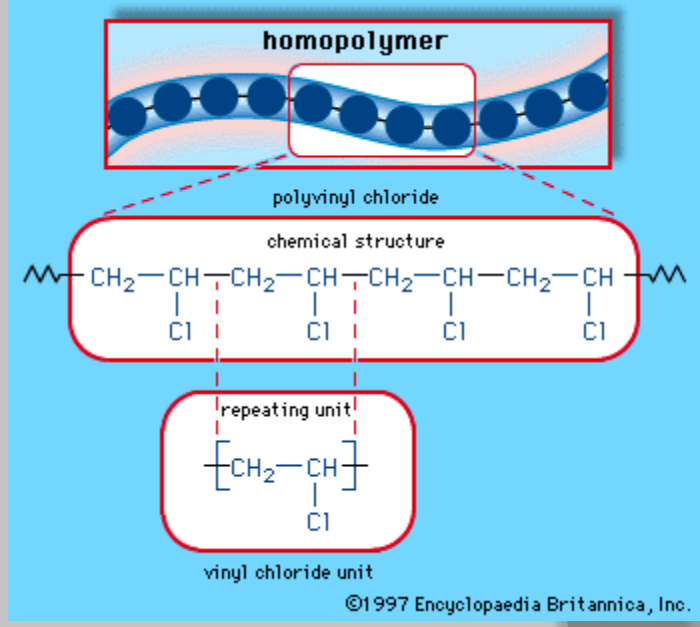


called Novalac

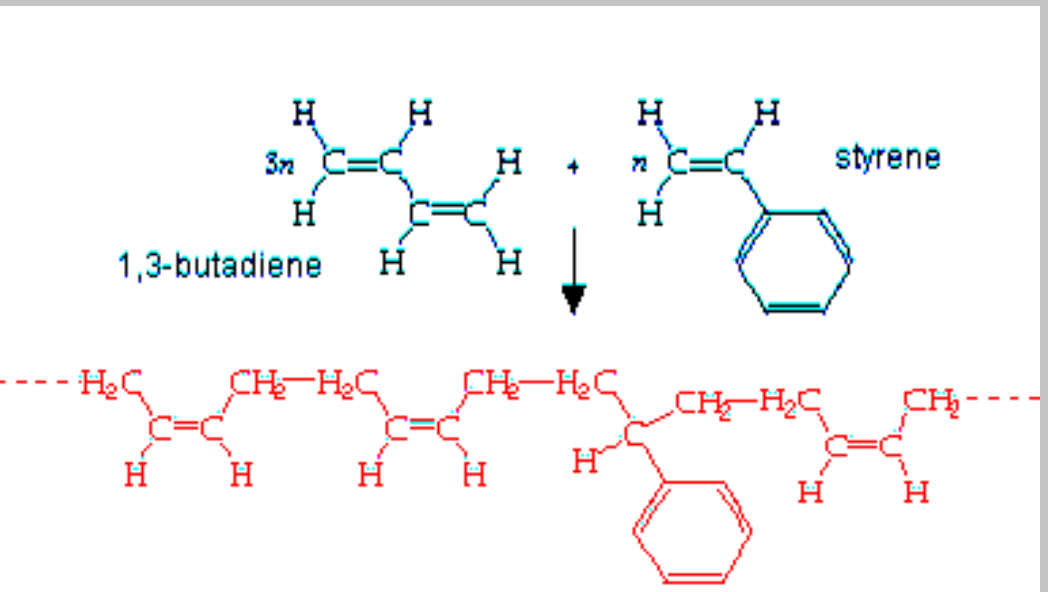


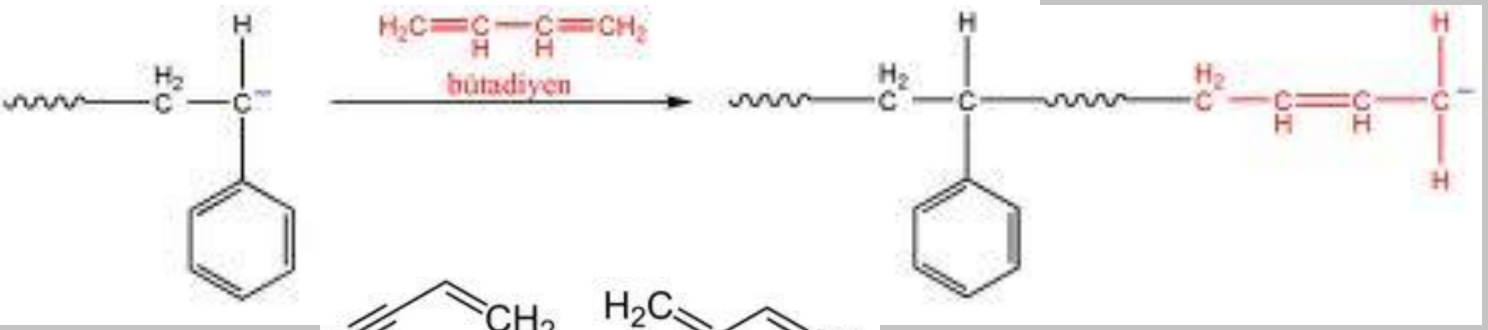
PVC Polivinil klorür

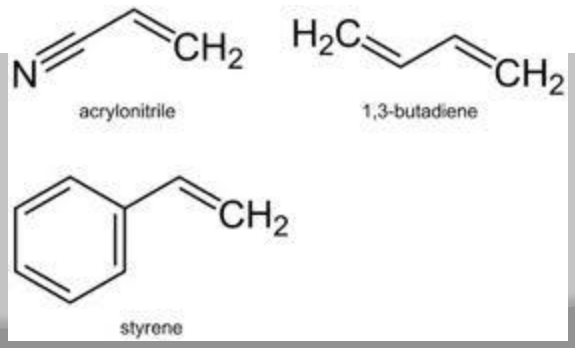


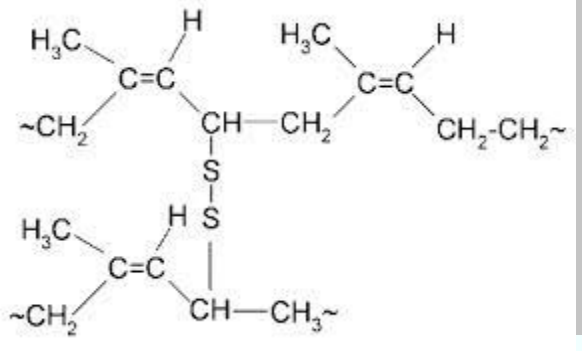


Stiren- Budadien Kauçuğu

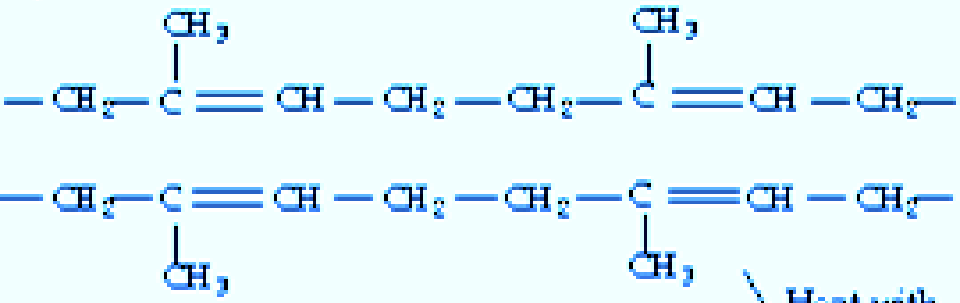


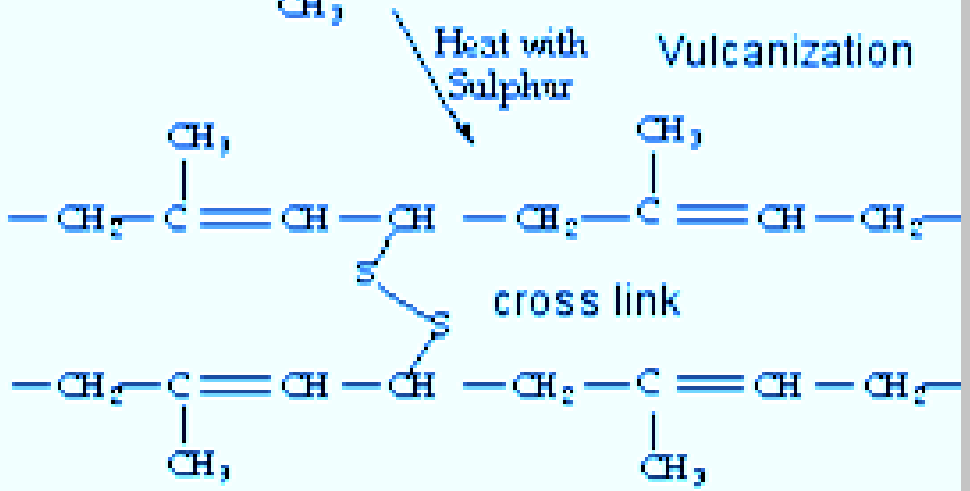


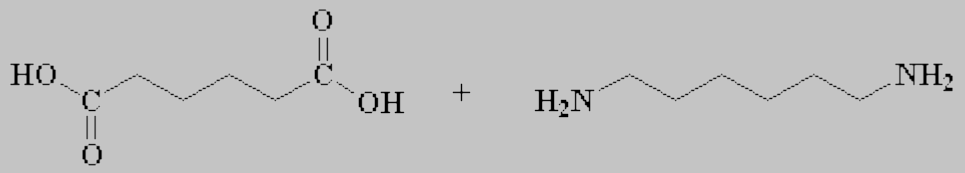




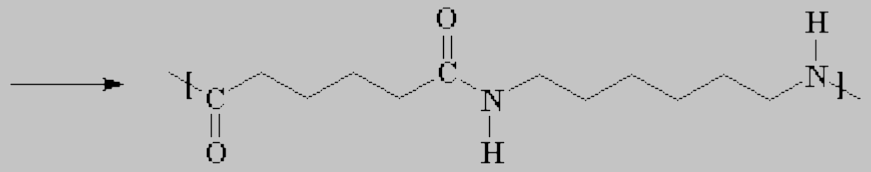
isoprene monomer unit



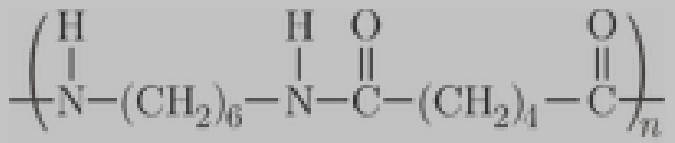




adipic acid + hexamethylene diamine



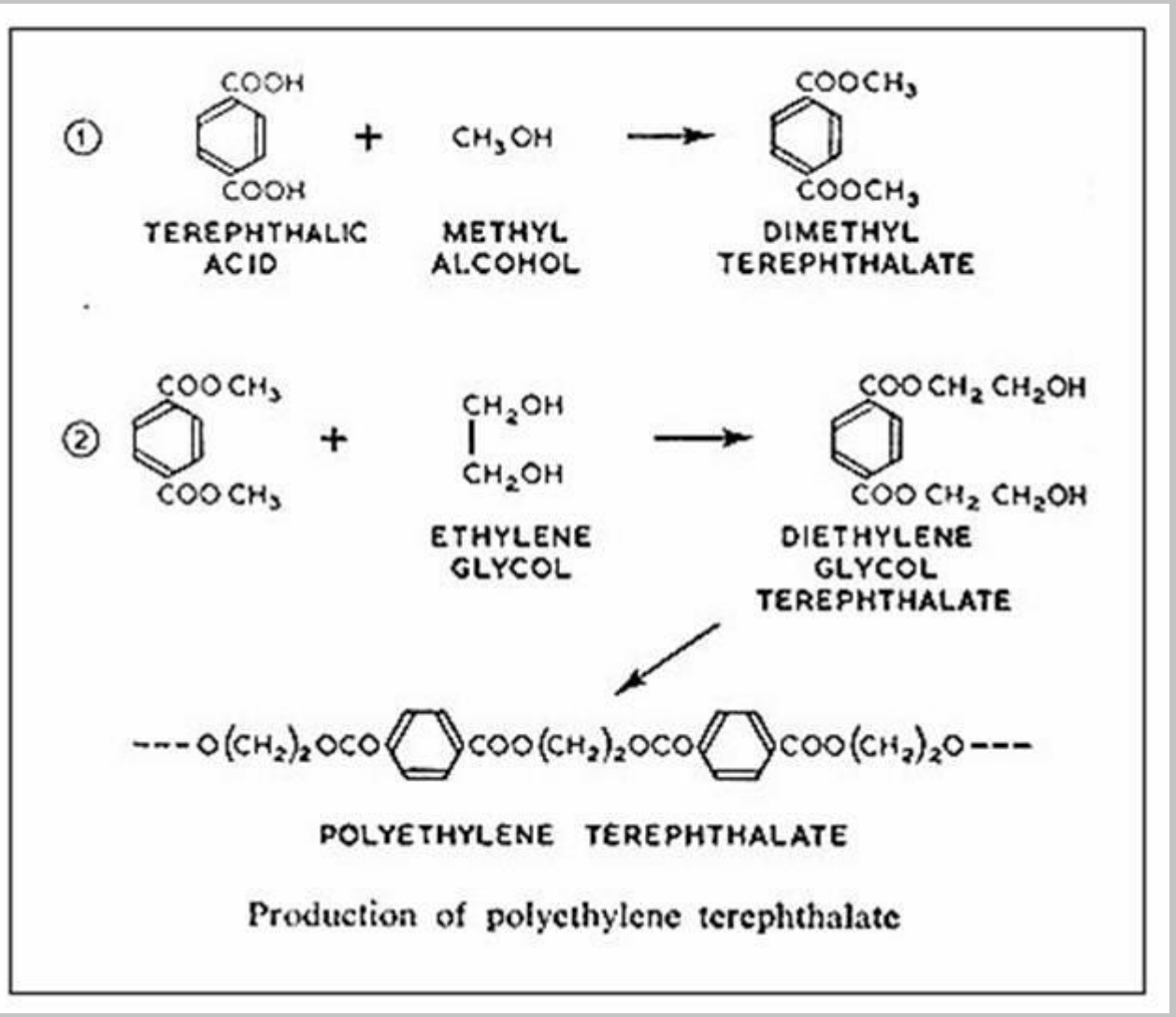
nylon 6,6



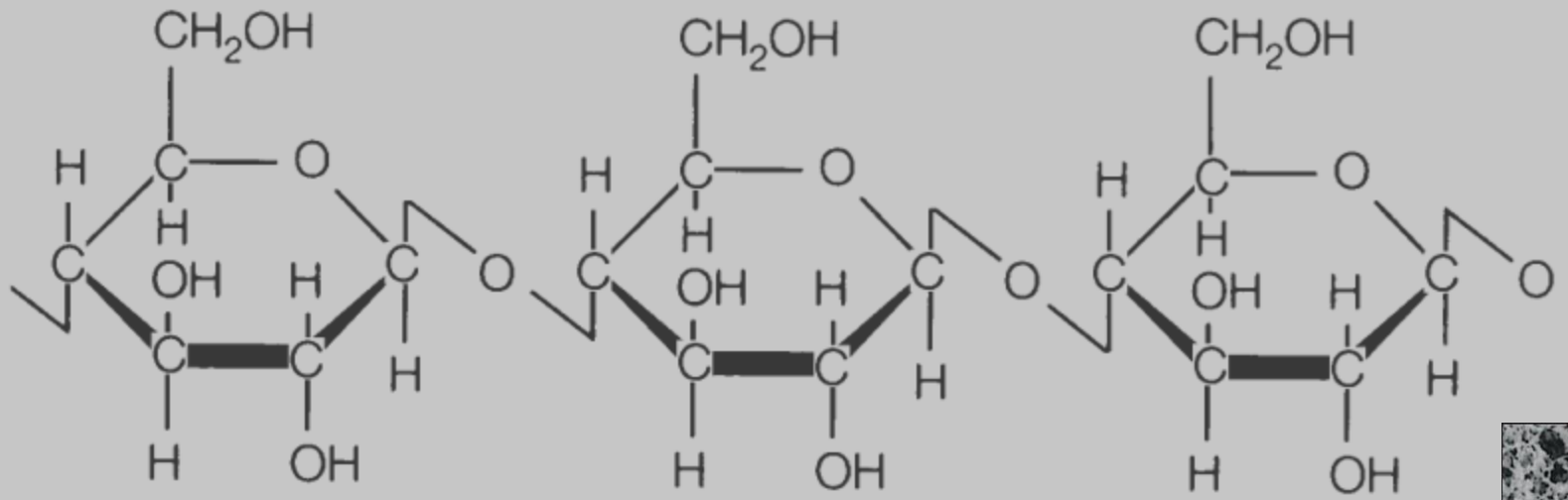
Nylon 66

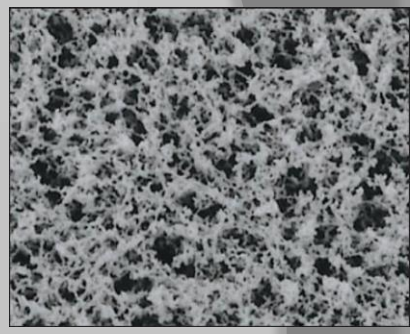
Nylon 6

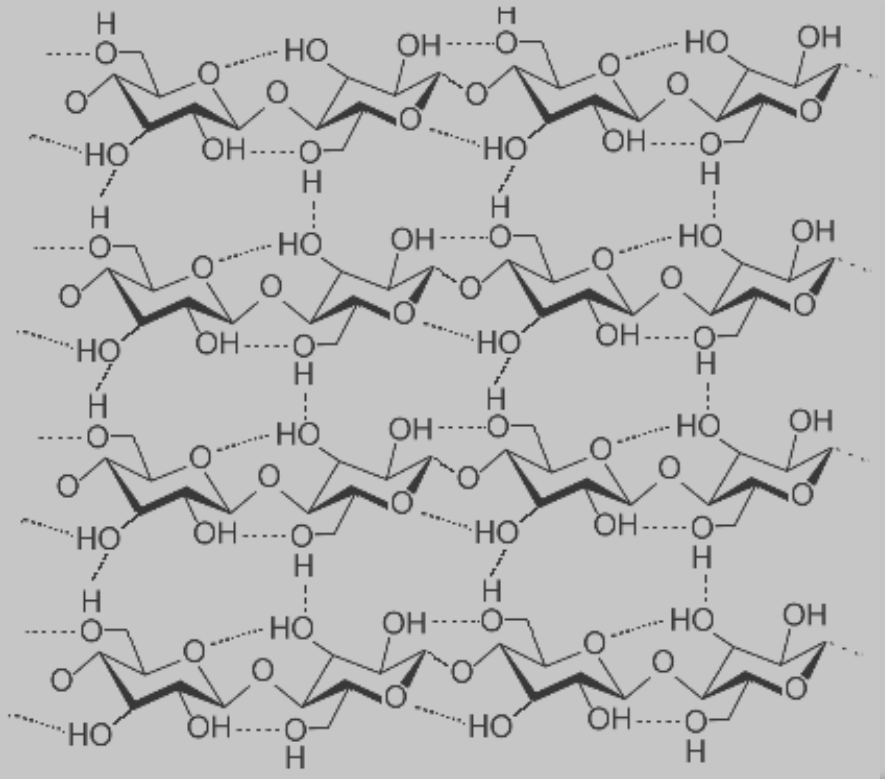
Naylon66 (1935 Caroters)

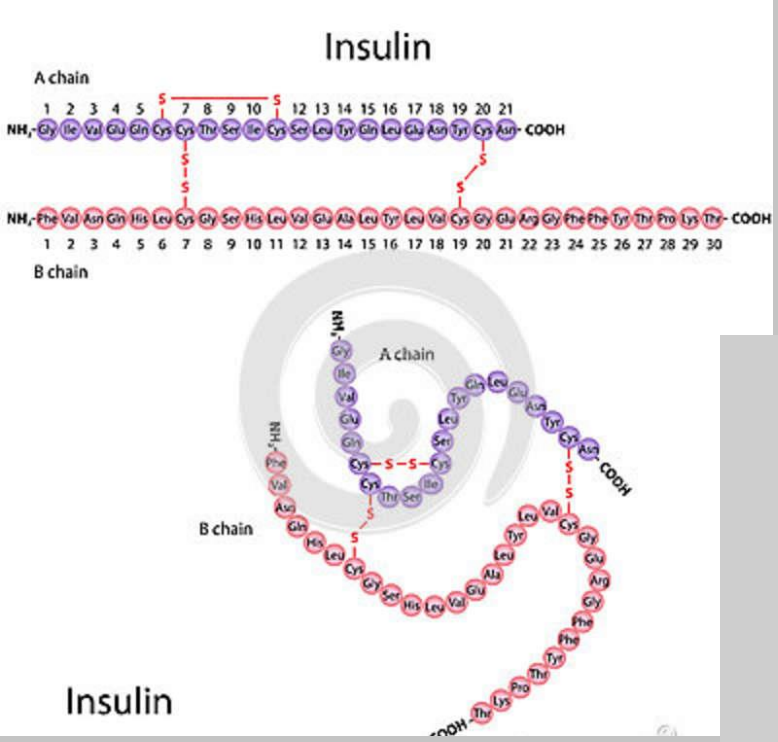


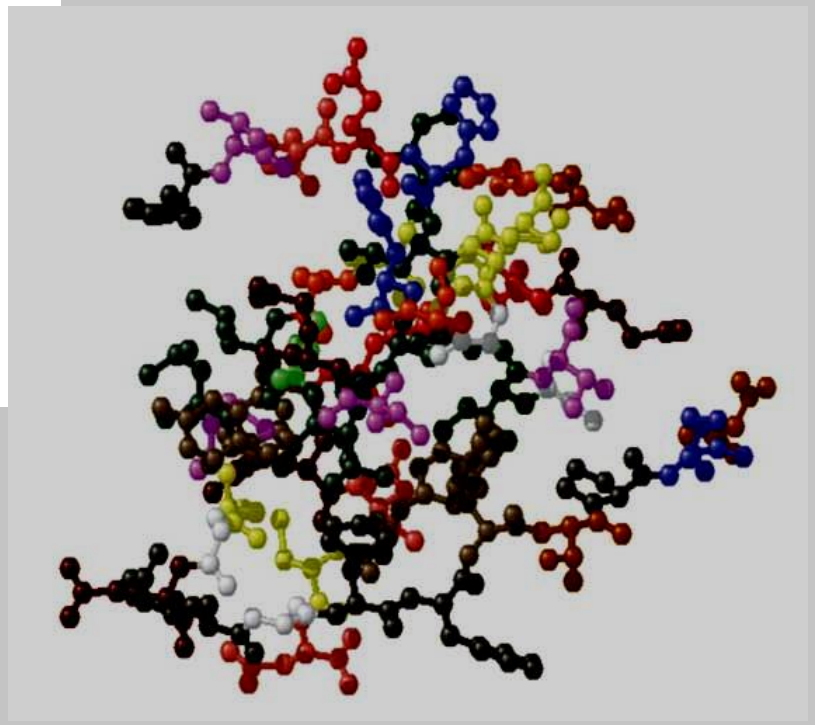
Production of polyethylene terephthalate

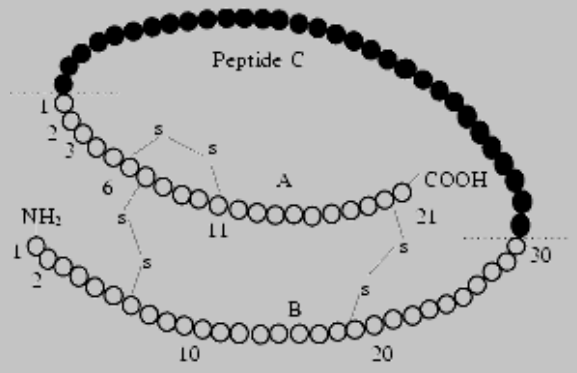







Insulin
A chain
B chain
Insulin




Peptide C
A
B
COOH
NH2

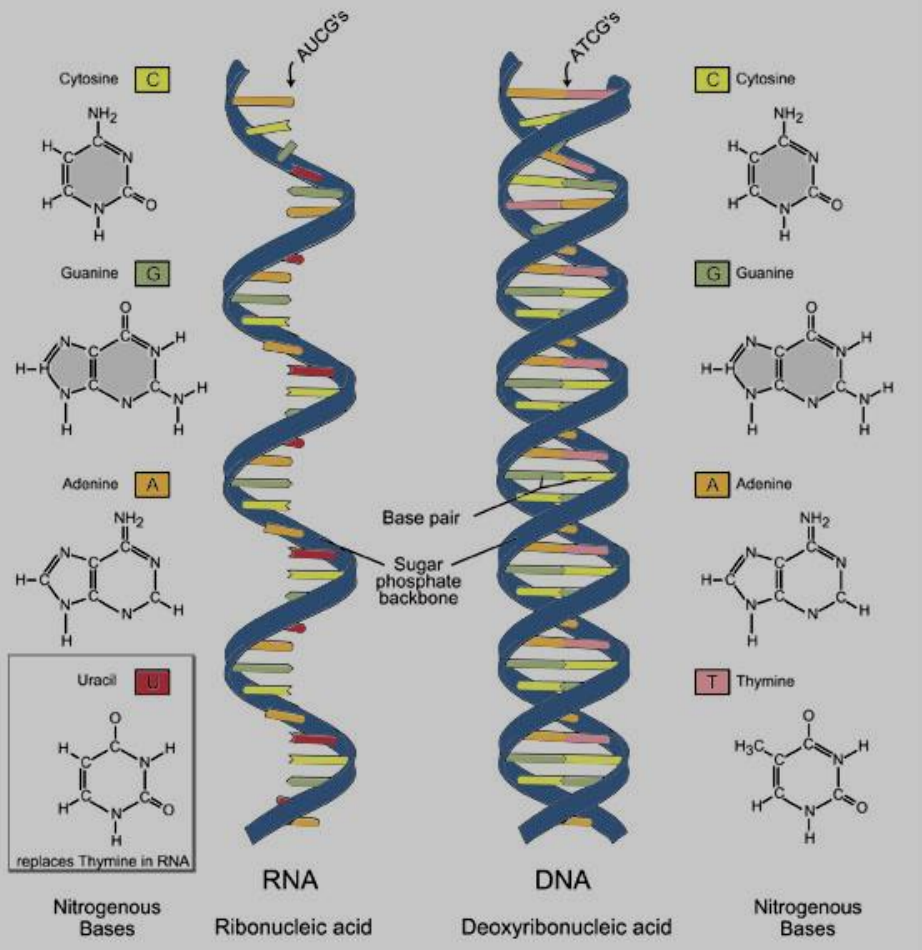
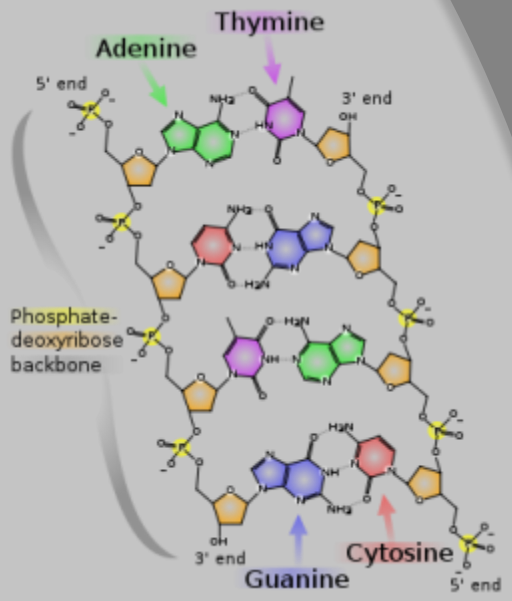


Image adapted from: National Human Genome Research Institute. Talking Glossary of Genetic Terms. Available at: www.genome.gov/Pages/Hyperion//DIR/VIP/Glossary/Illustration/rna.shtml.



DNA

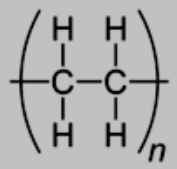
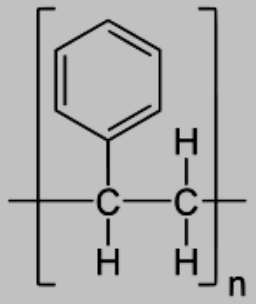
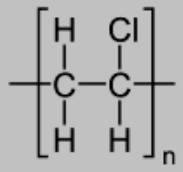
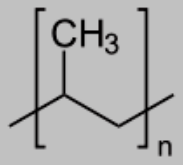
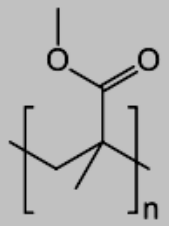
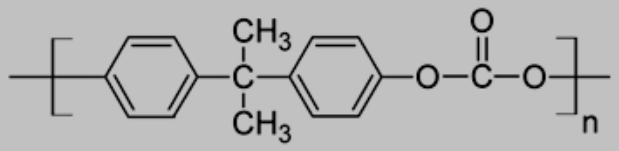
Material Type	Trade Names	Major Application Characteristics	Typical Applications
Polypropylene	Herculon Meraklon Moplen Poly-pro Pro-fax Propak Propathene	Resistant to heat distortion; excellent electrical properties and fatigue strength; chemically inert; relatively inexpensive; poor resistance to UV light	Sterilizable bottles, packaging film, TV cabinets, luggage
Polystyrene	Carinex Dylene Hostyren Lustrex Styron Vestyron	Excellent electrical properties and optical clarity; good thermal and dimensional stability; relatively inexpensive	Wall tile, battery cases, toys, indoor lighting panels, appliance housings
Vinyls	Darvic Exon Geon Pliovic Saran Tygon Vista	Good low-cost, general-purpose materials; ordinarily rigid, but may be made flexible with plasticizers; often copolymerized; susceptible to heat distortion	Floor coverings, pipe, electrical wire insulation, garden hose, phonograph records
Polyester (PET or PETE)	Celanar Dacron Eastapak Hylar Melinex Mylar Petra	One of the toughest of plastic films; excellent fatigue and tear strength, and resistance to humidity, acids, greases, oils, and solvents	Magnetic recording tapes, clothing, automotive tire cords, beverage containers
		Thermosetting Polymers	
Epoxies	Araldite Epikote Epon Epi-rez Lekutherm Lytex	Excellent combination of mechanical properties and corrosion resistance; dimensionally stable; good adhesion; relatively inexpensive; good electrical properties	Electrical moldings, sinks, adhesives, protective coatings, used with fiberglass laminates
Phenolics	Bakelite Amberol Arofene Durite Resinox	Excellent thermal stability to over 150°C (300°F); may be compounded with a large number of resins, fillers, etc.; inexpensive	Motor housings, telephones, auto distributors, electrical fixtures
Polyesters	Aropol Baygal Derakane Laminac Selectron	Excellent electrical properties and low cost; can be formulated for room- or high-temperature use; often fiber reinforced	Helmets, fiberglass boats, auto body components, chairs, fans

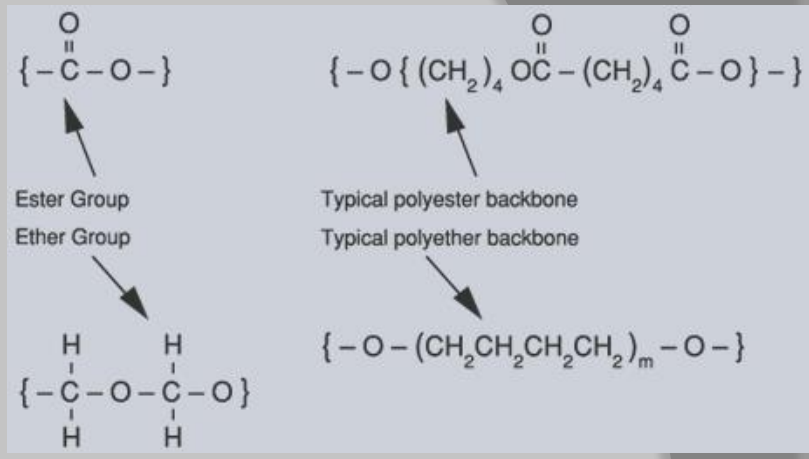
Source: Adapted from C. A. Harper (Editor), *Handbook of Plastics and Elastomers.*

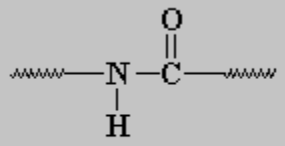
Material Type	*Trade Names*	*Major Application Characteristics*	*Typical Applications*
		Thermoplastics	
Acrylonitrile-butadiene-styrene (ABS)	Abson Cycolac Kralastic Lustran Novodur Tybrene	Outstanding strength and toughness, resistant to heat distortion; good electrical properties; flammable and soluble in some organic solvents	Refrigerator linings, lawn and garden equipment, toys, highway safety devices
Acrylics [poly(methyl methacrylate)]	Acrylite Diakon Lucite Plexiglas	Outstanding light transmission and resistance to weathering; only fair mechanical properties	Lenses, transparent aircraft enclosures, drafting equipment, outdoor signs
Fluorocarbons (PTFE or TFE)	Teflon Fluon Halar Hostaflon TF Neoflon	Chemically inert in almost all environments, excellent electrical properties; low coefficient of friction; may be used to 260°C (500°F); relatively weak and poor cold-flow properties	Anticorrosive seals, chemical pipes and valves, bearings, antiadhesive coatings, high-temperature electronic parts
Polyamides (nylons)	Nylon Baylon Durethan Herox Nomex Ultramid Zytel	Good mechanical strength, abrasion resistance, and toughness; low coefficient of friction; absorbs water and some other liquids	Bearings, gears, cams, bushings, handles, and jacketing for wires and cables
Polycarbonates	Calibre Iupilon Lexan Makrolon Merlon	Dimensionally stable; low water absorption; transparent; very good impact resistance and ductility; chemical resistance not outstanding	Safety helmets, lenses, light globes, base for photographic film
Polyethylene	Alathon Alkathene Fortiflex Hi-fax Petrothene Rigidex Rotothene Zendel	Chemically resistant and electrically insulating; tough and relatively low coefficient of friction; low strength and poor resistance to weathering	Flexible bottles, toys, tumblers, battery parts, ice trays, film wrapping materials

Chemical Type	*Trade (Common) Names*	*Elongation (%)*	*Useful Temperature Range [°C (°F)]*	*Major Application Characteristics*	*Typical Applications*
Natural polyisoprene	Natural rubber (NR)	500–760	−60 to 120 (−75 to 250)	Excellent physical properties; good resistance to cutting, gouging, and abrasion; low heat, ozone, and oil resistance; good electrical properties	Pneumatic tires and tubes; heels and soles; gaskets
Styrene-butadiene copolymer	GRS, Buna S (SBR)	450–500	−60 to 120 (−75 to 250)	Good physical properties; excellent abrasion resistance; not oil, ozone, or weather resistant; electrical properties good, but not outstanding	Same as natural rubber
Acrylonitrile-butadiene copolymer	Buna A, Nitrile (NBR)	400–600	−50 to 150 (−60 to 300)	Excellent resistance to vegetable, animal, and petroleum oils; poor low-temperature properties; electrical properties not outstanding	Gasoline, chemical, and oil hose; seals and O-rings; heels and soles
Chloroprene	Neoprene (CR)	100–800	−50 to 105 (−60 to 225)	Excellent ozone, heat, and weathering resistance; good oil resistance; excellent flame resistance; not as good in electrical applications as natural rubber	Wire and cable; chem. tank linings; belts, hoses, seals, and gaskets
Polysiloxane	Silicone (VMQ)	100–800	−115 to 315 (−175 to 600)	Excellent resistance to high and low temperatures; low strength; excellent electrical properties	High- and low-temperature insulation; seals, diaphragms; tubing for food and medical uses

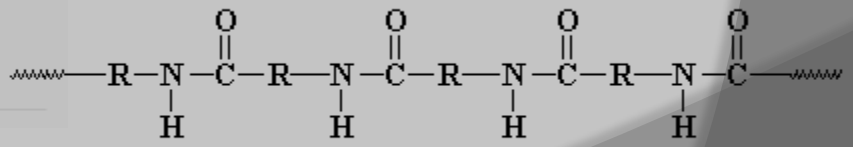
Sources: Adapted from C. A. Harper (Editor), *Handbook of Plastics and Elastomers.* Copyright © 1975 by McGraw-Hill Book Company, reproduced with permission; and Materials Engineering's *Materials Selector,* copyright Penton/IPC.

Polimer	Tekrarlayan yapı	Polimer	Tekrarlayan yapı
Polietilen (*Polyethylene*)		Polisitren (*Polystyrene*)	
Polivinil klorür (PVC) (*Polyvinyl chloride*)		Politetrafloroetilen (*Polytetrafluoroethylene*)	
Polipropilen (*Polypropylene*)		Polimetil metakrilat (*Polymethyl methacyrlate*)	
Polikarbonat (*Polycarbonate*)			





an amide group



a polyamide

Temel Polimer Yapıları

Sınıflandırma Şemaları

- Molekuler Yapı
  * lineer, dallı, homopolimer, kopolimer, çapraz bağlı vb..
- Fiziki Durum
  * kısmen kristalin, camsı, kauçuğumsu, viskoelastik vb..
- Kimyasal Yapı
  * eter, ester, hidroksil vb..
- Çevreye Reaksiyonu
  * termoset, defleksiyon sıcaklığı, termoplastik vb..
- Son Kullanım
  * elyaf, plastik, kaplama vb..
- Polimer maliyeti
  * düşük, yüksek, özel vb..

Doğal , Sentetik , Yarı Sentetik Polimerler Organik , İnorganik Polimerler

Kopolimer Homopolimer, Kondenzasyon, Katılma (Zincir) Polimerleri

Overview of the polymer industry

Industry	General product requirements
adhesive	Strong surface forces; epoxy, superglue
coatings	Film-forming; LDPE with good impact
composites	Structural materials; epoxy + fibers
elastomers	Large deformation and recovery; rubber in tire and seals
fibers	High strength/area; polyacrylonitrile
foams	Light weight, low thermal conductivity; polyurethane
plastics	Stable deformation under static load; HDPE, PP, PVC

Commodity plastics

Polymer	Major uses
LDPE	Packaging film, wire and cable insulation, toys, flexible bottles, housewares, coatings
HDPE	Bottles, drums, pipe, conduit, sheet, film, wire and cable insulation
PP	Automobile and appliance parts, rope, cordage, webbing, carpeting, film
PVC	Construction, rigid pipe, flooring, wire and cable insulation, film, sheet
PS	Foam and film packaging, foam insulation, appliances, housewares, toys

- PE (HDPE LDPE)
- PP
- PS
- PVC
- PET
- PTFE
- PU
- Poliamid / Poliakrilamid

1 PETE	**Polyethylene Terephalate Ethylene** PETE goes into soft drink, juice, water, detergent, and cleaner bottles. Also used for cooking and peanut butter jars.	5 PP	**Polypropylene** PP goes into caps, disks, syrup bottles, yogurt tubs, straws, and film packaging.
2 HDPE	**High Density Polyethylene** High Density Polyethylene HDPE goes into milk and water jugs, bleach bottles, detergent bottles, shampoo bottles, plastic bags and grocery sacks, motor oil bottles, household cleaners, and butter tubs.	6 PS	**Polystyrene** PS goes into meat trays, egg cartons, plates, cutlery, carry-out containers, and clear trays.
3 PVC	**Polyvinyl Cloride** PVC goes into window cleaner, cooking oils, and detergent bottles. Also used for peanut butter jars and water jugs.	7 OTHER	**Other** Includes resins not mentioned above or combinations of plastics.
4 LDPE	**Low Density Polyethylene** LDPE goes into plastic bags and grocery sacks, dry cleaning bags, flexible film packaging, and some bottles.		

Recycling Guidelines

BAĞLANMA

- Birincil bağlar : yapının ısıl ve fotokimyasal kararlılığını belirler

  Kovalent Bağlar

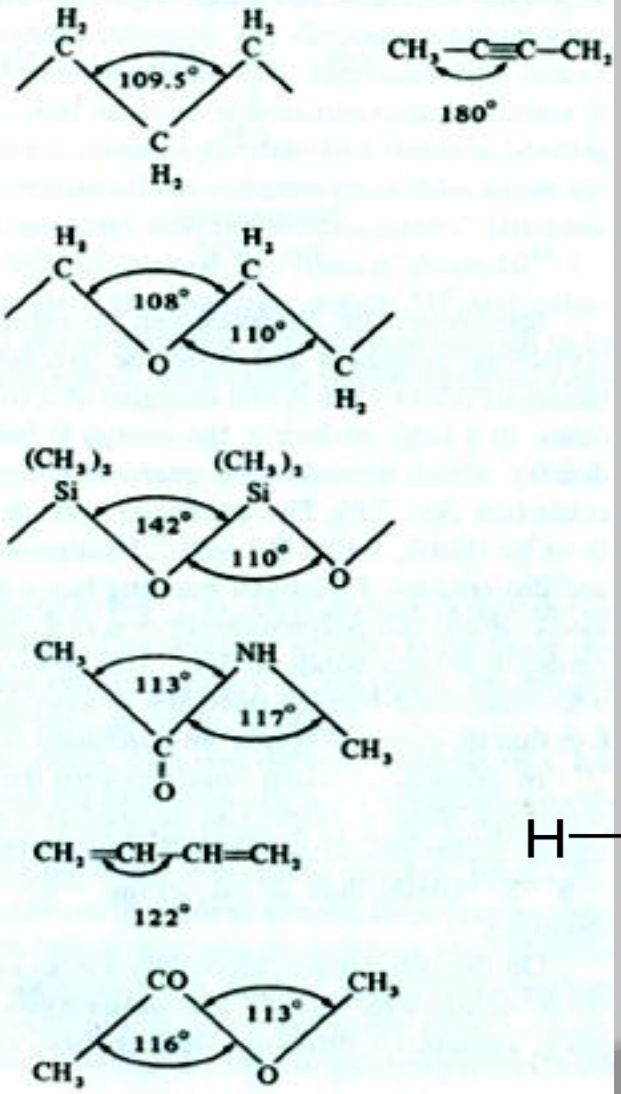
- İkincil Bağlar : yapının erime, çözünme, geçirgenlik, sorpsiyon, deformasyon gibi birçok önemli fiziksel, mekanik ve kimyasal özelliğini belirler

  Van der Waals Hidrojen Bağları London Kuvvetleri

Table 2.1 Covalent bonds.

Bond	Typical bond length, Å [2]	Typical average bond energy, kcal/mol [3]
C—C	1.54	83
C=C	1.34	147
C≡C	1.20	194
C—H	1.09	99
C—O	1.43	84
C=O	1.23	171
C—N	1.47	70
C=N	1.27	147
C≡N	1.16	213
C—Si	1.87	69
Si—O	1.64	88
C—S	1.81	62
C=S	1.71	114
C—Cl	1.77	79
S—S	2.04	51
N—H	1.01	93
S—H	1.35	81
O—H	0.96	111
O—O	1.48	33
Si—N	1.74	—

Some typical bond angles [2]



[a] 1 Å = 0.1 nm; 1 kcal = 4.185 kJ.

Büyük moleküllerde enerji : Birim molekül başına ?????

CED : koheziv enerji yoğunluğu

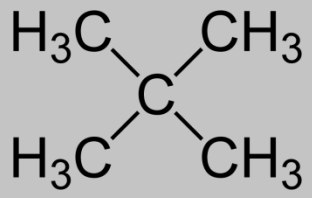
Çekim enerjisi

*Polarite

Kaynama noktası :

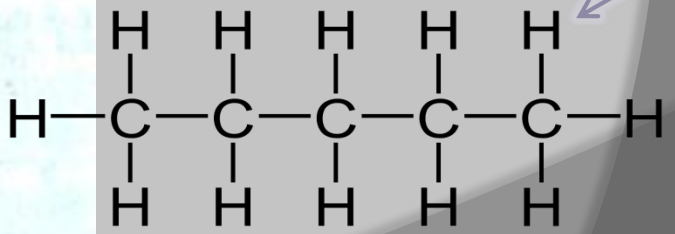
CH_4	CH_3Cl	CH_3OH
-164 °C	-24 °C	65 °C

*moleküller arası mesafe



neopentan

ODEV 1



n-pentan

Covalent Bonds

Dimensions and Energies[a]

Bond	Typical Bond Length (Å) [2]	Typical Average Bond Energy (kcal/mol) [3]
C—C	1.54	83
C═C	1.34	147
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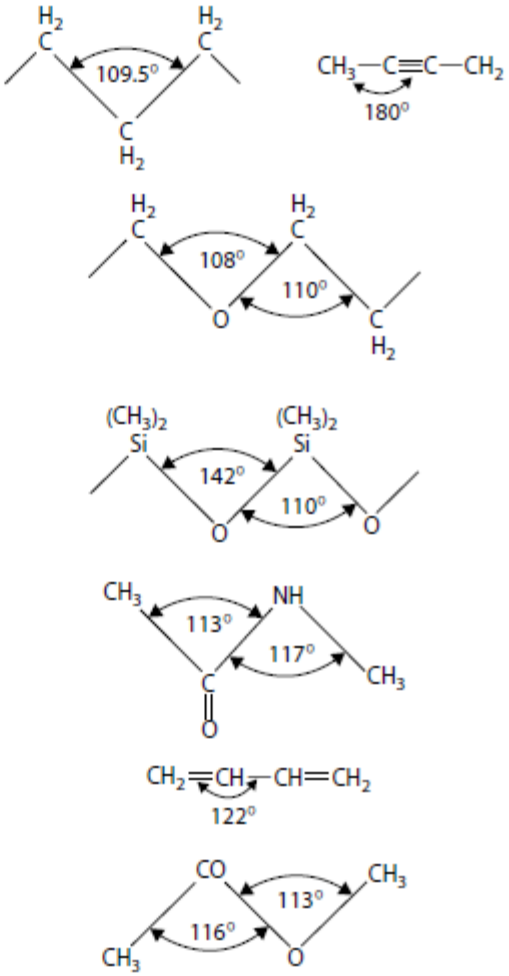
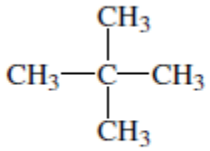
Some Typical Bond Angles [2]



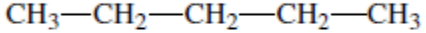
Büyük moleküllerde enerji : Birim molekül başına ?????

CED : koheziv enerji yoğunluğu

ODEV 1



Neopentane



n-Pentane

Çekim enerjisi

*Polarite

Kaynama noktası :

CH_4	CH_3Cl	CH_3OH
-164 °C	-24 °C	65 °C

*moleküller arası mesafe

BAĞLANMA

- Kovalent Bağlar :

Polimer molekülü C, O, N, H, Halojenler, S, P, Si, vb atomların kovalent bağlarla bağlandığı uzun bir zincirdir.

Ana zincirde 2 veya daha fazla değerlikli atomlar bulunabilir

2 veya daha fazla değerlikli her atom ana zincir üzerinde yer alamaz

Subtitiye olarak yer alabilirler

Düşük enerjili bağlarl (O-O, N-N vb..) kararlı polimer molekülleri oluşamaz

genellikle yüksek enerjili mağlardır (35-150 kcal/mol)

Molekuller arasındaki mesafe kısadır (1.1-1.6 Å)

Bağlar arasındaki açılar karakteristiktir

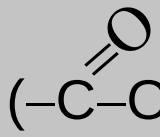
C-C Bağları

- Çok kararlı, nötral
- Isıl ve uv kararlılığı yüksek
- Sübsitiye gruplar bağın polaritesini değiştirir
  (polarite kazanınca bağ zayıflar)
- Çift bağ α pozisyonunda ise çok reaktifdir. Aromatik halkada ise rezonans nedeniyle çok sağlamdır . Çok sayıda çift bağ polimerik yapıyı renklendirir.

C-H Bağları

- Ana zinzirde bulunmaz
- C-C bağı kadar kararlı ve nötral değildir
- Oksijen, ısı ve ışıkla bozunur
- Alifatik yapılarda düşük yüzey enerjisi, yüzey gerilimi ve yapışmaya neden olur,Kolay sübstitüsyon verir
- Aromatiklerde daha sağlamdır
- Aynı karbonda hidrojen dısında üç farklı grup varsa çapraz bağlanma hidrojen üzerinden oluşur

Oksijen Bağları

- Hem ana zincirde hemde sübstitiye olarak bulunabilirler
- Oksijen bağları çok polardır
- Çiftleşmemiş (–O̤–) elektronlar kuvvetli hidrojen bağı yaparlar
- Yüksek yüzey gerilimine ne den olurlar
- Eter bağı (–C–O–C–) alifetiklerde karbona bağlı hidrojeni çok reaktif hale getirirken aromatiklerde çok sağlamdır.
- Karbonil bağı (–C=O) polimeik malzemelerde uv absorber olarak kullanılır.
- Ester bağı () kolay hidrolize olur
- Polikarbonat bağı alifetiklerde kolay hidrolize olurken aromatiklerde alkali ortamda hidrolize olur
- Peroksit çok kararsızdır radikal polimerizasyonunda başlatıcı olarak kullanılır.

Azot Bağları

- Elektronegativitesi karbon ile oksijen arasındadır
- (–C–N) bağı oldukça kuvvetlidir
- (–N–) çiftleşmemiş elektronlar hidrojen bağı yapar
- Nitril bağı (–C≡N) çok polardır.Kuvvetli hidrojen bağı yapar. Yüksek sıcaklıkta piroliz olunca HCN açığa çıkar.
- (N–H) bağı oldukça reaktiftir. Poliamidlerde farklı gruplar H bağı üzerinden sübstitüye edilir.
- Poliüretan bağı (–C(=O)–NH) çok yüksek yüzey enerjisi ve yüzey gerilimine sahiptir, iyi yapışma özelliği gösterir. Hidroliz olabilir.
- İzosiyanat bağı (–N=C=O) çok reaktiftir. Yüksek yapışma özelliği gösterir
- Nitro bağı (–O–NO_2) film yapımında kullanılır. Patlama özelliğine sahiptir.
- (N–N) bağı çok kararsızdır.

Halojen Bağları

- Ana zincir üzerinde bulunamazlar
- En elektronegatif atomlardır (F>Cl>Br>I)
- (C–F) çok düşük yüzey enerjisi ve yüzey gerilimi gösterirler. Çok kararlıdırlar. Yüksek sıcaklığa dayanıklıdırlar.
- (C–Cl) elektronegatifliği daha düşüktür. Kararlı bir bağdır. HCl çıkışı söz konusudur
- (C–Br) kolay bozunur. Yüksek alev direncine sahiptir.
- (C–I) karasız bir bağdır

Kükürt Bağları

- (C–S) elekronegativitesi oksijenden düşüktür. Atmosferik ve kimyasal oksidasyona uğrar.
- Sülfon bağları ($–SO_2–$) oldukça kararlıdırlar. Oksijen üzerinden hidrojen bağları yapar

Silisyum Bağları

- Elekropozitiftir.
- Organosilan bağı (Si–OH) yüksek sıcaklığa dayanıklıdır. Yüksek yüzey enerjisi ve yüzey gerilimi gösterir.
- Organosiloksan bağı (Si–O–R) zayıftır
- Silikon bağı (Si–O–Si)

Fosfor Bağları

- Elekropozitiftir.
- Oksijen ile yüzeyde oksit tabakası (koruyucu) oluşturur
- Alev direnci cok yüksektir

İkincil Bağlar

Moleküller arasında veya segmentler arasında
Düşük enerjili (1-20 kcal/mol)

Molekuller arasındaki mesafe (2 -5 Å)

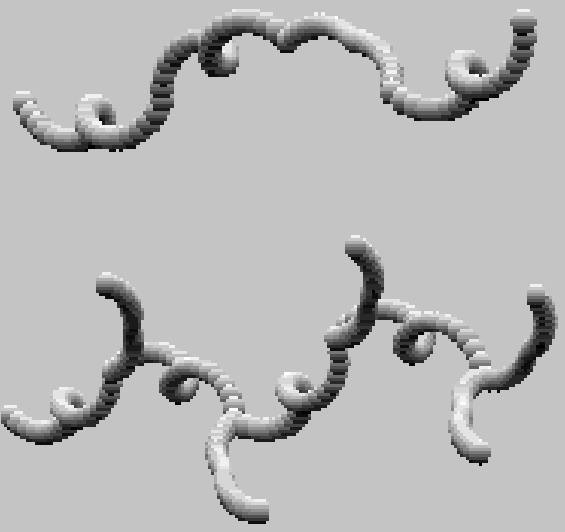
- Dipol dipol etkileşimleri
- Dipol-uyarılmış dipol etkileşimleri
- Dispersiyon kuvvetleri

POLİMER YAPISI

- Tek Moleküller
- Ağ Moleküller

- Bağlar
- Konfigürasyon ve Konformasyon
- Moleküller arası Düzen
- Isıl Geçişler
- Optik Özellikler
- Kimyasal Özellikler
- Molekül Ağırlığı ve Dağılımı

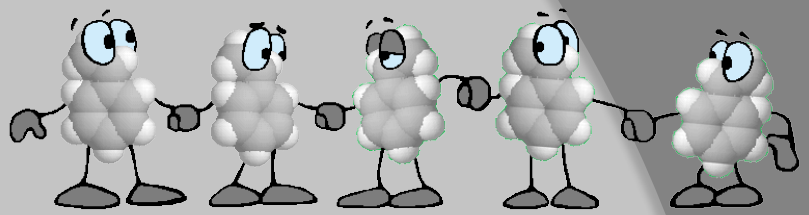
Tek Moleküller



Doğrusal (Lineer) Polimer

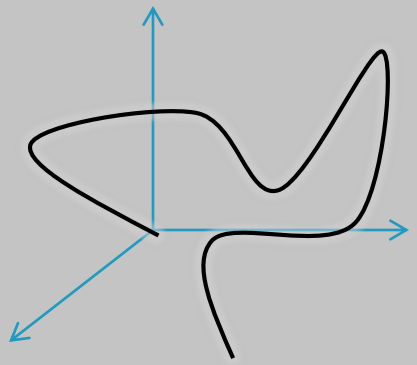
Dallanmış (Branched) Polimer

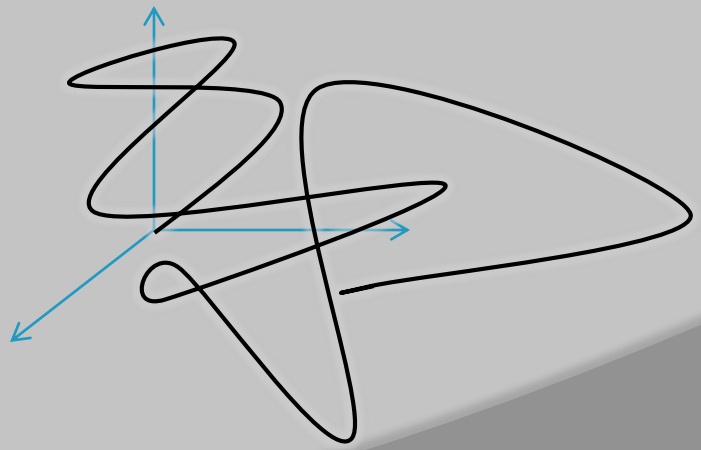
Tek Moleküller

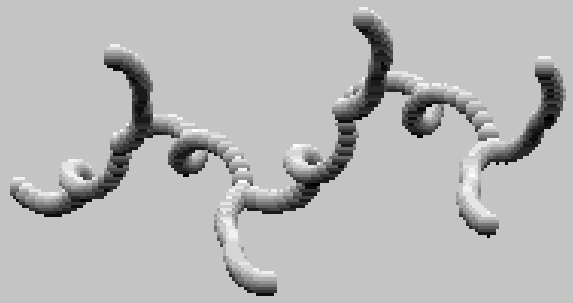


Doğrusal (Lineer) Polimer

Lineer polimerler, organik çözücülerde çözünürler



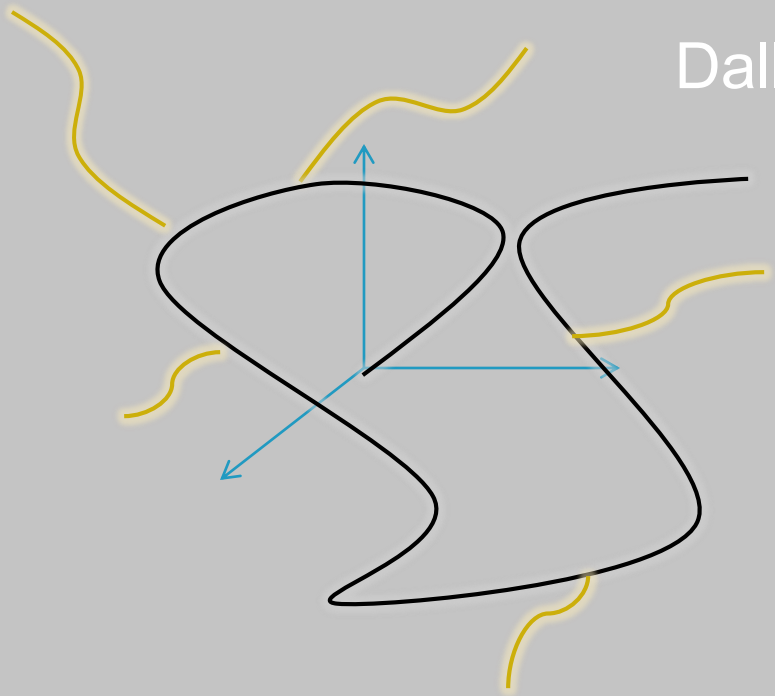




Dallanmış (Branched) Polimer

Lineer polimerlerin belirli noktalarında yan zincirlere sahip polimerlerdir

Dallanma kristalliği etkiler



Natural Plastics

- Shellac
  - Polymer from insects, lac
  - Native to India and Southeast Asia
  - Hardened secretion
  - Can dissolve in alcohol, and apply to surfaces as a clear coat.
  - Moldable using heat and pressure.
  - Some of the first records for phonographs were made from shellac.