

**Corso di Laurea Magistrale in Ingegneria dell'Innovazione del Prodotto**  
**a.a. 2022-23**  
**Anno I – Semestre I**



# Tecnologia dei materiali polimerici

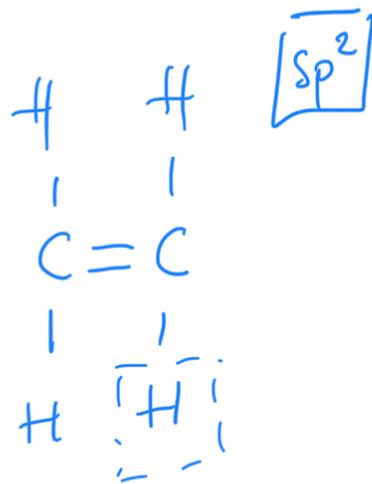
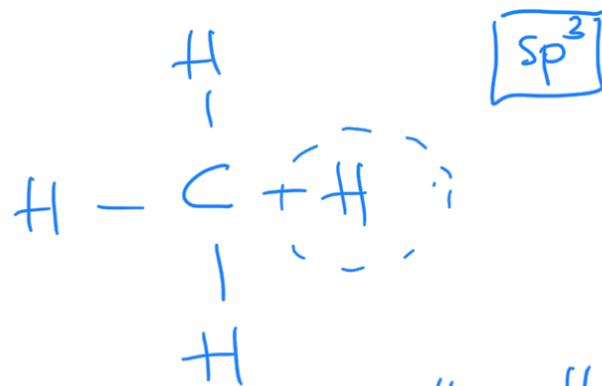
## Lezione 4

Prof. **Lisa Biassetto**

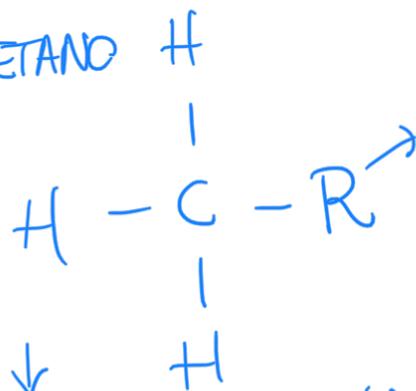
E-mail: [lisa.biassetto@unipd.it](mailto:lisa.biassetto@unipd.it)

# IDROCARBUR (ALIFATICI)

- ALCANI ( $C_nH_{2n+2}$ )  $\rightarrow$   $CH_4$
- ALCENI ( $C_nH_{2n}$ )
- ALCHINI ( $C_nH_{2n-2}$ )

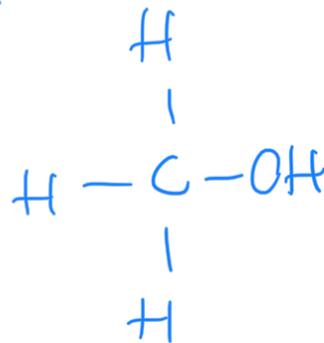


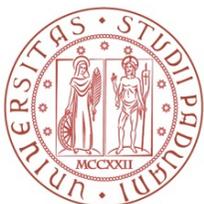
METANO



$\rightarrow$  gruppo funzionale

METANO



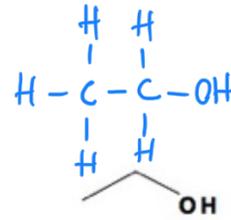
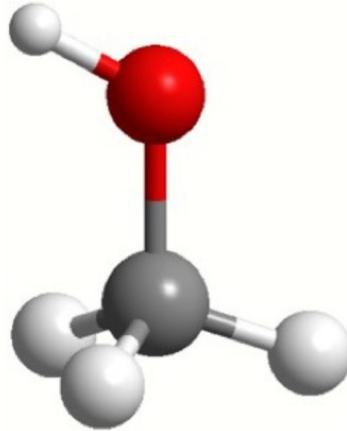
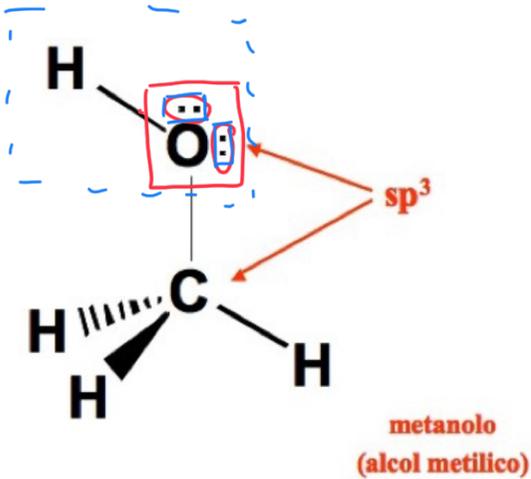
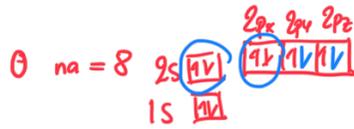


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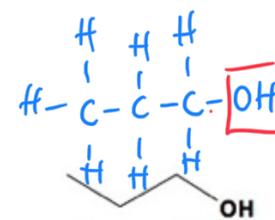


- ❖ Gli alcoli
  - ❖ Le ammine
  - ❖ Acidi ed esteri
  - ❖ Gli epossidi
  - ❖ Alcune tipologie di polimeri e loro formulazioni
  - ❖ Reazioni di polimerizzazione
- } → GRUPPI FUNZIONALI  
specie chimiche che sostituiscono  
il 'H' negli idrocarburi

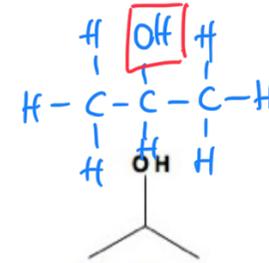
# ALCOLI



**Etanolo**  
(alcol etilico)



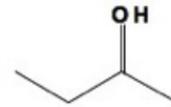
**1-propanolo**  
(alcol propilico)



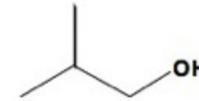
**2-propanolo**  
(alcol isopropilico)



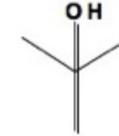
**1-butanolo**  
(alcol butilico)



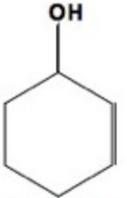
**2-butanolo**  
(alcol sec-butilico)



**2-metil-1-propanolo**  
(alcol isobutilico)



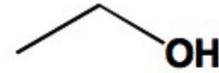
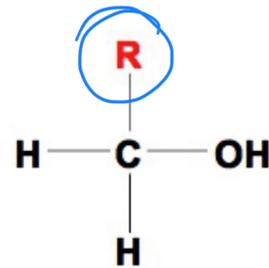
**2-metil-2-propanolo**  
(alcol *terz*-butilico)



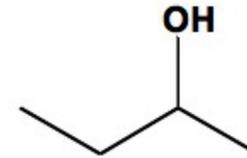
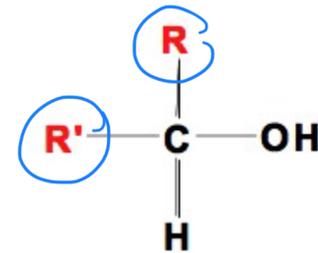
**cicloesanololo**  
(alcol cicloesilico)

SOLUBILI in ACQUA

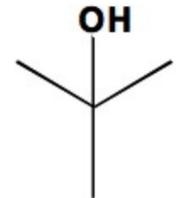
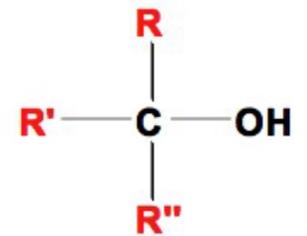
# ALCOLI



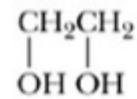
alcol primario



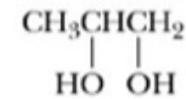
alcol secondario



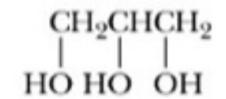
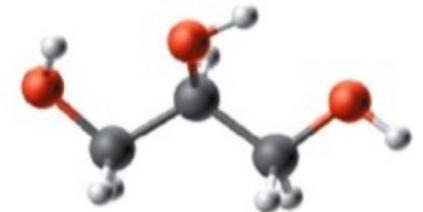
alcol terziario



1,2-Etandiolo  
(Glicole etilenico)

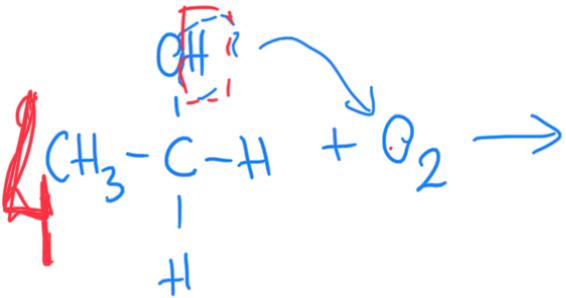


1,2-Propandiolo  
(Glicole propilenico)

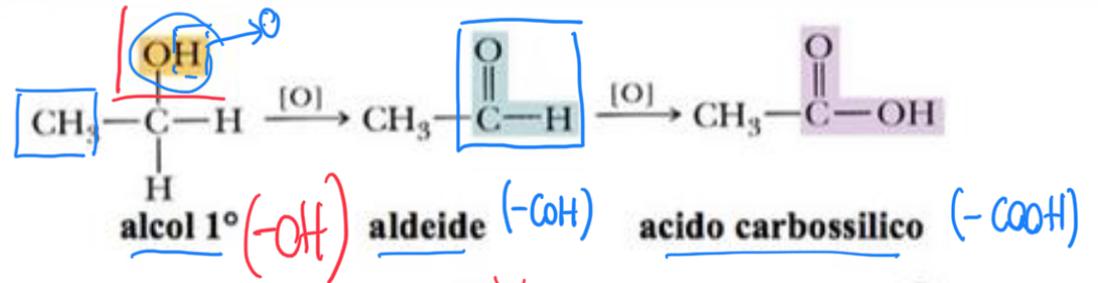


1,2,3-Propantriolo  
(Glicerolo, Glicerina)

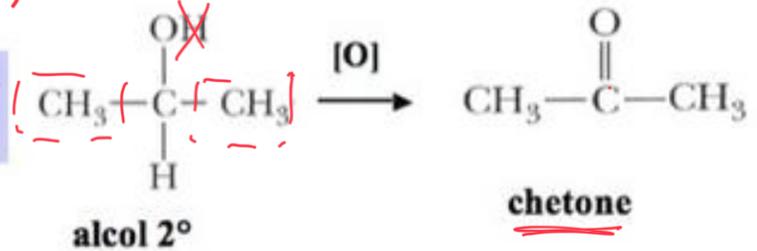
# ALCOLI



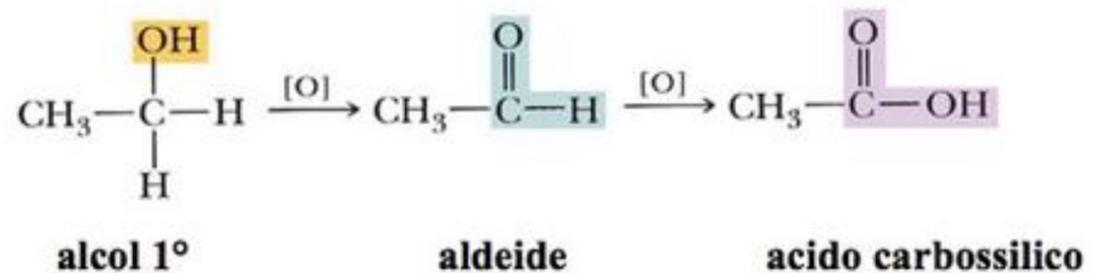
Un alcol 1° si ossida ad aldeide e successivamente ad acido carbossilico



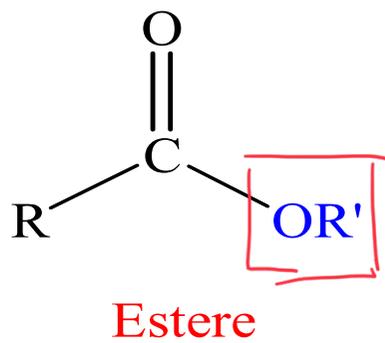
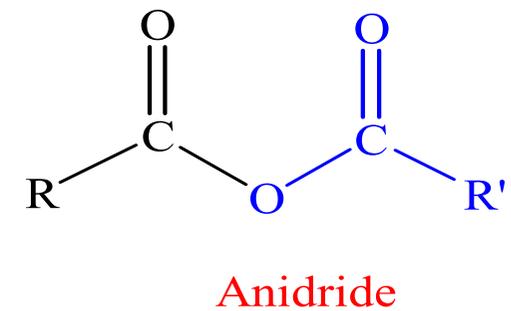
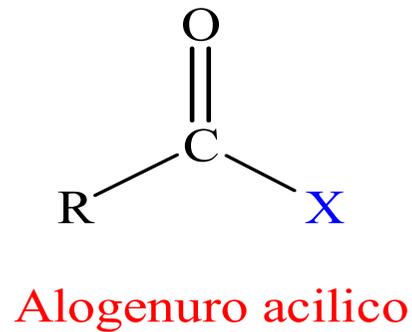
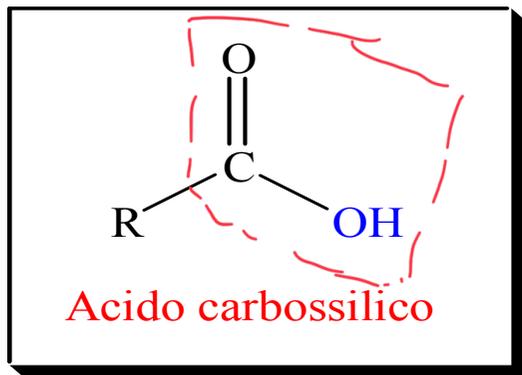
Un alcol 2° si ossida a chetone



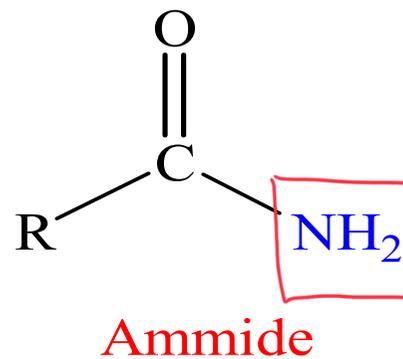
Un alcol 3° non si ossida facilmente



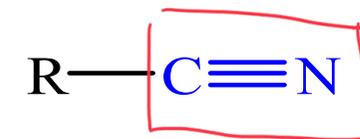
# ACIDI CARBOSSILICI E DERIVATI



↓  
POLIESTERE [PET]

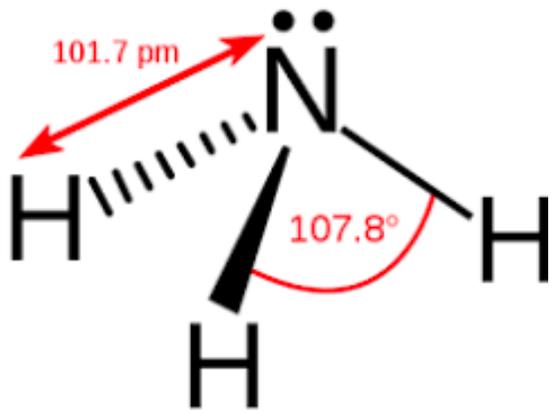


↓  
POLIAMMIDI



↓  
Nylon 6,6  
Nylon 6,12

# AMMINE



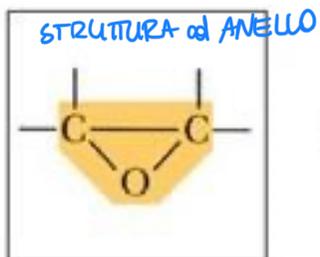
Ammine Primarie

Ammine Secondarie

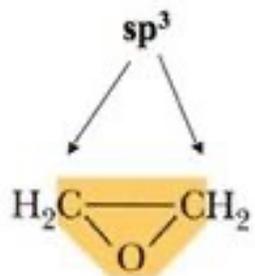
Ammine Terziarie

# EPOSSIDI

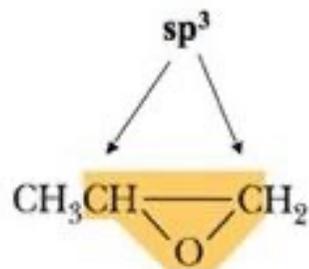
*Resina Epossidica*



gruppo funzionale  
di un epossido

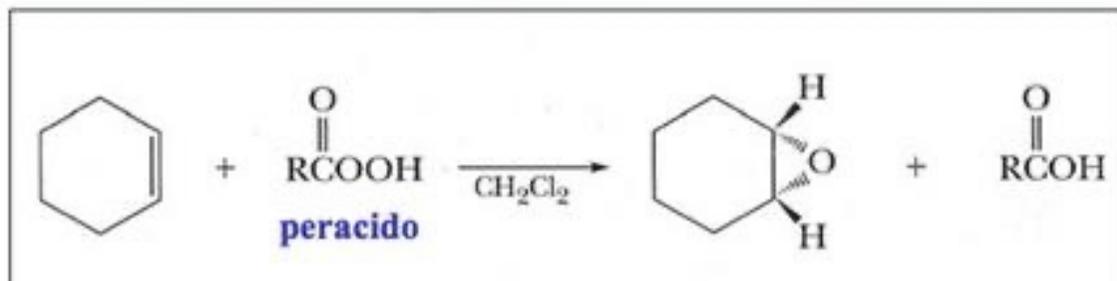


ossido di etilene



ossido di propilene

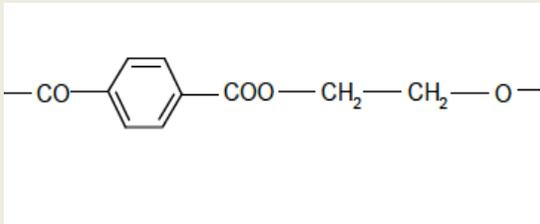
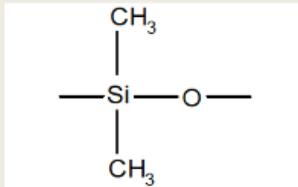
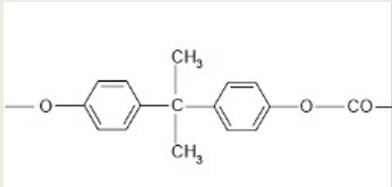
Si ottengono dagli alcheni per ossidazione con peracidi:

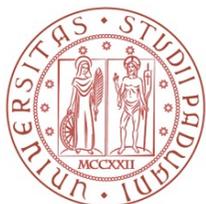


| <b>POLIMERO</b>          | <b>SIGLA</b> | <b>MONOMERO/<br/>REAGENTI</b>                                       | <b>UNITA' DI<br/>RIPETIZIONE</b>                                                            |
|--------------------------|--------------|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>POLIETILENE</b>       | <b>PE</b>    | Etilene<br>$\text{CH}_2=\text{CH}_2$                                | $-\text{CH}_2-\text{CH}_2-$                                                                 |
| <b>POLIMERI VINILICI</b> |              |                                                                     |                                                                                             |
| <b>POLIPROPILENE</b>     | <b>PP</b>    | Propilene<br>$\text{CH}_2=\text{CH}-\text{CH}_3$                    | $  \begin{array}{c}  -\text{CH}_2-\text{CH}- \\    \\  \text{CH}_3  \end{array}  $          |
| <b>POLISTIRENE</b>       | <b>PS</b>    | Stirene<br>$\text{CH}_2=\text{CH}-\text{C}_6\text{H}_5$             | $  \begin{array}{c}  -\text{CH}_2-\text{CH}- \\    \\  \text{C}_6\text{H}_5  \end{array}  $ |
| <b>ACETATO DI VINILE</b> | <b>PVAc</b>  | Acetato di vinile<br>$\text{CH}_2=\text{CH}-\text{OCO}-\text{CH}_3$ | $  \begin{array}{c}  -\text{CH}_2-\text{CH}- \\    \\  \text{OCOCH}_3  \end{array}  $       |

| POLIMERO                    | SIGLA       | MONOMERO/<br>REAGENTI                                                         | UNITA' DI<br>RIPETIZIONE                                                                                       |
|-----------------------------|-------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| <b>POLIMERI ACRILICI</b>    |             |                                                                               |                                                                                                                |
| <b>POLIMETILMETACRILATO</b> | <b>PMMA</b> | Metacrilato di Metile<br>$\text{CH}_2=\text{C}(\text{CH}_3) - \text{COOCH}_3$ | $  \begin{array}{c}  \text{CH}_3 \\    \\  - \text{CH}_2 - \text{C} - \\    \\  \text{COOCH}_3  \end{array}  $ |
| <b>POLIACRILONITRILE</b>    | <b>PAN</b>  | Nitrile dell'acido acrilico<br>$\text{CH}_2=\text{CH}-\text{CN}$              | $  \begin{array}{c}  - \text{CH}_2 - \text{CH} - \\    \\  \text{CN}  \end{array}  $                           |

| POLIMERO                 | SIGLA       | MONOMERO/<br>REAGENTI                                                                                                                                                                               | UNITA' DI RIPETIZIONE                                            |
|--------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| <b>POLIMERI DIENICI</b>  |             |                                                                                                                                                                                                     |                                                                  |
| <b>POLIBUTADIENE 1,4</b> | <b>PB</b>   | Butadiene<br>$\text{CH}_2=\text{CH}-\text{CH}=\text{CH}_2$                                                                                                                                          | $-\text{CH}_2-\text{CH}_2-$                                      |
| <b>POLIISOPRENE 1,4</b>  | <b>PI</b>   | Isoprene<br>$\text{CH}_2=\text{CH}-\text{C}(\text{CH}_3)=\text{CH}_2$                                                                                                                               | $\text{CH}_2-\text{CH}-\text{C}(\text{CH}_3)-\text{CH}_2$        |
| <b>POLIAMMIDI</b>        |             |                                                                                                                                                                                                     |                                                                  |
| <b>POLIAMMIDE 6</b>      | <b>PA6</b>  | $\epsilon$ -caprolattame<br><ul style="list-style-type: none"> <li>◦ <math>\text{H}_2\text{N}(\text{CH}_2)_5\text{COOH}</math></li> <li>• <math>\text{HN}(\text{CH}_2)_5\text{CO}</math></li> </ul> | $-\text{HN}(\text{CH}_2)_5\text{CO}-$                            |
| <b>POLIAMMIDE 6,6</b>    | <b>PA66</b> | Acido Adipico<br>+esametildiammina<br>$\text{HOCO}(\text{CH}_2)_4\text{COOH} + \text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$                                                                        | $-\text{HN}(\text{CH}_2)_6\text{NHCO}(\text{CH}_2)_4\text{CON}-$ |

| POLIMERO              | SIGLA | MONOMERO/<br>REAGENTI                                                                                                            | UNITA' DI RIPETIZIONE                                                                 |
|-----------------------|-------|----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>POLIESTERI</b>     |       |                                                                                                                                  |                                                                                       |
| POLIETILENTEREFTALATO | PET   | Acido tereftalico<br>+ glicole etilenico<br>$\text{HOOC-C}_6\text{H}_4\text{-COOH}$<br>+<br>$\text{HOCH}_2\text{-CH}_2\text{OH}$ |    |
| <b>ALTRI</b>          |       |                                                                                                                                  |                                                                                       |
| POLIDIMETILSILOSSANO  | PDMS  | dimetilsilandiolo<br>$\text{HO-Si(CH}_3)_2\text{-OH}$                                                                            |   |
| POLICARBONATO         | PC    | Acido Adipico<br>+esametildiammina<br>$\text{HOCO(CH}_2)_4\text{COOH} + \text{H}_2\text{N(CH}_2)_6\text{NH}_2$                   |  |



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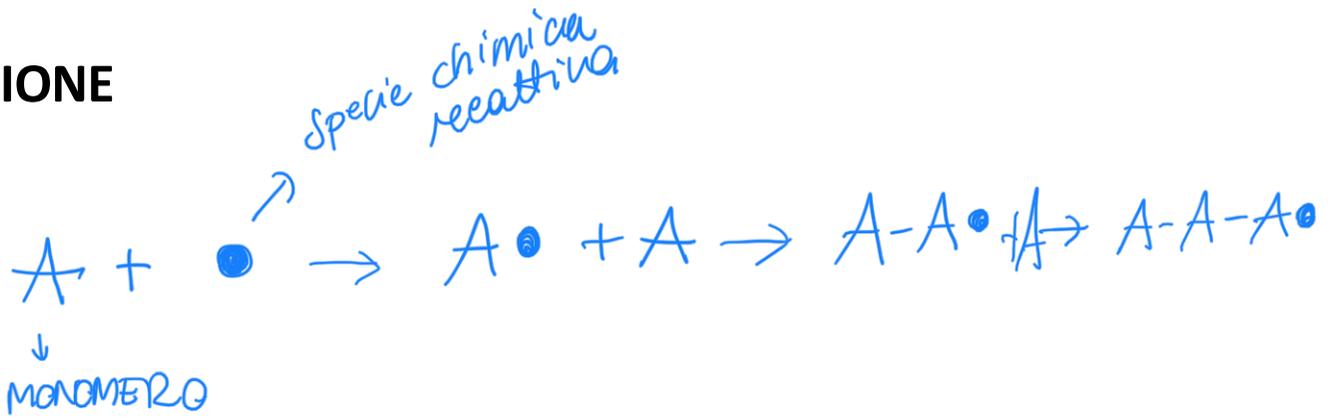
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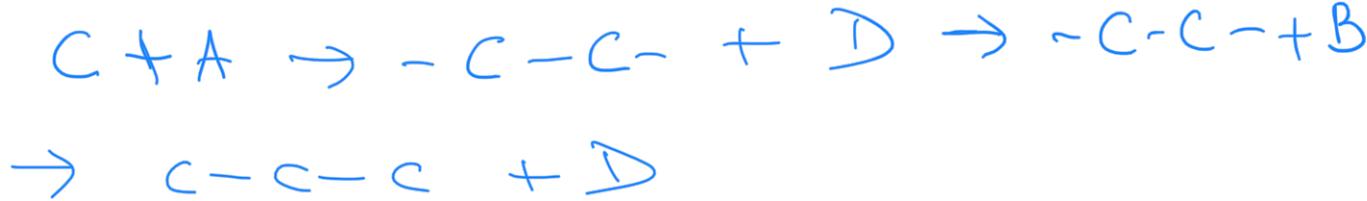
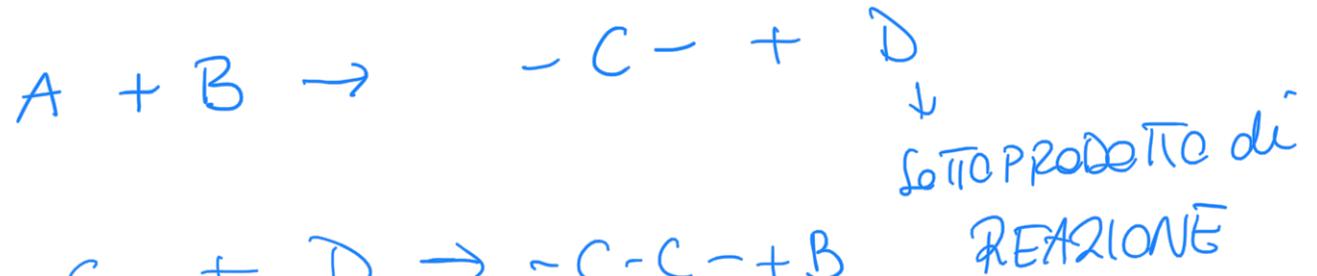
- ❖ Reazioni di polimerizzazione
- ❖ Reazioni di poliaddizione
- ❖ Poliaddizioni radicaliche

# REAZIONI DI POLIMERIZZAZIONE

## ① POLIADDIZIONI



## ② PROCESSI A STADIO



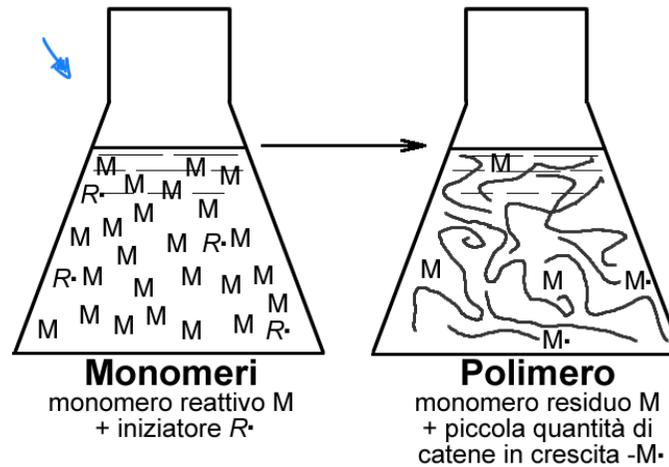
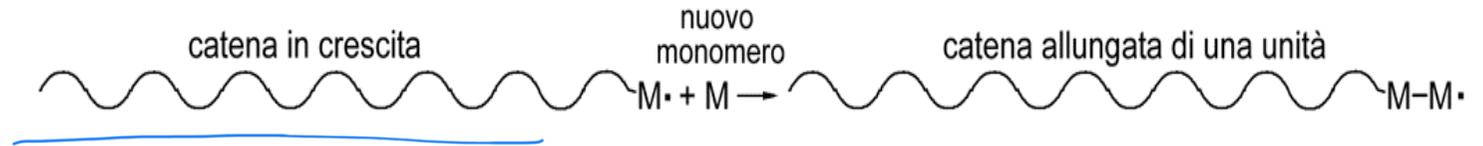
# REAZIONI A CATENA

*Monomero*  
*POLIADDIZIONE*  
*specie reattiva*

## 1) INIZIO



## 2) PROPAGAZIONE



## 3) TERMINAZIONE

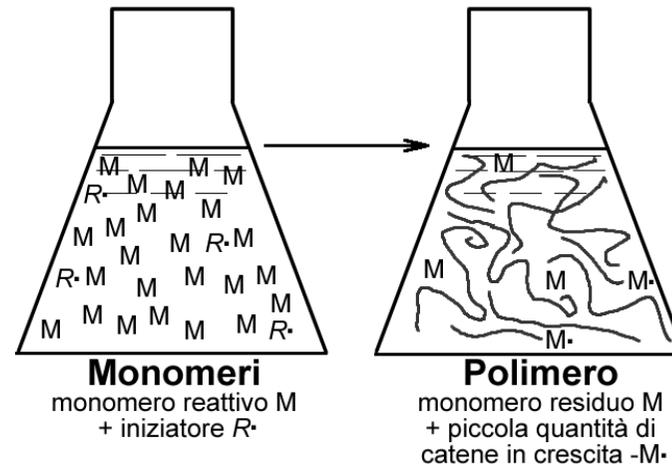
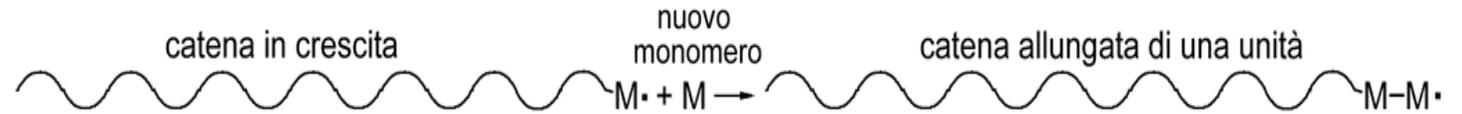


# REAZIONI A CATENA

## 1) INIZIO



## 2) PROPAGAZIONE



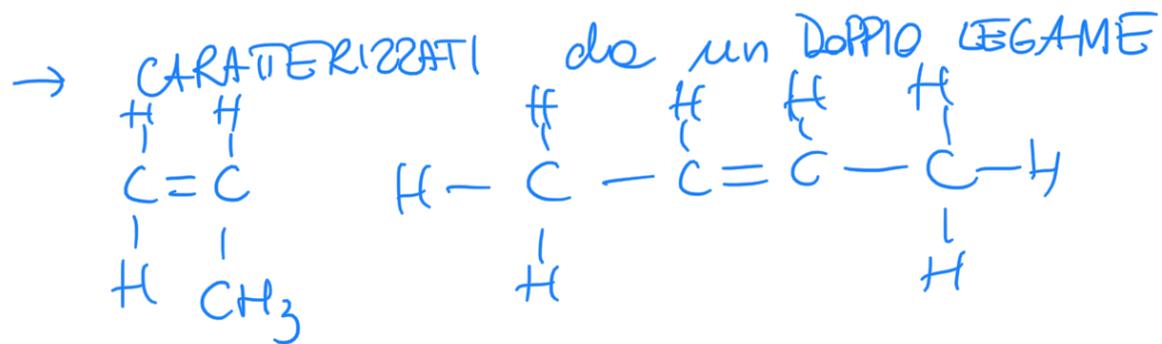
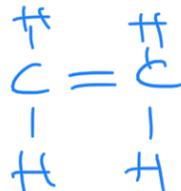
## 3) TERMINAZIONE



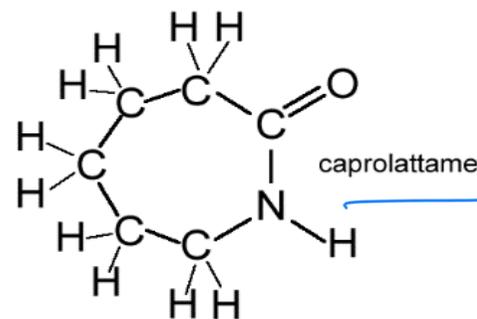
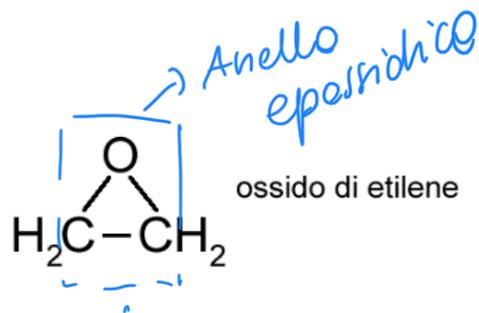
# REAZIONI A CATENA

## MONOMERI

### ➤ MONOMERI INSATURI

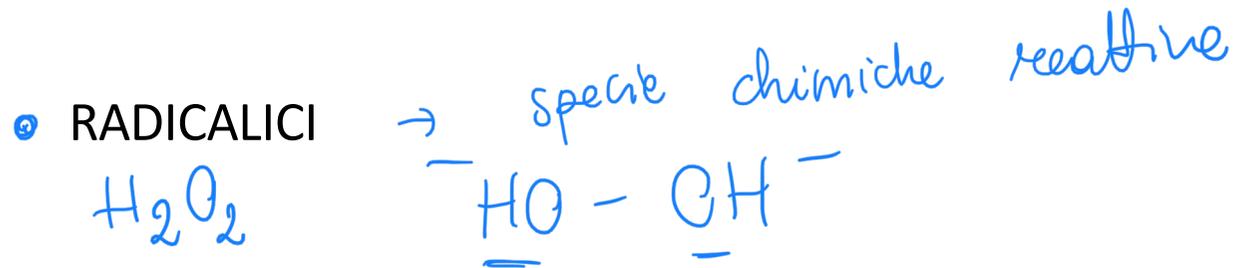


### ➤ STRUTTURA AD ANELLO



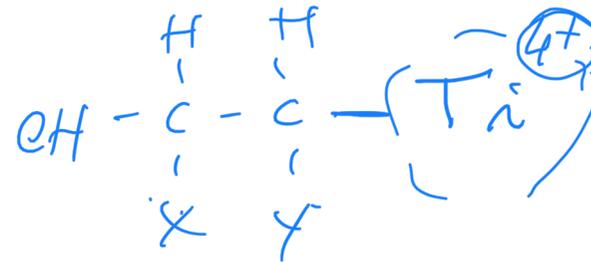
# REAZIONI A CATENA

## INIZIATORI



• STEREOSPECIFICI

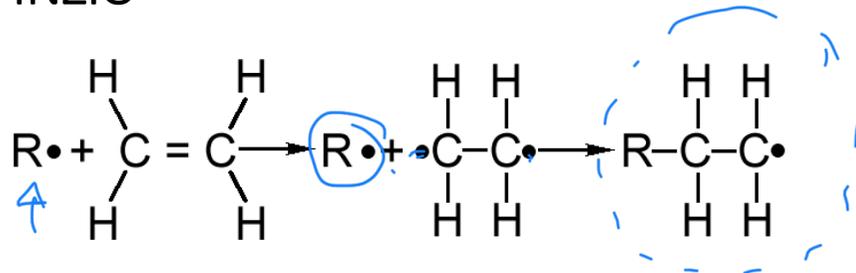
### METALLOORGANICI



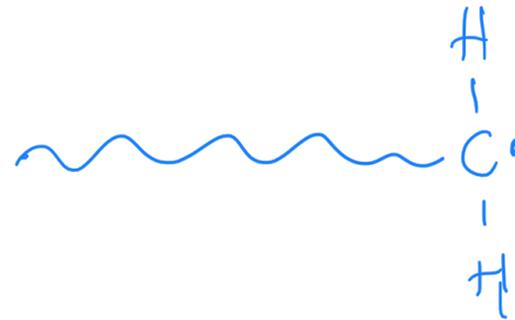
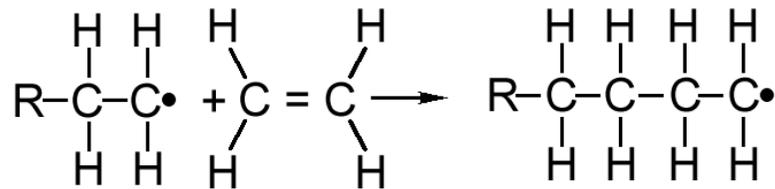
# REAZIONI A CATENA: RADICALICA

POLIETILENE

INIZIO



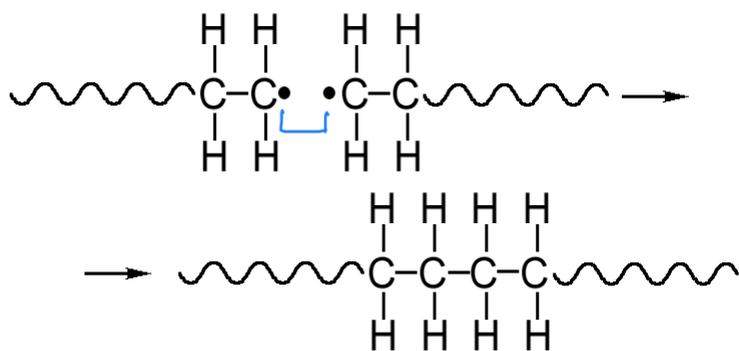
PROPAGAZIONE



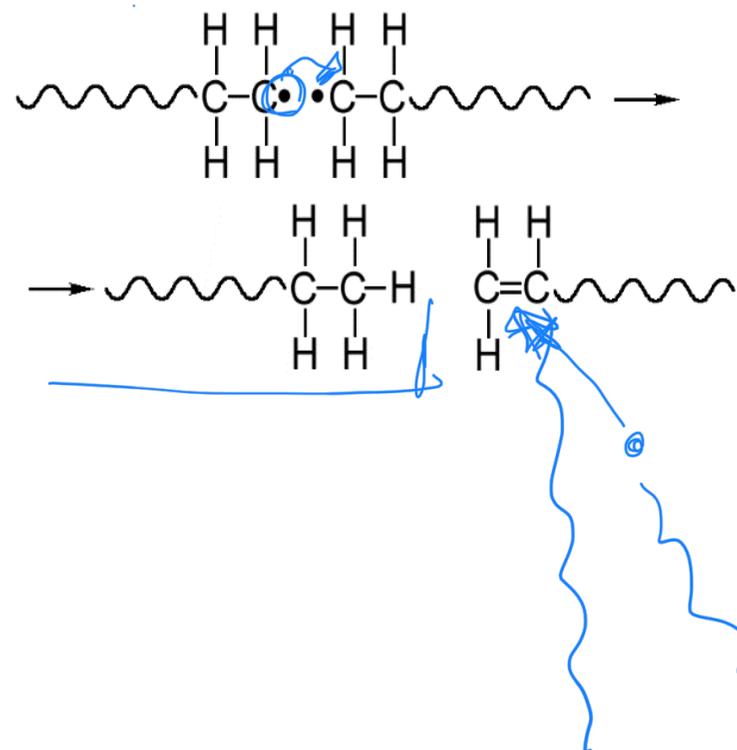
# REAZIONI A CATENA: RADICALICA

## TERMINAZIONE

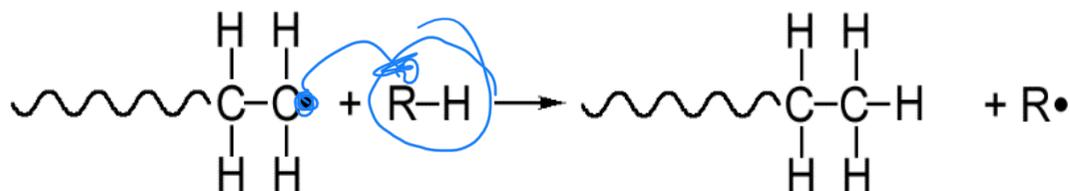
### 1. Combinazione di radicali



### 2. Disproporzionamento



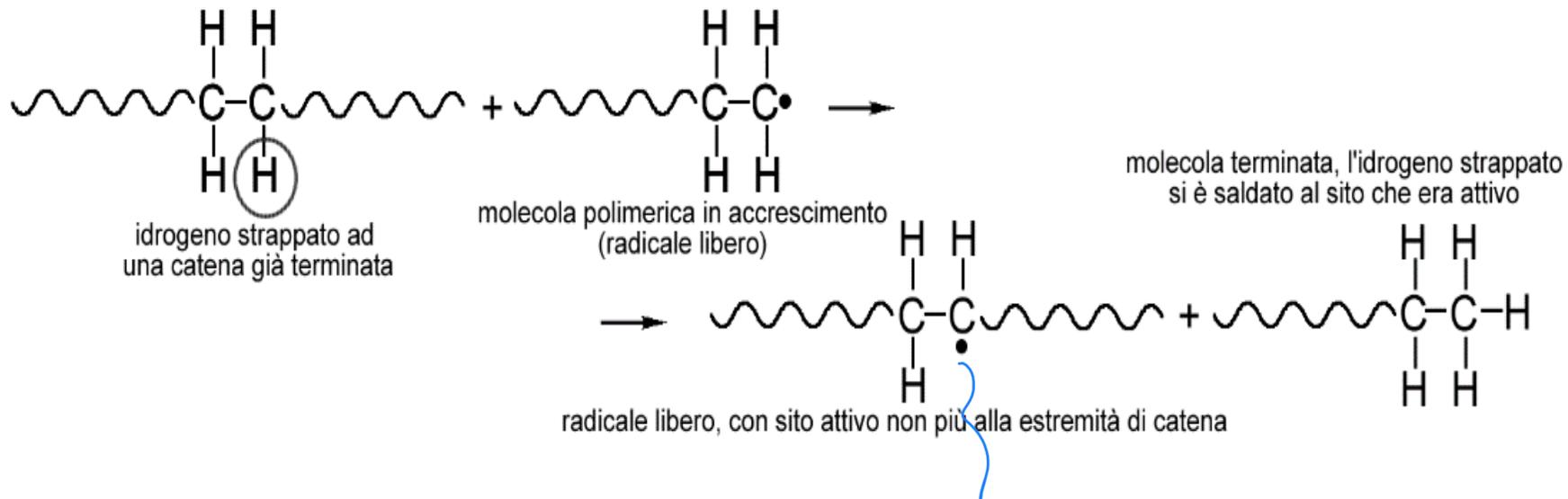
### 3. Trasferimento di catena



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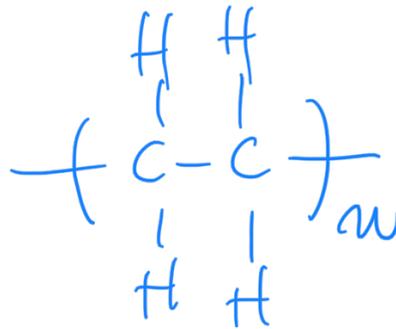
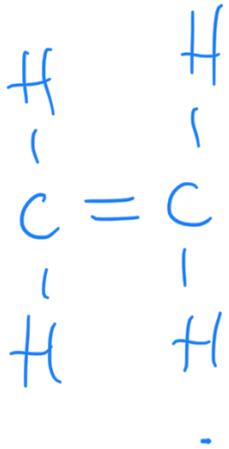
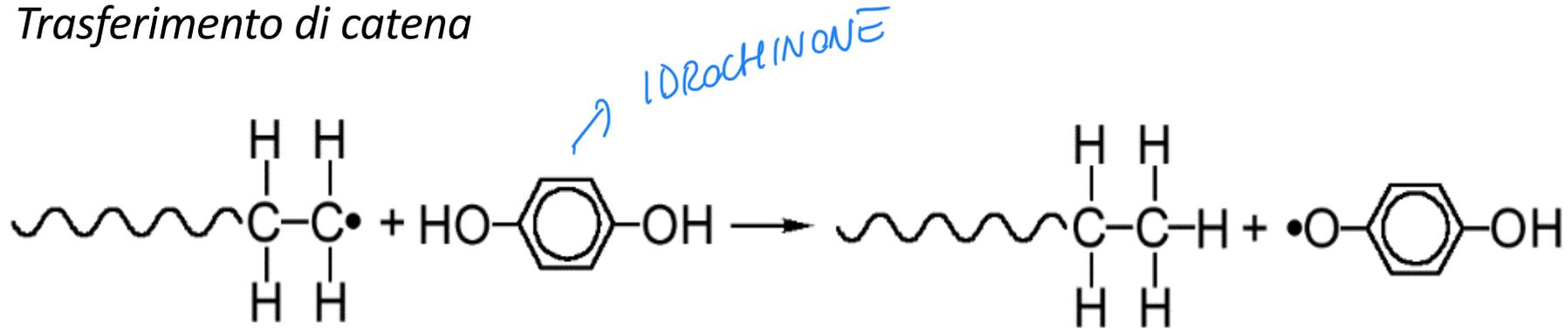
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↓ grado di polimerizzazione