

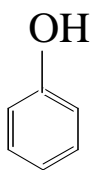
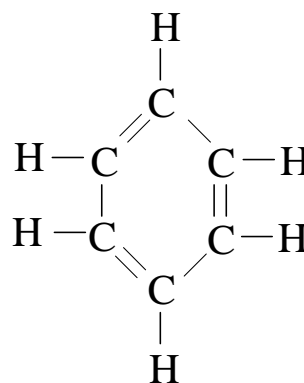
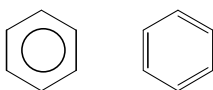
## Chapter 7.

### Petrochemicals from Benzene, Toluene, the Xylens

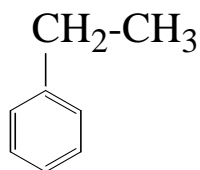
- Benzene, Toluene, Xylene (BTX)

- aromatic hydrocarbons

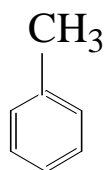
1. Benzene :  $C_6H_6$ ,



phenol

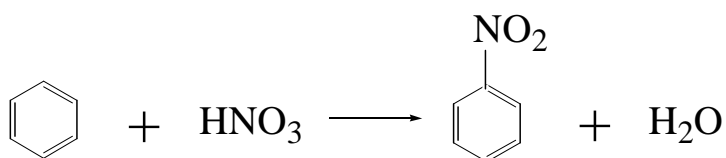


ethyl benzene



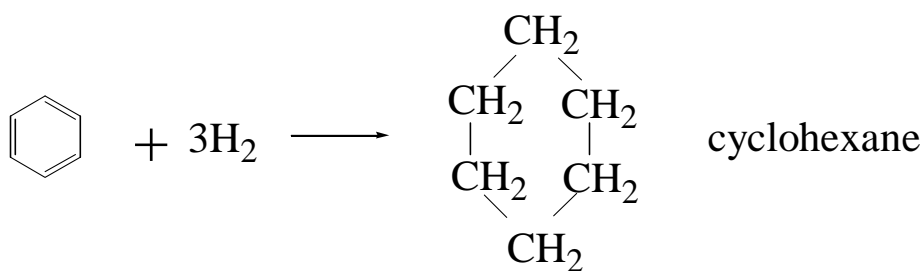
toluene (methyl benzene)

(i) substitution :



nitrobenzene

(ii) addition :

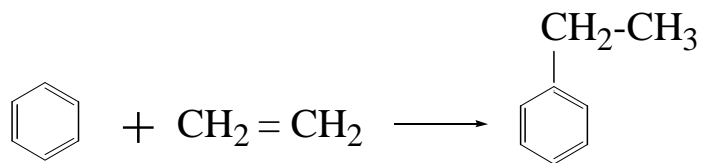


cyclohexane

(ex) Benzene      cyclohexane      caprolactam      Nylon -6  
 Benzene      ethyl benzene      styrene      polystyrene

(1) Ethylbenzene :  $C_6H_5CH_2CH_3$

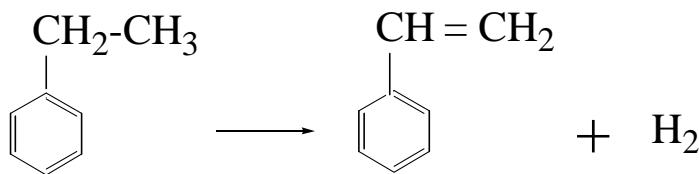
- produced by the alkylation reaction between benzene and ethylene



( ) styrene

(2) Styrene :  $C_6H_5CH=CH_2$

- produced by the catalytic dehydrogenation of ethylbenzene



( ) plastic

polystyrene (PS)

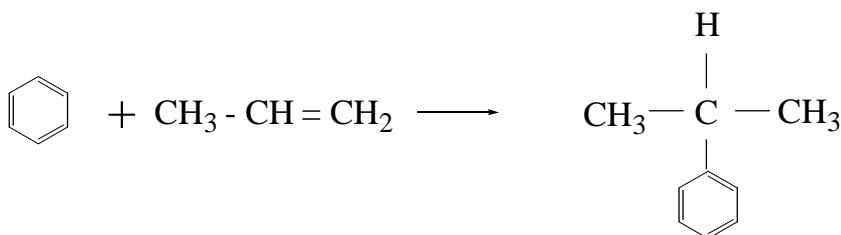
poly(acrylonitrile -butadiene -styrene) (ABS)

styrene -acrylonitrile copolymer (SAN)

styrene -butadiene rubber (SBR)

(3) Cumene ( $C_6H_5CHCH_3CH_3$ )

- produced by propylene alkylation of benzene

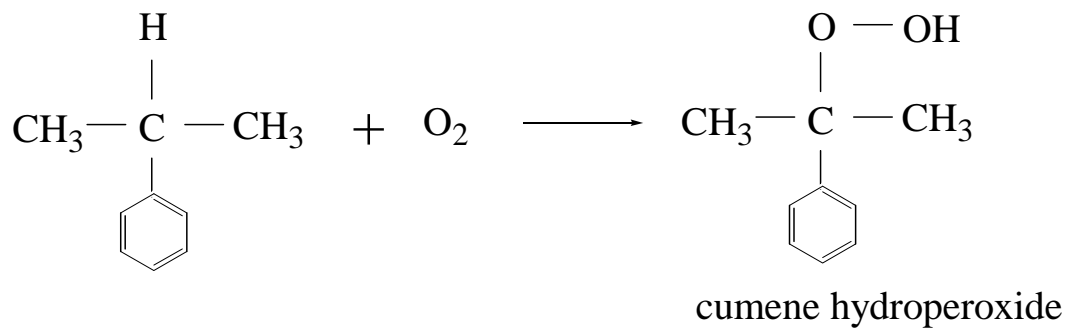


( ) phenol (C<sub>6</sub>H<sub>5</sub>OH)

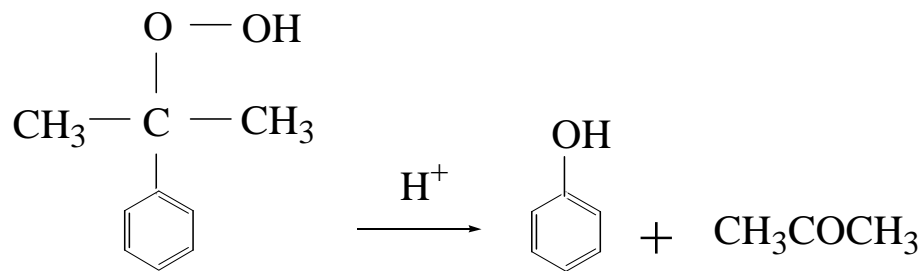
(4) phenol

- the cumene process can be regarded as the only one currently with industrial significance

(i) The cumene hydroperoxidation reaction

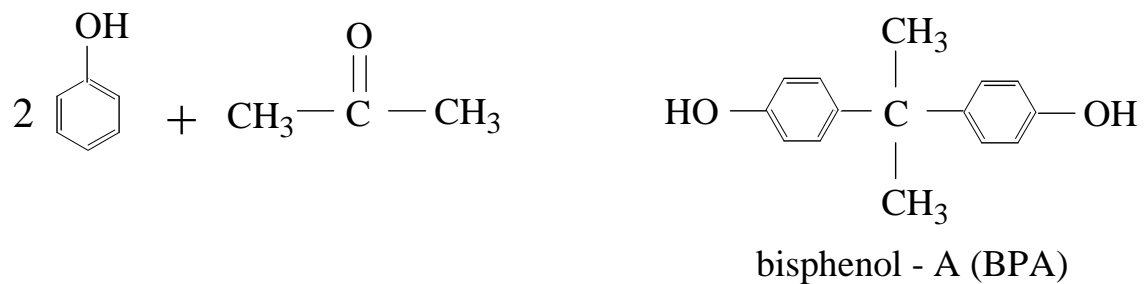


(ii) The hydroperoxide decomposition rx



( ) phenolic resin

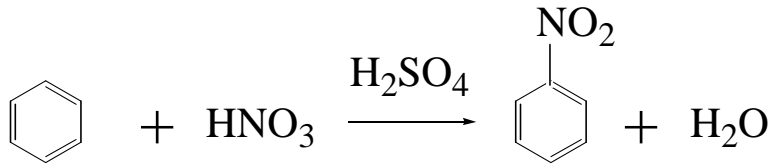
bisphenol - A



BPA : BPA -Polycarbonate

Epoxy resin

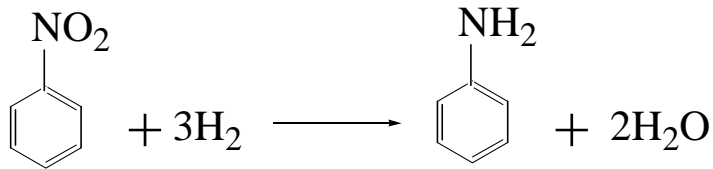
(5) Nitrobenzene



( ) aniline

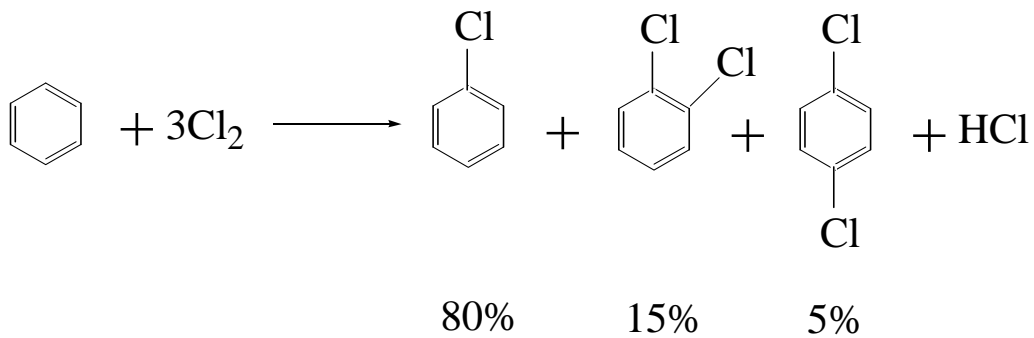
(6) Aniline

- produced by the hydrogenation of nitrobenzene



( ) isocyanate

(7) chlorobenzene :  $\text{C}_6\text{H}_5\text{Cl}$



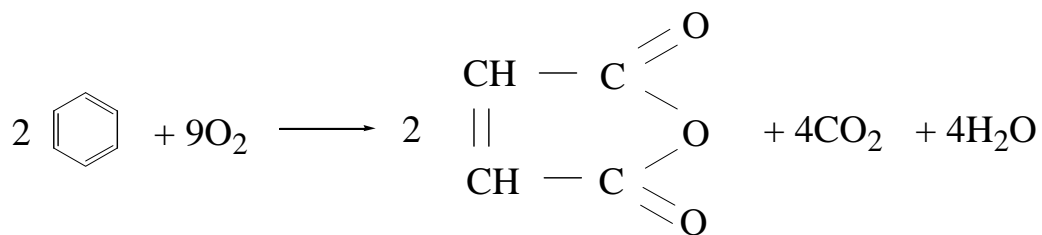
( ) , Phenol, DDT

(8) Cyclohexane :  $\text{C}_6\text{H}_{12}$

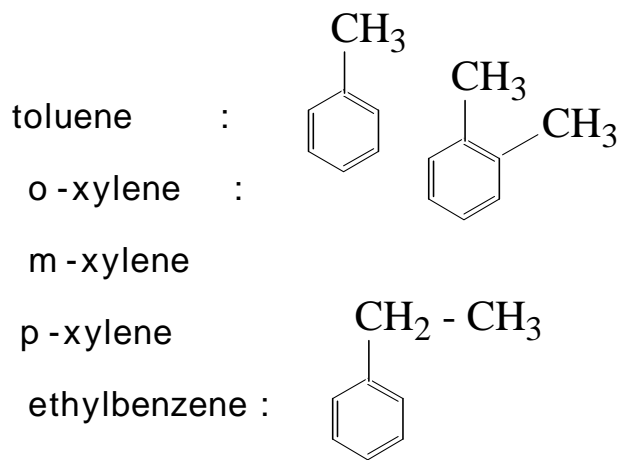
- produced by the hydrogenation of benzene

(9) Maleic anhydride

- by the oxidation of benzene



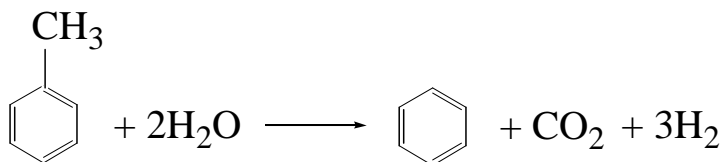
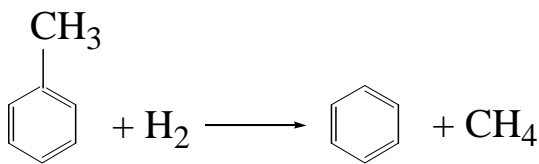
- The methylbenzene



(1) Toluene :  $C_6H_5CH_3$

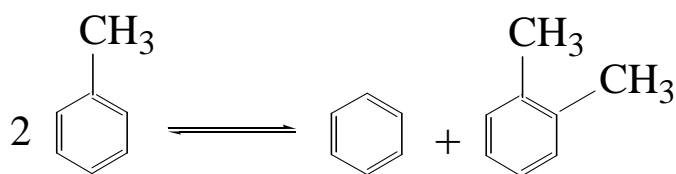
(i) Benzene

- produced by dehydroalkylation of toluene



(ii) Benzene and Xylene

- obtained by the catalytic disproportionation of toluene in the presence of hydrogen
- disproportionation is the conversion of 2 mols of a single aromatic compound to one mole each of two different aromatic compounds

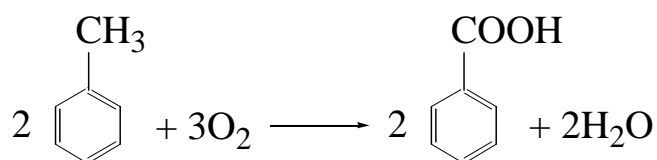


:  $\text{C}_6\text{O}-\text{M}_2\text{O}_3$  on aluminosilicate/alumina

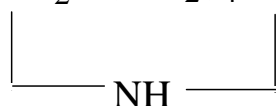
axylene / m-xylene / p-xylene : 22 / 55 / 23

(iii) Benzoic acid :  $\text{C}_6\text{H}_5\text{COOH}$

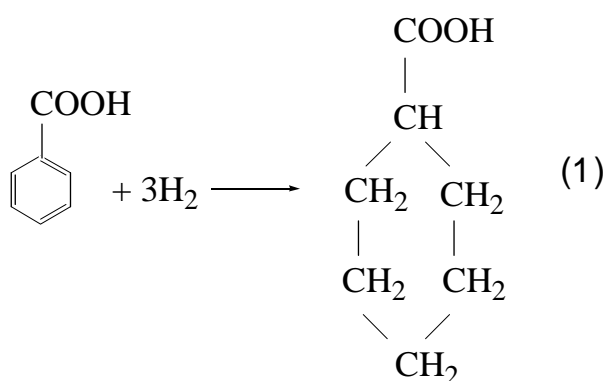
- produced by the liquid phase catalytic oxidation of toluene



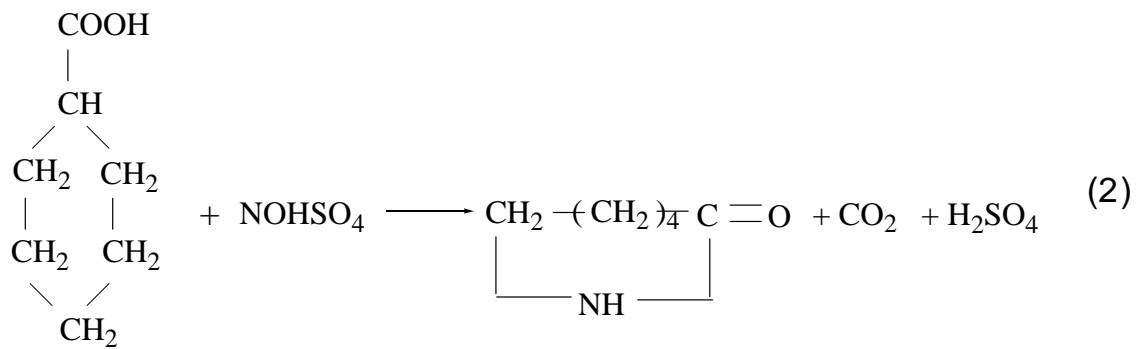
(iv) Caprolactam :  $\text{CH}_2-(\text{CH}_2)_4-\text{C}(=\text{O})-\text{NH}$  : Nylon-6



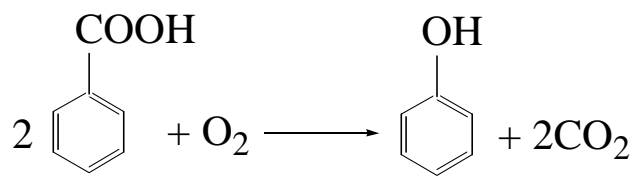
- synthesized from benzoic acid by hydrogenation to cyclohexane carboxylic acid



- this acid is converted to caprolactam by reaction with nitrosyl-sulfuric acid,  $\text{NaHSO}_4$



(v) phenol, C<sub>6</sub>H<sub>5</sub>OH



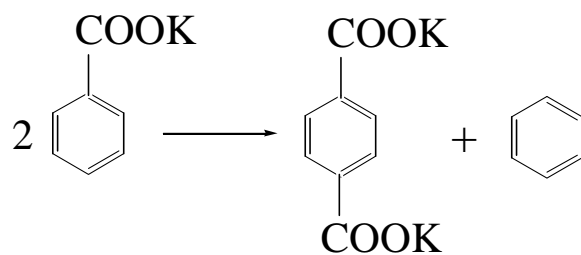
(benzoic acid)

( ) Bisphenol -A , phenolic resin

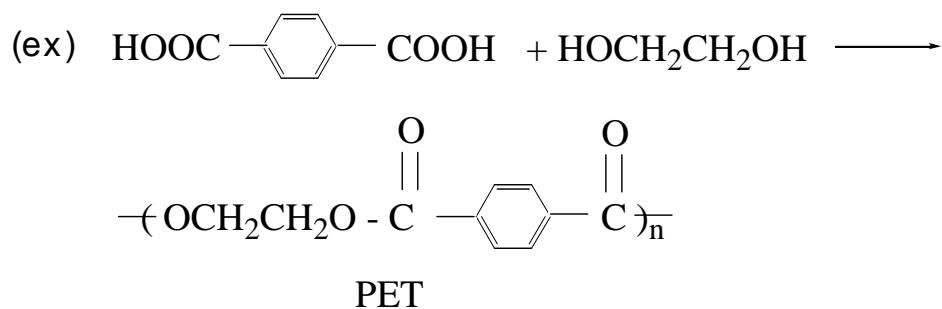
(vi) Terephthalic acid : HOOC -C<sub>6</sub>H<sub>4</sub> -COOH

- produced by solid phase disproportionation of potassium benzoate

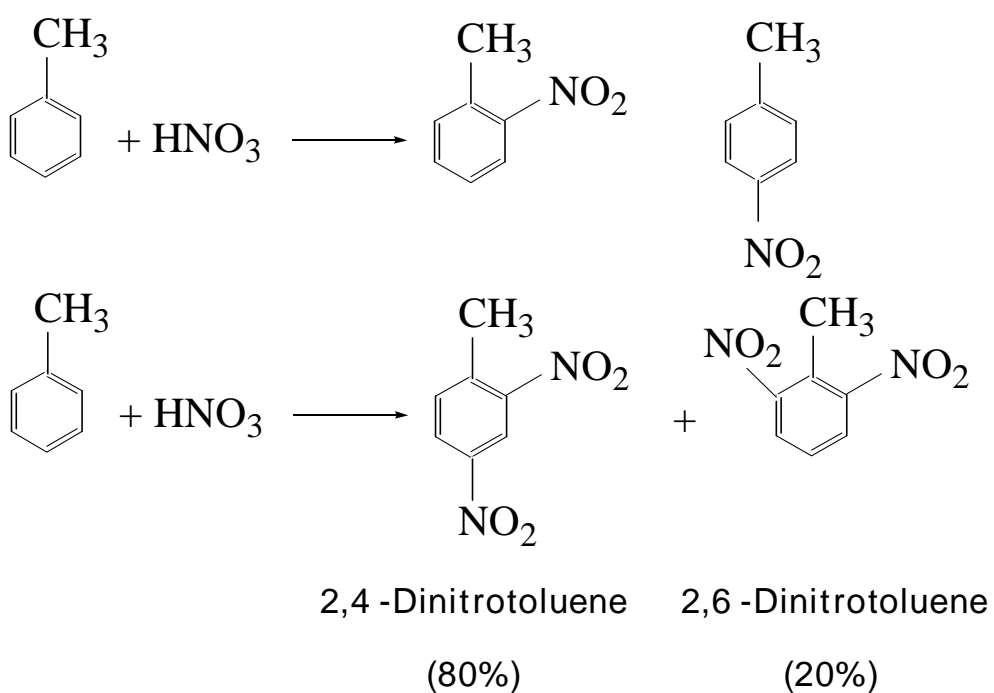
- obtained by mineral acid treatment and the byproduct potassium salt is recycled



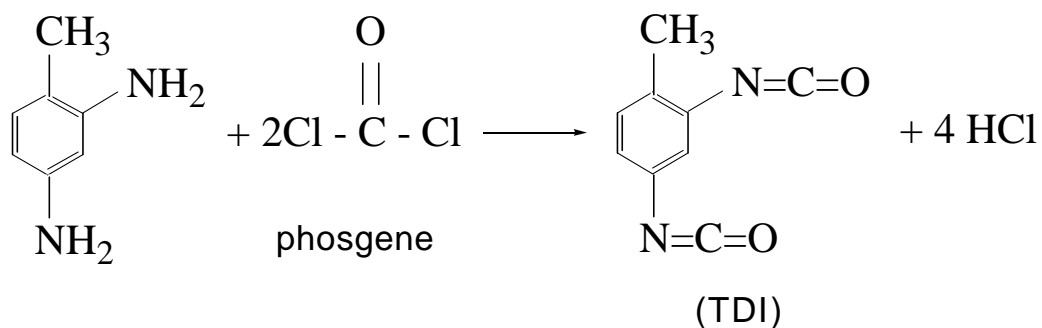
( ) poly(ethylene terephthalate)



(vii) Nitrotoluene

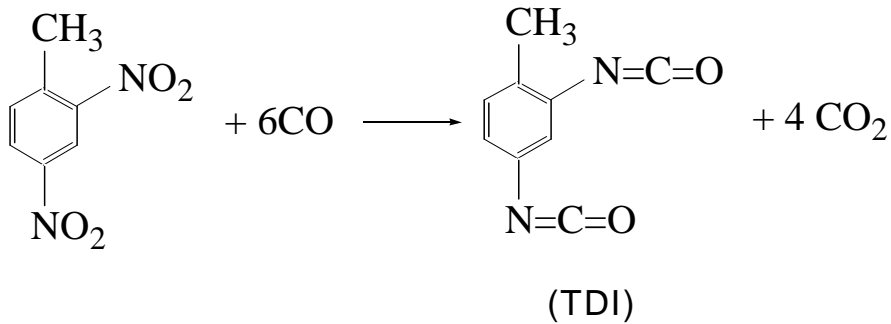


- Toluene diisocyanate (TDI) :





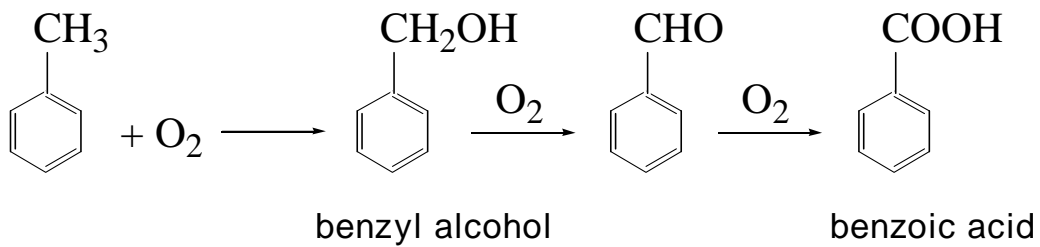
- also produced directly from the dinitrotoluene



( ) polyurethane

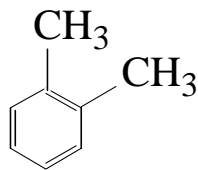
(viii) Benzaldehyde ,  $\text{C}_6\text{H}_5\text{CHO}$

- produced by the oxidation of toluene



( ) solvents , synthetic perfume

• The Xylenes,



o-xylene 20.1%

m-xylene 40.4%

p-xylene 18.3%

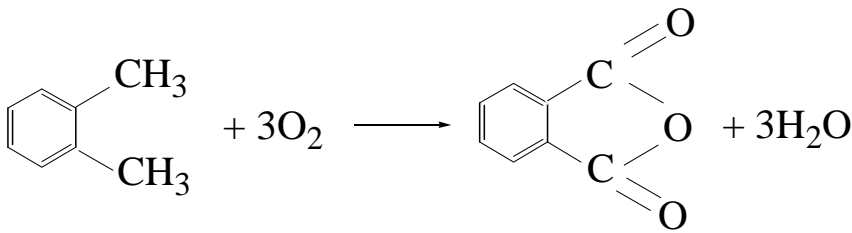
ethyl benzene 21.2%

- the xylenes are obtained from refinery reformat streams

- xylene (i) blended with gasoline : 16 %
- (ii) solvent : 17%
- (iii) : 67%

(i) o-xylene

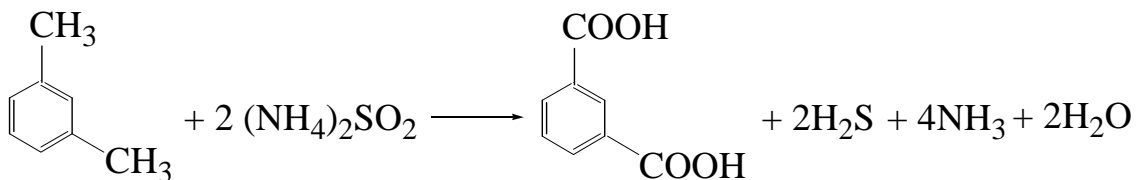
- phthalic anhydride



( ) PVC 가 (plasticizer)

(ii) m-xylene

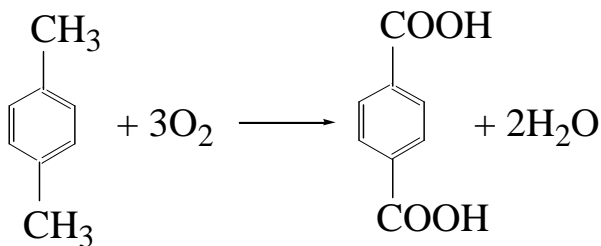
- isophthalic acid : produced by the liquid phase oxidation of m-xylene by use of ammonium sulfide,  $(\text{NH}_4)_2\text{SO}_3$



( ) glycol urethane .

polyester

(iii) p-xylene



( ) ethylen glycol PET