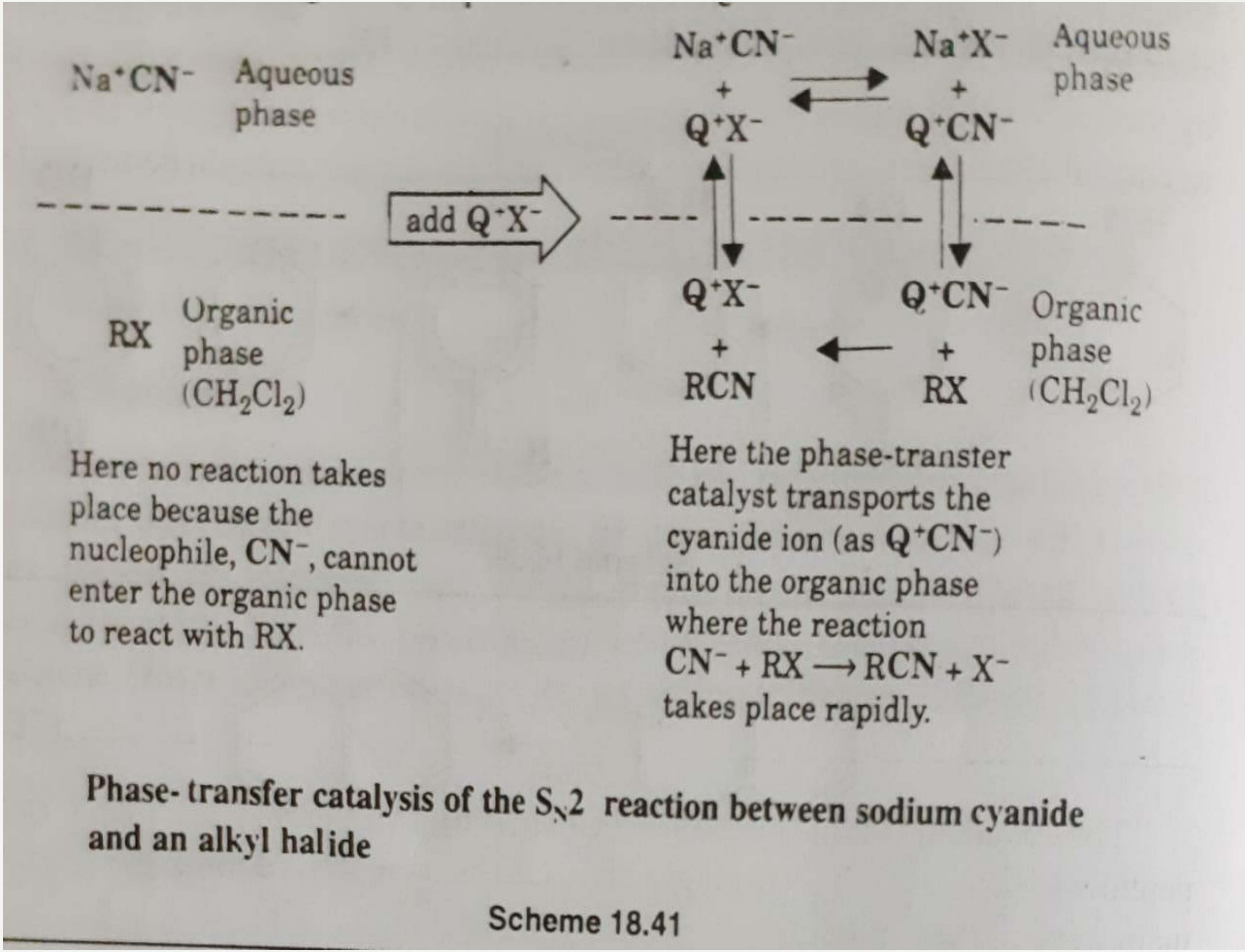
PHASE TRANSFER CATALYST

- Phase-transfer catalysis (PTC) is a powerful tool in many areas of chemistry.
- It is a technique for conducting reactions between two or more reagents in two or more phases, when reaction is inhibited because the reactants cannot easily come together.
- A “phase-transfer agent” is added to transfer one of the reagents to a location where it can conveniently and rapidly react with another reagent.
- It is also necessary that the transferred species be in a highly active state when transferred; otherwise large amounts of phase-transfer agent will be required.

- This activation function, and the transfer function, allows phase-transfer catalysis to occur with only a catalytic amount of phase-transfer agent.
- Phase transfer catalysts are compounds whose addition to a two phase organic-water system helps transfer a water soluble reactant across the interface to the organic phase where a homogeneous reaction can occur and thereby enhancing the rate of reaction.
- An example of phase-transfer catalysis is an SN2 reaction (Scheme 18.41).



Here no reaction takes place because the nucleophile, CN^-, cannot enter the organic phase to react with RX.

Here the phase-transfer catalyst transports the cyanide ion (as Q^+CN^-) into the organic phase where the reaction $CN^- + RX \longrightarrow RCN + X^-$ takes place rapidly.

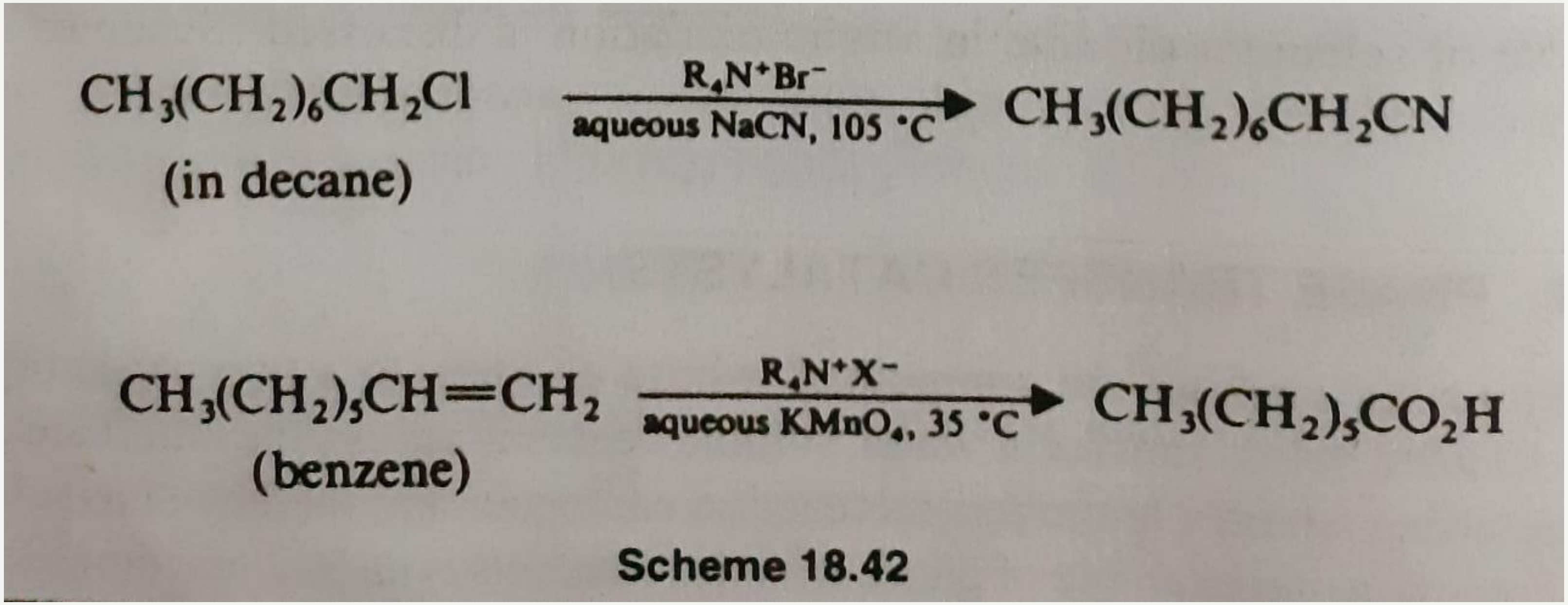
Phase- transfer catalysis of the S_N2 reaction between sodium cyanide and an alkyl halide

Scheme 18.41

- The phase-transfer catalyst (Q^+x^-) is usually a quaternary ammonium halide ($R_4N^+X^-$) e.g., tetrabutylammonium halide, $(CH_3CH_2CH_2CH_2)_4N^+X^-$.
- The phase-transfer catalyst causes the transfer of the nucleophile (e.g., CN) as an ionpair [Q^+CN^-] into the organic phase.
- This transfer is feasible because the cation(Q^+)of the ion pair, with its four alkyl groups, resembles a hydrocarbon in spite of its positive charge.
- It is lipophilic i.e., it prefers a nonpolar environment to e aqueous one.

- In the organic phase the nucleophile of the ion pair (CN-) reacts with the organic substrate RX.
- The cation (Q+) and anion (X-) then migrate back the aqueous phase to complete the cycle. The process continues until all of the nucleophile or the organic compound has undergoes reaction.

- An example of a nucleophilic substitution reaction carried out in the presence of phase transfer catalyst is the reaction of 1-chlorooctane (in decane) and sodium cyanide (in water).
- The reaction (at 105° C) is complete in less than 2 h and gives a 95% yield of the substitution product (Scheme 18.42).
- Similarly the oxidation of an alkene dissolved in benzene is carried out using an aqueous solution of $KMNO_4$ in the presence of a quaternary ammonium salt.
- KMnO4 is transferred to benzene by quaternary ammonium salt where the oxidation is carried out by "purple benzene"



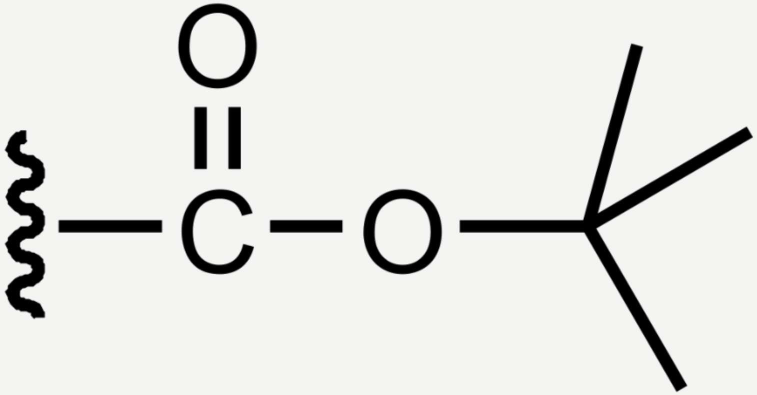
$$\underset{\text{(in decane)}}{CH_3(CH_2)_6CH_2Cl} \xrightarrow[\text{aqueous NaCN, 105 °C}]{R_4N^+Br^-} CH_3(CH_2)_6CH_2CN$$

$$\underset{\text{(benzene)}}{CH_3(CH_2)_5CH{=}CH_2} \xrightarrow[\text{aqueous KMnO}_4\text{, 35 °C}]{R_4N^+X^-} CH_3(CH_2)_5CO_2H$$

Scheme 18.42

t- BUTOXY CARBONYL CHLORIDE

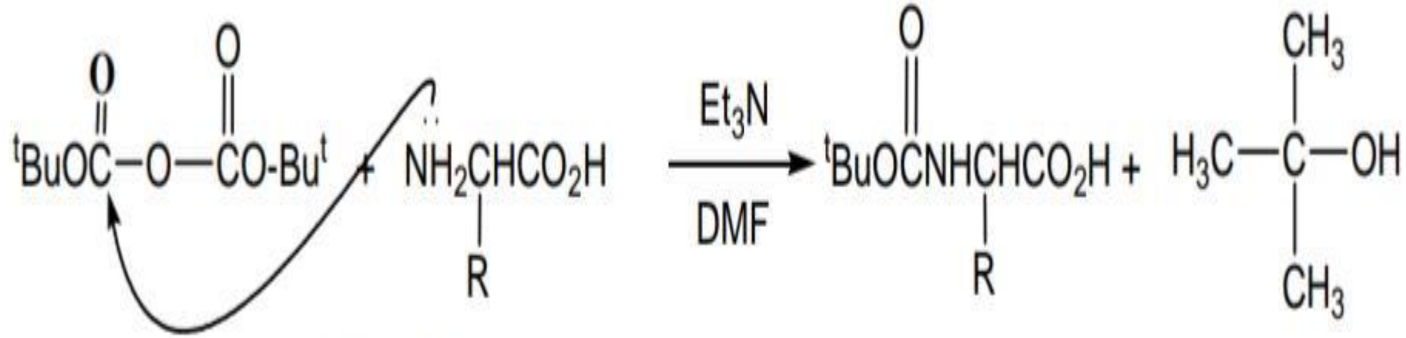
- The ***tert*-butyloxycarbonyl protecting group** or ***tert*-butoxycarbonyl protecting group** (**BOC group**) is a protecting group used in organic synthesis.
- The BOC group can be added to the amine under aqueous conditions using di-*tert*-butyl dicarbonate in the presence of a base such as sodium carbonate(soda ash):



- Removal of the BOC in amino acids can be accomplished with strong acids such as trifluoroacetic acid in dichloromethane, or with HCl in methanol

Amine protection

- The BOC (tert-butyloxycarbonyl) protecting group, chemically a di-tert-butyl dicarbonate (Boc_2O), is probably the most common amine protecting group in non-peptide chemistry.
- The reaction conditions for the amine protection are quite flexible.
- The process usually achieves high yields and fast conversions under relatively mild conditions.



BOC

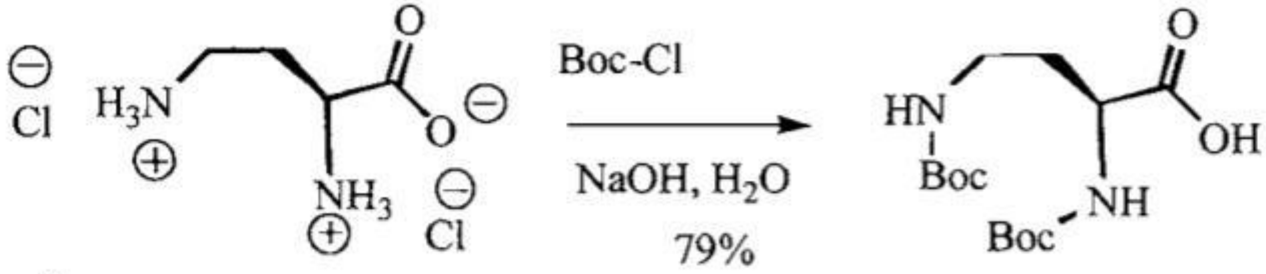
(Di-t-Butyl dicarbonate)

Phenylalanine

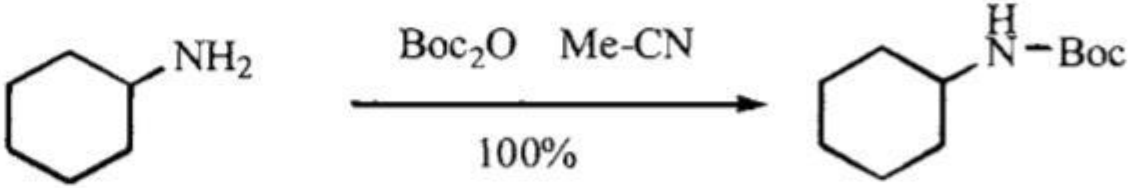
Carbamate

Examples:

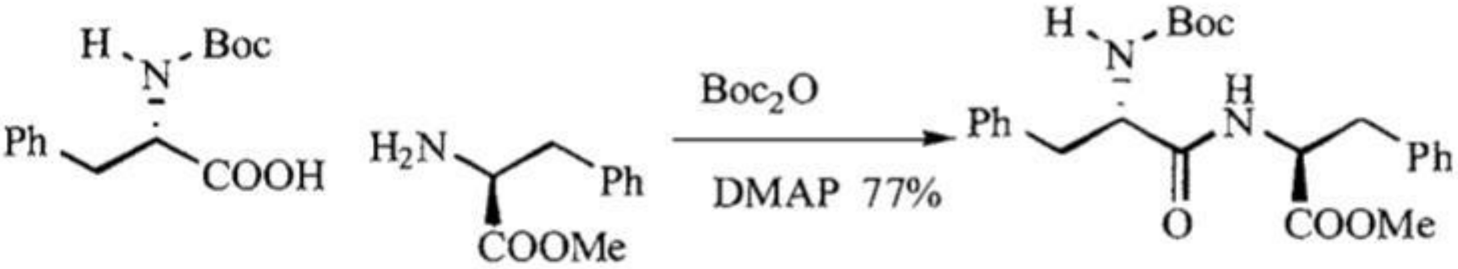
1.[1]



2.[2]

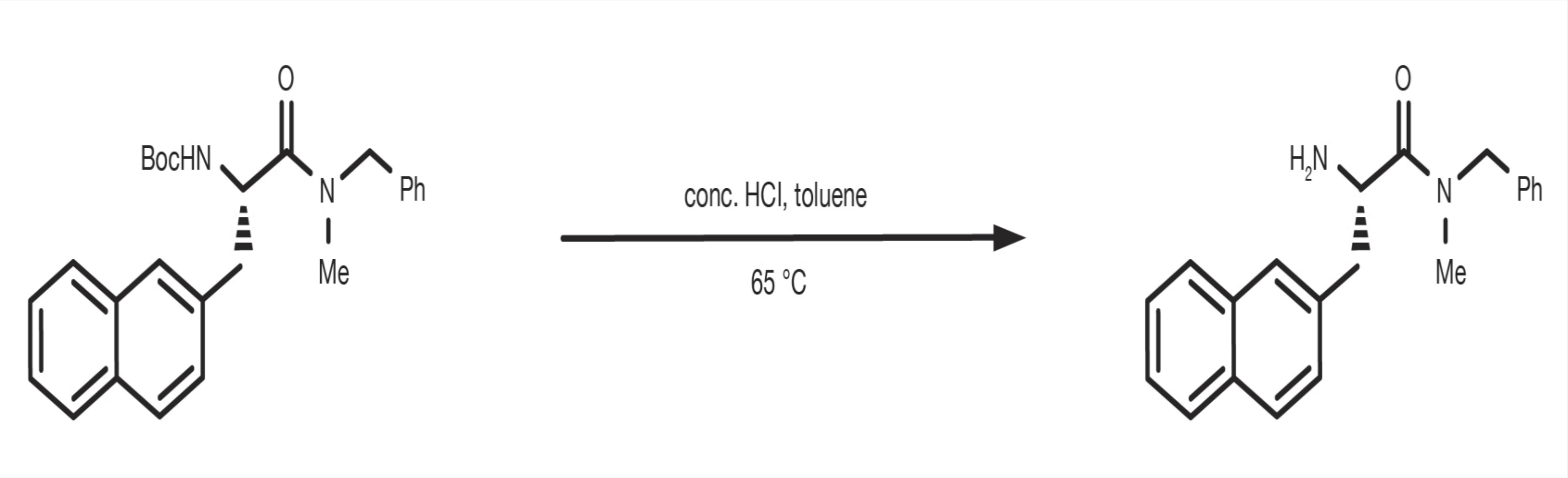


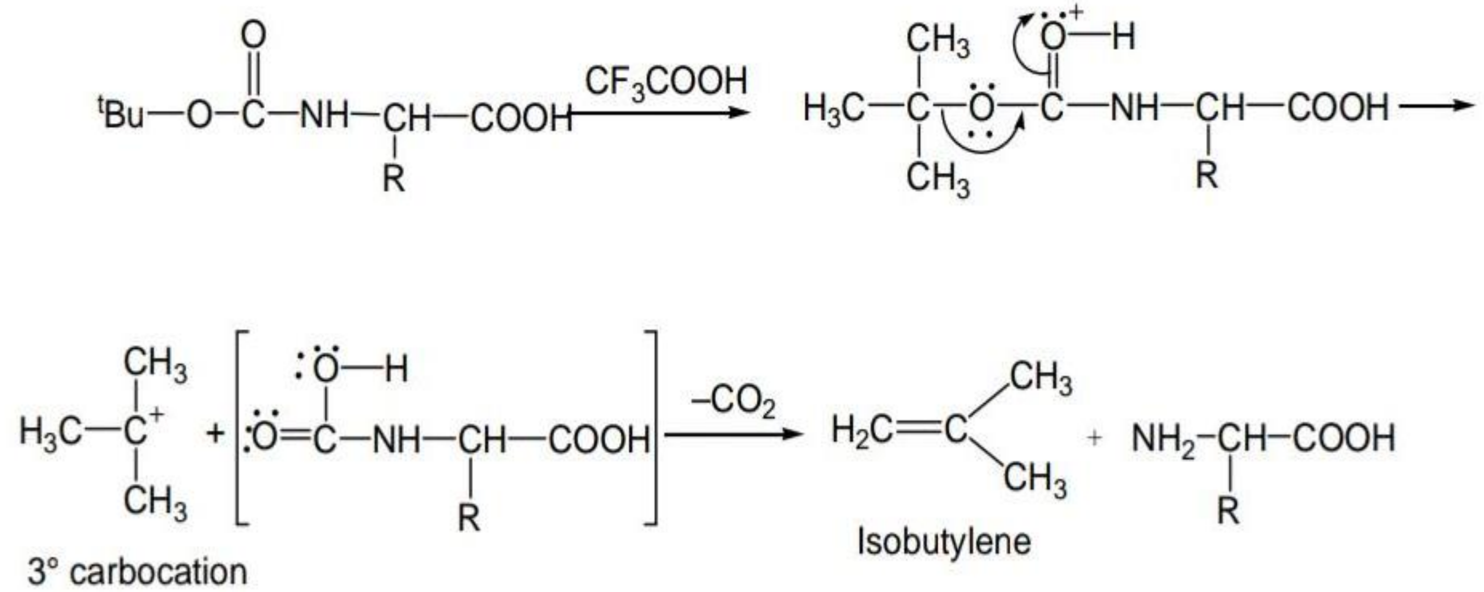
3.[3]



Deprotection

- The starting material is dissolved in water or organic solvent, such as toluene, dichloromethane, or ethyl acetate.
- Concentrated hydrochloric acid, or trifluoroacetic acid (TFA) are the acids of choice.
- The reaction is usually fast and happens at room temperature.
- Biphasic systems can be used, with the protected amine dissolved in the organic phase mixed with the aqueous solution of the acid.





(Deprotection : Regeneration of Amino group)