Tri-n-butyltin hydride Reagents

(Bu_3SnH)

The chemistry of organotin compounds was arises in of 19th century. Carl Jacob Lowig (1803-1890), a professor at Zurich University, laid the foundation forthe chemistry of organotin compounds. Organotin compounds are versatile reagents in organic chemistry and have wide range of applications in synthetic organic chemistry.

The applications of organotin compounds as reagents or intermediates in organic synthesis are rapidly growing. Among the organotin compounds organotin hydridesand organo stannanes have found extensive applications in synthetic organic chemistry. The use of organotin hydrides includes reduction of organic halides, carbonyl compounds, nitro compounds, carbon-carbon multiple bond and also preparation of other organotin compounds, which allow the straight forward preparation of various types of useful starting materials for cross coupling reactions. Thus organotinhydrides have wide scope in reactions such as C-C bond formation, ring closure and addition reactions. Organostannanes are also of tremendous synthetic utility as building blocks in organic synthesis as they can undergo a large number of carbon-carbon bond forming reactions and concomitant C-C bond formation leading to ring closures.

Tri-n-Butyltinhydride Hydride:

Tri-n-butyltinhydride is a very good radical reducing agent due rto the relatively weak, nonionic bond between tin and hydride (Bu_3Sn-H 74kcal/mole) that can homolytically. It is a colourless liquid that is soluble in most organic solvents. The compound is used as hydrogen atom in organic synthesis.

Preparations:

1. The most general method to preparation of organo tinhydride is to reduces organotin halide derivatives with metal halide**.**

$$Bu_3SnX_4 + LiAlH_4 \longrightarrow Bu_3SnH + AlCl_3 + HCl$$

2. Reaction of tributyltin oxide with polymetylhydrosilane.

$$x(n\text{-}Bu_3Sn)_2O + 2(MeSiHO)_x \longrightarrow 2(n\text{-}Bu)_3SnH + 2(MeSiO_{1.5})_x$$

3. Reaction of silyl monohydrides such as Ph_3SiH with bis(tribulyltin) oxide.

$$(n\text{-}Bu_3Sn)_2O + Ph_3SiH \longrightarrow n\text{-}Bu_3SnH + Ph_3SiOSnBu_3$$

4. Tributyltinhydride is also prepared from reduction of bis(tribulyltin) oxide.

$$2(n\text{-}Bu_3Sn)_2O + LiAlH_4 \longrightarrow 4(n\text{-}Bu_3SnH) + LiAlO_2$$

Synthetic Applications:

Reduction of halides

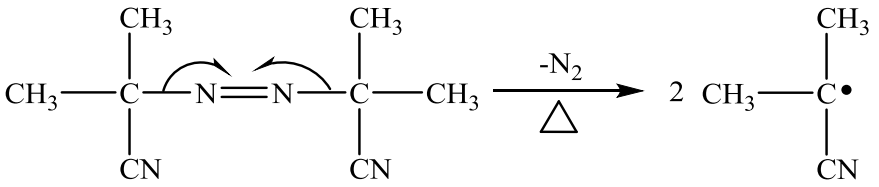
Tributyltin hydride converts organic halides and its related groups to the corresponding hydrocarbon in presence of AIBN or shining UV light.

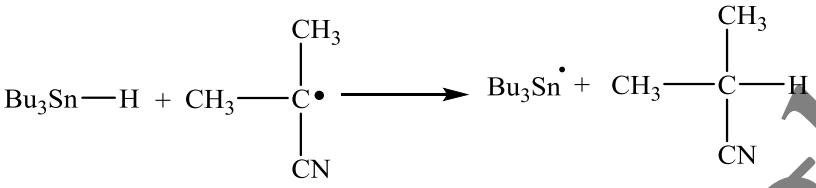
$$RBr + Bu_3SnH \xrightarrow[\text{or UV}]{\text{AIBN}} RH + Bu_3SnBr$$

Mechanism:

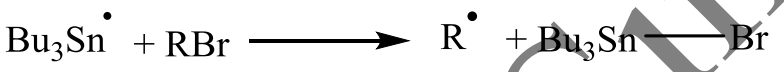
The mechanism is goes through free radical mechanism. The free radical chain mechanism involves the basic three steps.

Initiation step: The free radical initiator AIBN, tri-n-butyltin hydride generates the tributyltin (Stannyl free radical) free radical.





Propagation step: The free radical can cleave an alkyl/ aryl halide bond forming alkyl/ aryl radical and Bu_3SnX



Another molecule of Bu_3SnH provides a hydrogen free radical for making an alkyl/aryl hydrogen bond and propagates the radical chain reaction.

Termination step: All the free radical combines to stop the reaction.

Notes:

- The relative rate of abstraction of halogen by tri-n-butyltin radical depends upon the halogen in order.

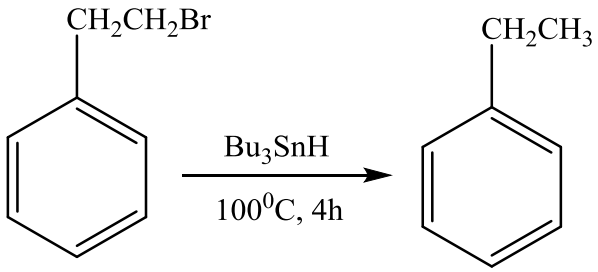
$$I > Br > Cl > F$$

- Relative rate of reaction depends upon the stability order of free radicals.

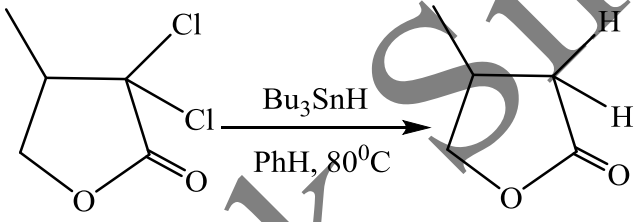
$$Benzyl > Allyl > 3^0 > 2^0 > 1^0 > CH_3$$

- The reactivity order for different halides according to the mechanism is as follows:

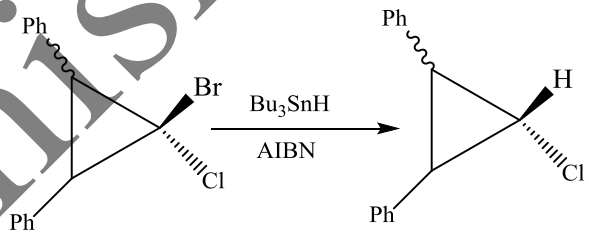
Benzyl halide >Allyl halide > 3^0 alkyl halide > 2^0 alkyl halide >2^0 alkyl halide >1^0 alkyl halide > methyl halide > vinyl halide > aryl halide

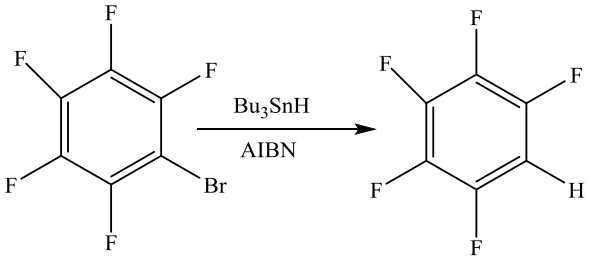


The selective reduction of halogen depends on their position as chlorine atom at alpha to carbonyl group.



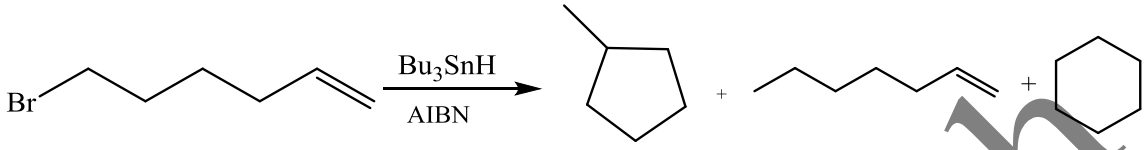
Alkyl/aryl bromides are more reactive towards tri-n-butyltin hydride than chlorides or fluorides



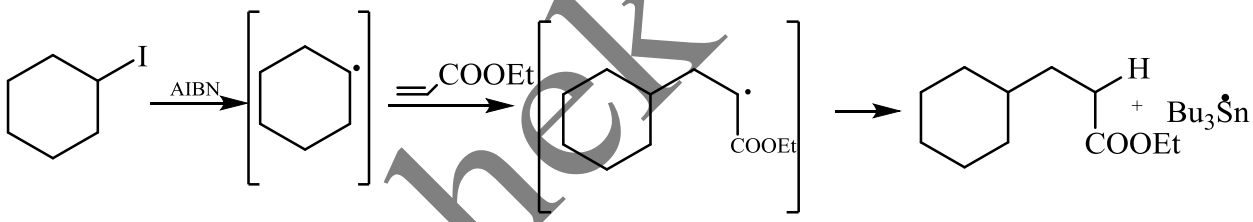


Cyclisation reactions:

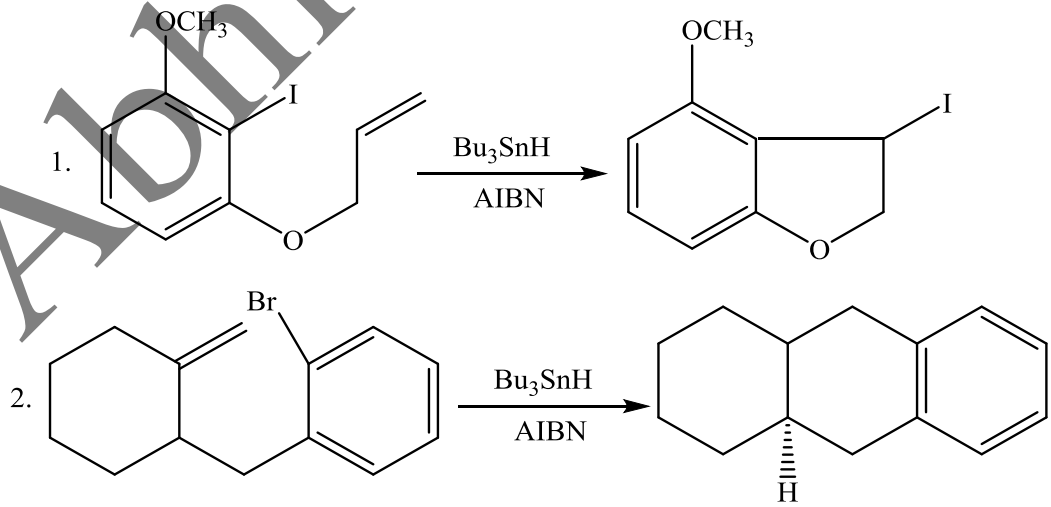
The cyclisation reactions are occur due to unsaturated moiety may be a carbon-carbon, carbon-oxygen, carbon nitrogen multiple bond. The unsaturation can sometimes be included in a highly complex structure.



Alkene is to heat an alkyl halide with AIBN, in presence of tri-n-butyltin hydridre. In this example, AIBN react with iodocyclohexane to produce a intermediate cyclohexyl free radical, which react with ethyl acrylate to yield desired product.

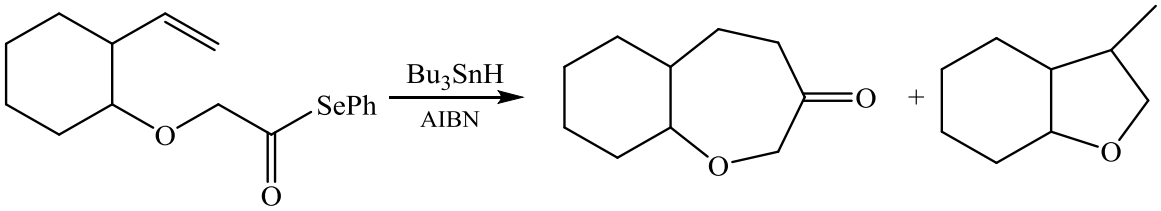


Tri-n-butyltin hydride (TBTH), also finds use in related cyclisaton reactions involving dehalogination.



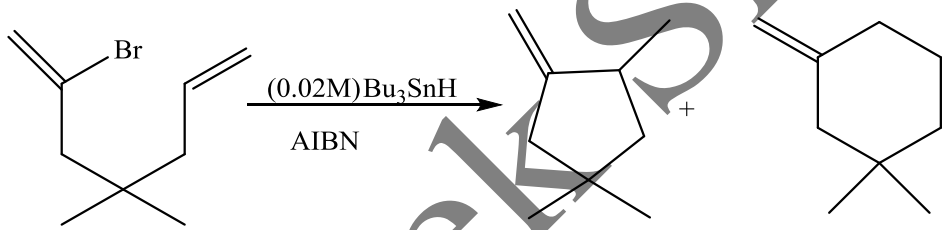
Cyclisation of Acyl Radicals:

Intermolecular addition of acyl radicals to terminal alkenes favors cyclisation.



Cyclisation of Vinyl and Aryl Radicals:

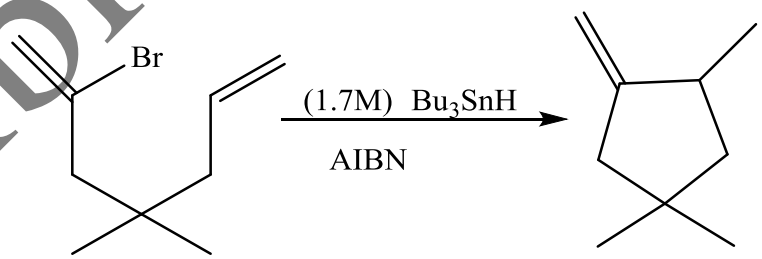
Cyclisation of vinyl and aryl radicals follows a path parallel to that of acyl radicals. Mechanistic studies have been shown that at very low Bu_3SnH concentration (0.02M) reduction of vinyl bromide gave a 3:1 ratio mixture of product.



75% 25%

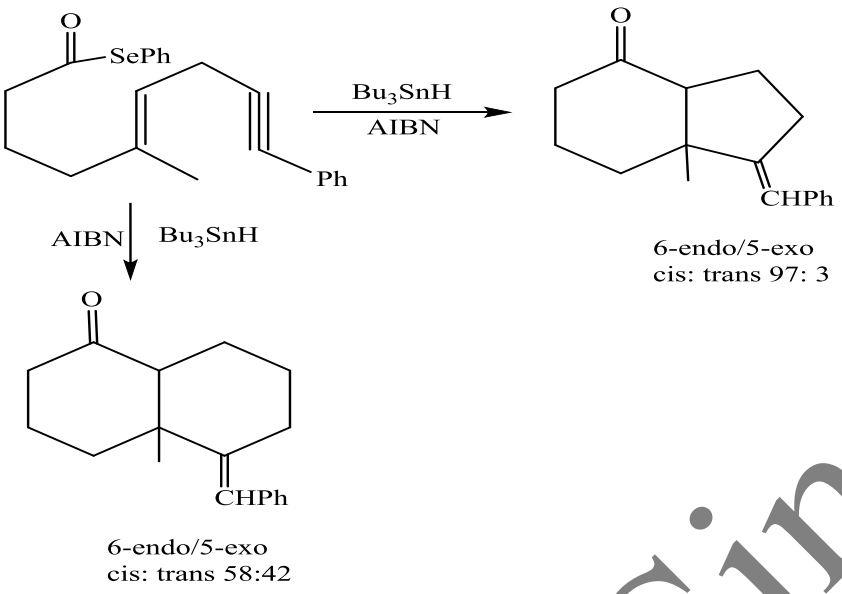
However, at high Bu_3SnH concentration (1.7M) 100% exo product is formed.

At high Bu_3SnH concentration the radical resulting from 5- exo cyclisation undergoes rearrangement by one carbon ring expansion to the thermodynamically more favorable 6-endo radical.



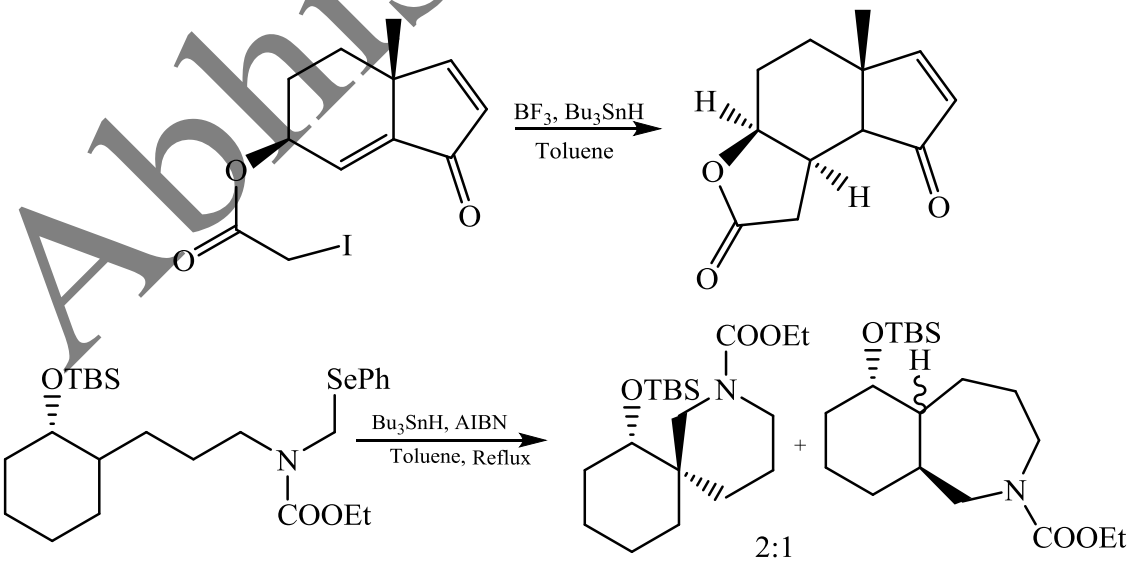
100%

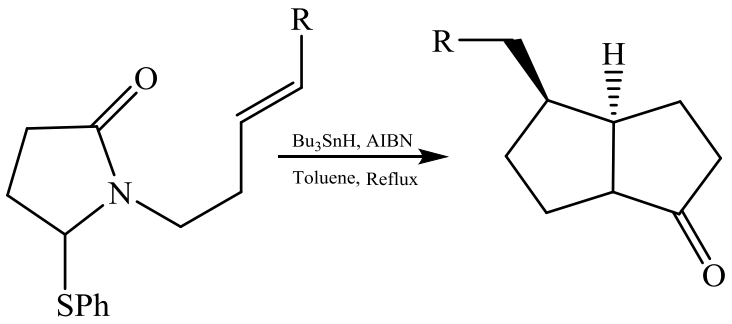
The acyl radical addition to trisubtituted olefins to produce 6-endo/5-exo or 6-endo/6-exo cyclisation products



Heterocyclic ring closure:

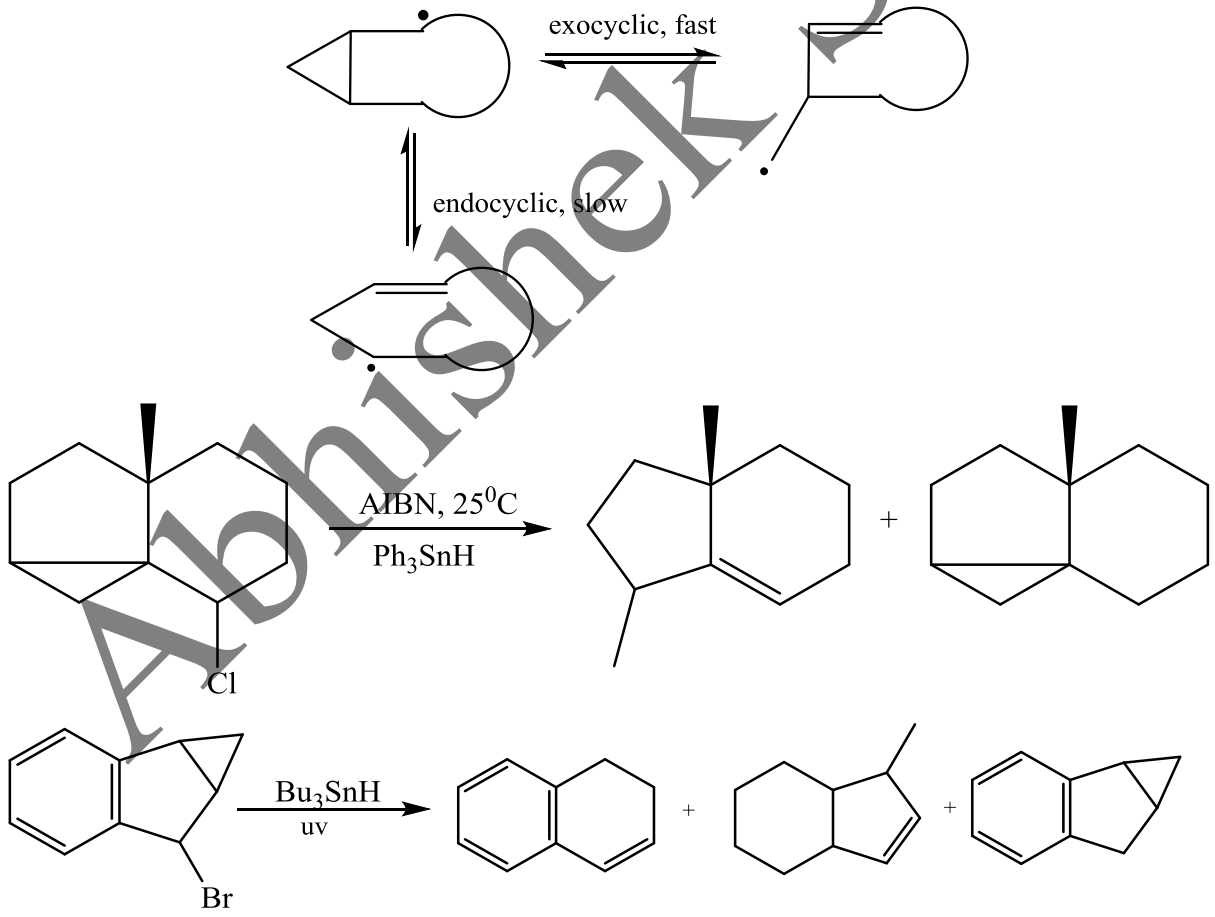
Many compounds that have heterocyclic ring can be prepared by radical cyclisation. Indeed the heteroatoms can be part of the chain that links the radical precursor and the alkene. The standard reagents of AIBN and tri-n-butyltin hydride, heated at reflux in benzene, are common but other solvent can also be used.





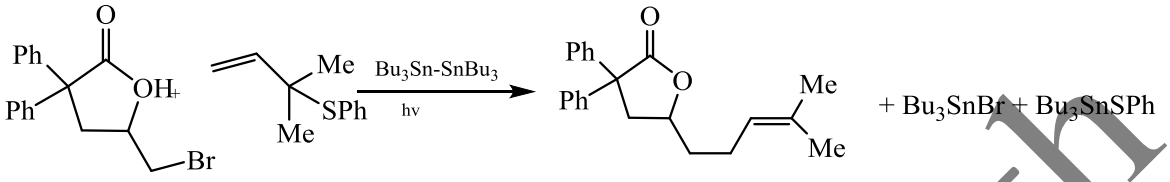
Ring Expansion of cyclopropylcarbinyl Radicals:

Ring opening of the cyclopropylcarbinyl radical has also be a useful strategy for ring expansion because of the ease with which cleavage of the three- member ring take place. The exocyclic radical ring opening as opposed to thermodynamically favored endocyclic ring opening.



Reaction in presence of tributyltin dimer (Bu_3Sn-$SnBu_3$):

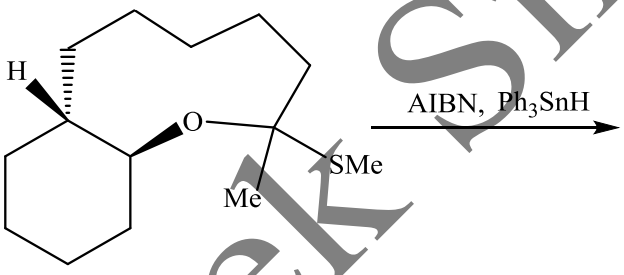
The photolysis of tributyltin dimer generates two equivalent of Bu_3Sn^0, which initiates the reaction.



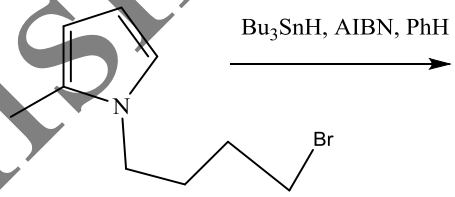
PROBLEMS:

1. Draw their structures and discuss the mechanism of their formation.

A.

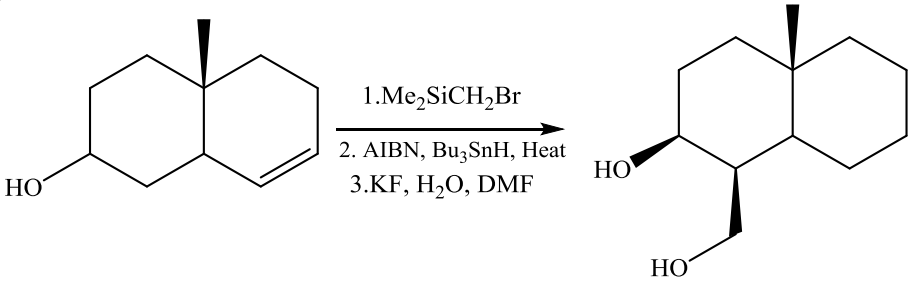


B.



2. Explain the following transformation.

A.



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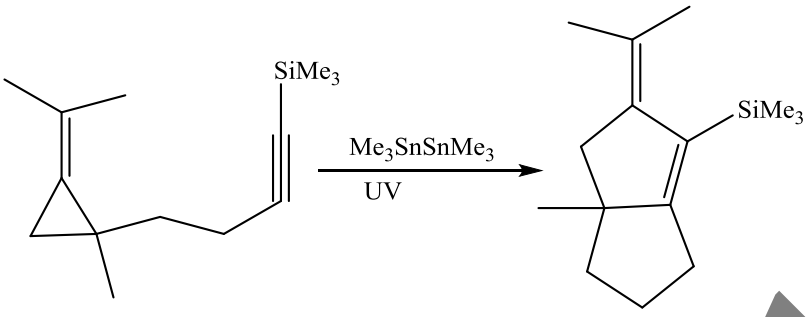

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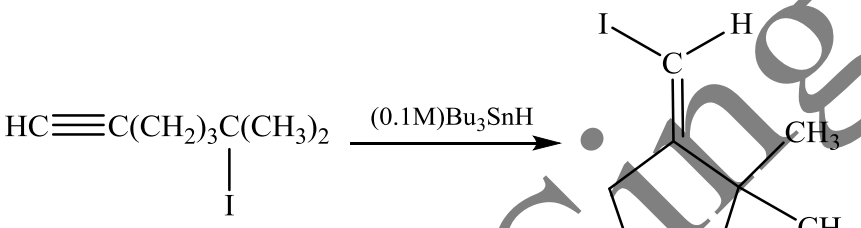

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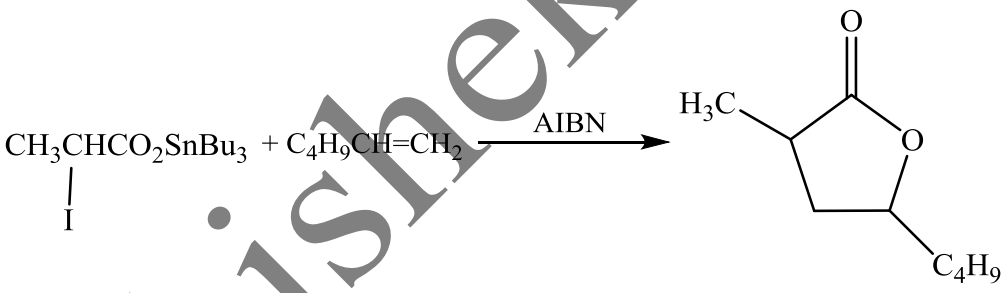

E.