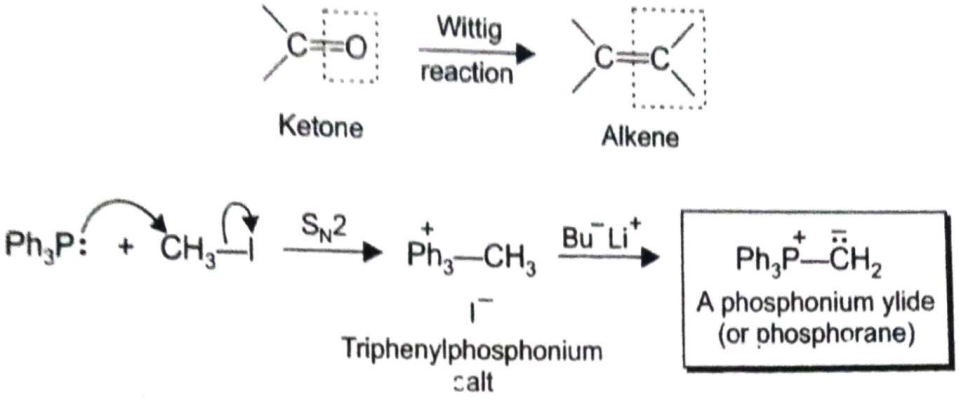
...discussed in sec. 7.7D.

7.3 PHOSPHORUS CONTAINING REAGENTS

(A) Use of Phosphorus Ylides—Wittig Reaction and its Variants

The Wittig reaction (George Wittig, Nobel Prize 1979) is used primarily for the conversion of a carbonyl compound to an alkene (Scheme 7.9) using a special class of carbanion reagents

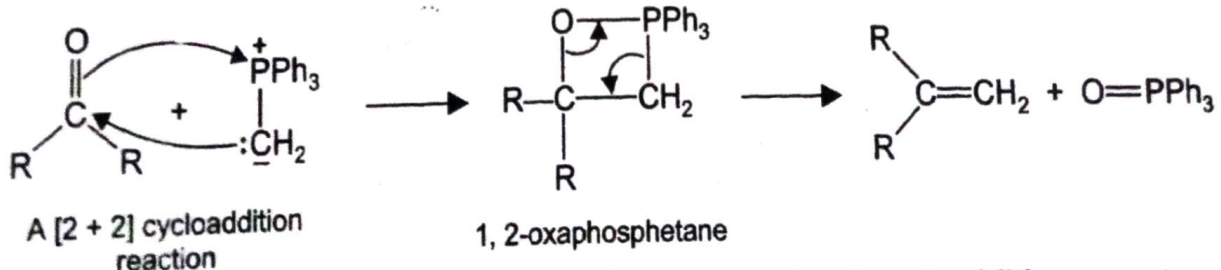


Wittig reaction-generating a phosphonium ylide

SCHEME 7.9

called *ylides*. A phosphorus ylide is prepared involving two steps, firstly an S_N2 reaction between triphenylphosphine and an appropriate alkyl halide gives a triphenylphosphonium salt. The proton on the carbon adjacent to the positively charged phosphorus which is sufficiently acidic ($pK_a = 35$) is then removed by a strong base like butyllithium (Scheme 7.9).

The ylide (nucleophilic carbanion) reacts with the electron-deficient centers like a carbonyl group to generate a cyclic 1, 2-oxaphosphetane. The cyclic intermediate is thought to get generated via a [2 + 2] cycloaddition reaction involving four electrons in the transition state. Decomposition of the cyclic 1, 2-oxaphosphetane eliminates phosphine oxide and brings about a regiospecific formation of an alkene (Scheme 7.10).



A [2 + 2] cycloaddition reaction

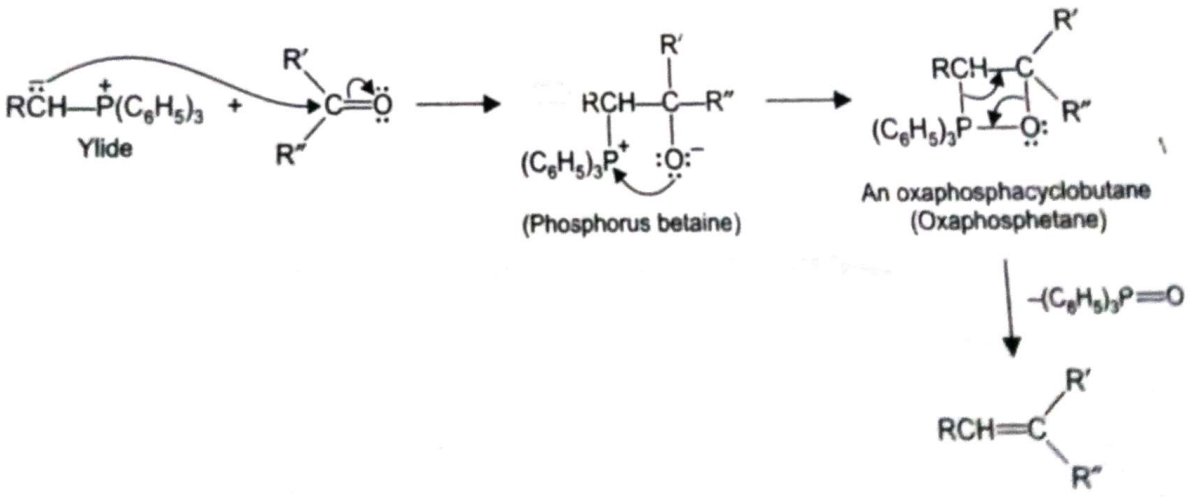
1, 2-oxaphosphetane

Mechanism of Wittig reaction involving a [2 + 2] cycloaddition

SCHEME 7.10

MECHANISM OF WITTIG REACTION

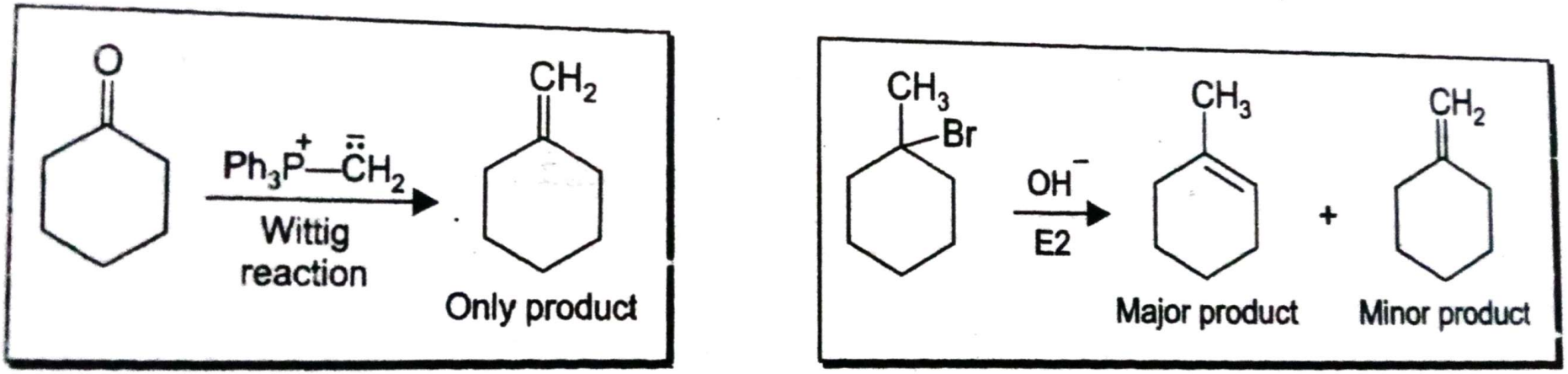
The negatively polarized carbon in the ylide is nucleophilic and can attack the carbonyl group (Scheme 7.10a). The result is a phosphorus betaine, a dipolar species. The betaine is short lived and may not be on the reaction pathway and rapidly forms a neutral oxaphosphacyclobutane (oxaphosphetane), characterized by a four-membered ring containing phosphorus and oxygen. This substance then decomposes to the product alkene. The consideration of a betaine structure is often invoked to explain the stereochemical outcome of Wittig reaction.



SCHEME 7.10a

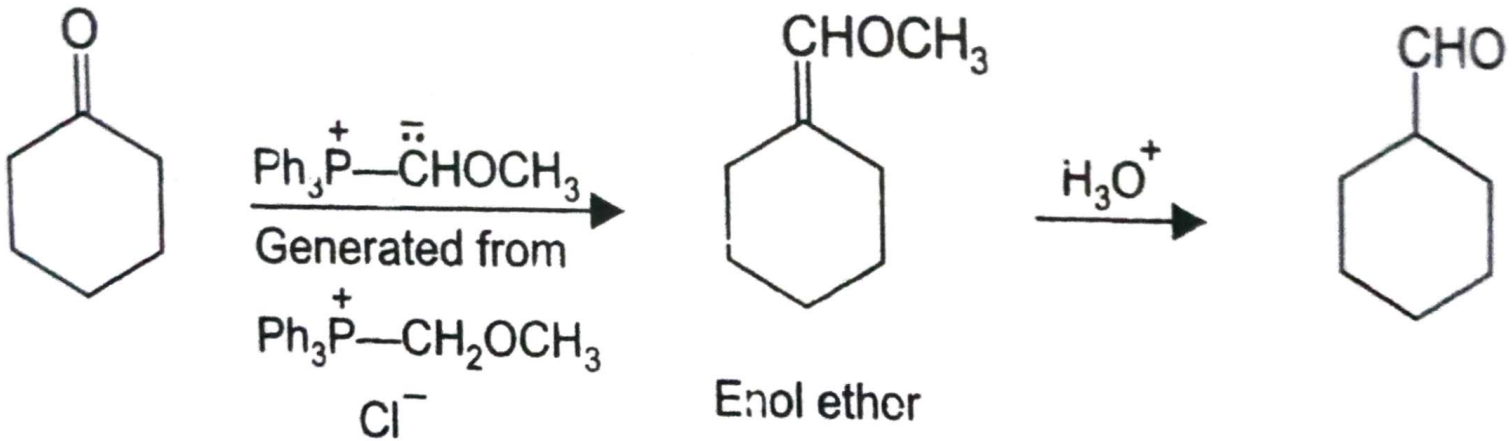
MERITS OF WITTIG REACTION

The reaction is the best method to prepare less substituted double bond (the double bond is placed at the carbonyl group of an aldehyde or a ketone). Thus only one isomer is formed, the reaction is regiospecific and best method to make a terminal alkene (Scheme 7.14c), since other methods e.g., E2 reaction will give terminal alkene only as the minor product.



SCHEME 7.14c

When methoxymethylene is used as an ylide one can step up a ketone to an aldehyde with one more carbon atom. The reaction (Scheme 7.14d) involves an acid labile enol ether (see Scheme 14.37).


O
Ph3P+—C̈HOCH3
Generated from
Ph3P+—CH2OCH3
Cl−
CHOCH3
Enol ether
H3O+
CHO

SCHEME 7.14d