Objectives

After completing this section, you should be able to

1. write an equation to describe the reaction of an acetylide ion with an alkyl halide.
2. discuss the importance of the reaction between acetylide ions and alkyl halides as a method of extending a carbon chain.
3. identify the alkyne (and hence the acetylide ion) and the alkyl halide needed to synthesize a given alkyne.
4. determine whether or not the reaction of an acetylide ion with a given alkyl halide will result in substitution or elimination, and draw the structure of the product formed in either case.

Key Terms

Make certain that you can define, and use in context, the key term below.

• alkylation

Study Notes

The alkylation of acetylide ions is important in organic synthesis because it is a reaction in which a new carbon-carbon bond is formed; hence, it can be used when an organic chemist is trying to build a complicated molecule from much simpler starting materials.

The alkyl halide used in this reaction must be primary. Thus, if you were asked for a suitable synthesis of 2,2-dimethyl-3-hexyne, you would choose to attack iodoethane with the anion of 3,3-dimethyl-1-butyne rather than to attack 2-iodo-2-methylpropane with the anion of 1-butyne. The reasons will be made clear in Chapter 11.

Nucleophilic Substitution Reactions of Acetylides

Acetylide anions are strong bases and strong nucleophiles. Therefore, they are able to displace halides and other leaving groups in substitution reactions. The product is a substituted alkyne.

$$\text{R}^-\text{C≡C:} + \text{R'}^-\text{X} \xrightarrow{\text{Sn2}} \text{R}^-\text{C≡C}^\text{−}\text{R'^+ X^-}$$

Because the ion is a very strong base, the substitution reaction is most efficient with methyl or primary halides without...
substitution near the reaction center,

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{C} & \equiv \text{C}^-\text{Na}^+ \quad \text{Br} \quad \text{CH}_3\text{CH}_2\text{C} \equiv \text{C}(\text{CH}_2)_3\text{CH}_3 \\
\text{C} & \equiv \text{C}^-\text{H} \quad \text{1) NaNH}_2 \quad \text{2) CH}_3\text{CH}_2\text{Br} \quad \text{C} \equiv \text{C}^-\text{CH}_2\text{CH}_3
\end{align*}
\]

Secondary, tertiary or even bulky primary substrates will give elimination by the E2 mechanism.

\[
\text{HC} \equiv \text{C}^-\text{Na}^+ \quad \text{Br} \quad \text{E2} \quad \text{HC} \equiv \text{CH} \quad \text{C} \equiv \text{C}^-\text{CH}_2\text{CH}_3 + \text{Br}^-
\]

**Nucleophilic Addition of Acetylides to Carbonyls**

Acetylide anions will add to aldehydes and ketones to form alkoxides, which, upon protonation, give propargyl alcohols.

\[
\text{HC} \equiv \text{C}^- \quad \text{OR} \quad \text{R'} \quad \text{H} \quad \text{OR}^- \quad \text{H}^+ \quad \text{R} \quad \text{R'} \quad \text{OH}
\]

With aldehydes and non-symmetric ketones, in the absence of chiral catalyst, the product will be a racemic mixture of the two enantiomers.

**Exercises**

1. The $pK_a$ of ammonia is 35. Estimate the equilibrium constant for the deprotonation of pent-1-yne by amide, as shown above.

   **Answers:**

   1. Assuming the $pK_a$ of pent-1-yne is about 25, then the difference in $pK_a$s is 10. Since pentyne is more acidic, the formation of the acetylide will be favored at equilibrium, so the equilibrium constant for the reaction is about $10^{10}$

**Questions**

Q9.8.1

Give the possible reactants for the following formations:
Q9.8.2

Propose a synthetic route to produce 2-pentene from propyne and an alkyl halide.

Solutions

S9.8.1

S9.8.2

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