Draw The Organic Product Of The Bromination Of Ethane In A Limited Supply Of Bromine. Ethane Reacts With

Draw The Organic Product Of The Bromination Of Ethane In A Limited Supply Of Bromine. Ethane Reacts With

The bromination of ethane is a fundamental organic reaction that exemplifies substitution processes in alkanes. When ethane (C_2H_6) is exposed to bromine (Br_2), especially in conditions where bromine is limited, the reaction pathway and the resulting product are influenced significantly by the availability of bromine molecules. Under controlled or limited bromine conditions, the reaction tends to produce monobrominated ethane derivatives rather than extensive substitution, which is characteristic of excess bromine. Understanding this reaction involves exploring the mechanism, the influence of reaction conditions, and the nature of the organic product formed.

Understanding Ethane and Bromine Reactivity

Properties of Ethane

- Ethane (C_2H_6) is a simple alkane consisting of two carbon atoms single-bonded and saturated with hydrogen atoms.
- It is relatively unreactive under mild conditions but can undergo substitution reactions with halogens in the presence of suitable catalysts or energy input.

Properties of Bromine

- Bromine (Br_2) is a halogen that exists as a diatomic molecule.
- It is a reactive halogen capable of undergoing substitution reactions with hydrocarbons, especially under UV light or heat.

Significance of Limited Bromine Supply

- When bromine is limited, the reaction tends to be controlled, leading to selective monobromination rather than multiple substitutions.

- This condition allows for the selective synthesis of monobrominated products, which are useful intermediates in organic synthesis.

Mechanism of Bromination of Ethane

Free Radical Substitution Process

The bromination of ethane proceeds via a free radical chain mechanism, which involves three main steps:

1. Initiation
- Bromine molecules absorb energy (often from UV light) resulting in homolytic cleavage:
- $Br_2 \rightarrow 2\ Br\bullet$
- This produces bromine radicals (Br•), which are highly reactive.

2. Propagation
- The bromine radical abstracts a hydrogen atom from ethane:
- $C_2H_6 + Br\bullet \rightarrow C_2H_5\bullet + HBr$
- The ethyl radical ($C_2H_5\bullet$) then reacts with a bromine molecule:
- $C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$
- This cycle propagates, producing more brominated ethane and regenerating bromine radicals.

3. Termination
- Two radicals combine to form a stable molecule, ending the chain:
- $Br\bullet + Br\bullet \rightarrow Br_2$
- $C_2H_5\bullet + Br\bullet \rightarrow C_2H_5Br$
- $C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ (but this is less common under limited bromine conditions due to lower radical concentration)

Effect of Limited Bromine on the Reaction Outcome

Monobromination Preference

- Under limited bromine, the reaction is less likely to proceed beyond the initial substitution.
- The primary product is bromoethane (ethyl bromide, C_2H_5Br), formed after a single substitution.

- The reaction halts once the available bromine molecules are consumed or the concentration decreases significantly.

Reaction Control and Selectivity

- Limiting bromine reduces the probability of multiple substitutions, leading to higher selectivity for mono-substituted products.
- Reaction conditions such as temperature, presence of light, and bromine concentration are critical factors influencing the extent of substitution.

Possible Side Reactions

- In some cases, radical recombination or side reactions may occur, but these are minimized under controlled conditions.
- The formation of polybrominated products is less likely due to limited bromine.

Drawing the Organic Product

Structure of Bromoethane

- The primary organic product formed is bromoethane.
- Its molecular structure is:

```
H H
| |
H - C - C - H
| |
H Br
```

- The structure indicates a two-carbon chain with one hydrogen replaced by a bromine atom.

Key Features of Bromoethane

- It is an alkyl halide, specifically a primary alkyl halide.
- It retains the saturated hydrocarbon backbone of ethane with one hydrogen substituted by bromine.

Summary of the Bromination of Ethane in Limited Bromine

- The reaction proceeds via a free radical chain mechanism initiated by UV light or heat.
- Under limited bromine conditions, the predominant product is monobrominated ethane (bromoethane).
- The process involves selective hydrogen abstraction and substitution, controlled by the availability of bromine.
- The structure of the organic product is ethyl bromide, which can be utilized as an intermediate in various organic syntheses.

Applications and Significance

Industrial and Laboratory Uses

- Bromoethane is used as an intermediate in the synthesis of pharmaceuticals, agrochemicals, and other organic compounds.
- The controlled bromination process exemplifies how reaction conditions influence selectivity and yield in organic synthesis.

Understanding Reaction Conditions

- The study of limited bromine reactions helps chemists design selective pathways for functionalizing hydrocarbons.
- It demonstrates the importance of controlling reactant ratios and reaction parameters to achieve desired products.

Conclusion

The bromination of ethane under limited bromine conditions exemplifies the principles of radical substitution and reaction control in organic chemistry. The key organic product, bromoethane, is formed through a selective mono-substitution process facilitated by free radical mechanisms. This reaction showcases how manipulating reactant quantities and conditions can steer the outcome toward specific,

valuable compounds, highlighting the nuanced nature of organic synthesis techniques. Understanding this process not only deepens knowledge of halogenation reactions but also provides foundational insight into the broader field of functional group transformations in organic chemistry.

Frequently Asked Questions

What is the main organic product formed when ethane reacts with bromine in limited supply?

The main product is bromoethane, resulting from the substitution of one hydrogen atom in ethane with a bromine atom.

How does limited supply of bromine affect the bromination of ethane?

Limited bromine favors monobromination, leading predominantly to the formation of bromoethane rather than multiple brominated products.

What is the mechanism behind the bromination of ethane with limited bromine?

The process involves a free radical substitution mechanism, initiated by heat or light, where bromine radicals replace hydrogen atoms in ethane one at a time.

What is the structural formula of the organic product formed from bromination of ethane?

The product is CH3CH2Br, known as bromoethane.

Why is monobromination favored in the reaction of ethane with limited bromine?

Because the amount of bromine is limited, it restricts the reaction to substitution of only one hydrogen atom, preventing further bromination and formation of di- or tribrominated products.

Additional Resources

Draw The Organic Product Of The Bromination Of Ethane In A Limited Supply Of Bromine. Ethane Reacts With bromine under specific conditions, leading to a fascinating example of radical substitution chemistry. This process not only exemplifies fundamental organic reactions but also highlights how

reaction conditions—such as limited reagent supply—can influence product formation. Understanding this reaction in detail provides valuable insights into the mechanisms of halogenation, the influence of reaction parameters, and the structural identification of organic compounds resulting from substitution reactions.

Introduction to Bromination of Ethane

Bromination of ethane is a classic example of a free radical substitution reaction in organic chemistry. When ethane reacts with bromine (Br_2), the process involves the replacement of hydrogen atoms with bromine atoms, resulting in bromoalkanes such as bromomethane, dibromomethane, and even tribromomethane, depending on the reaction conditions and extent of substitution.

Why Focus on Limited Bromine Supply?

In typical lab scenarios, excess bromine is used to push the reaction toward complete substitution, often leading to polybrominated products. However, when the supply of bromine is limited, the reaction predominantly yields mono- or di-brominated products, with minimal further substitution. This limitation offers a unique opportunity to observe and analyze specific organic products, understand reaction control, and predict the structural outcome.

Understanding the Reactants and Conditions

Ethane (C_2H_6)

Ethane is a simple alkane characterized by single sigma bonds between carbon and hydrogen atoms. It's relatively unreactive under normal conditions but can undergo radical substitution in the presence of halogens and suitable initiators.

Bromine (Br_2)

Bromine exists as a diatomic molecule (Br_2) and is a moderate electrophile under radical conditions. Its reactivity in substitution reactions depends significantly on the presence of radicals and reaction conditions.

Reaction Conditions

- Limited Bromine Supply: A small amount of bromine is introduced, ensuring only partial substitution.
- UV Light or Heat: Typically used to generate bromine radicals via homolytic cleavage.
- Radical Initiator: Sometimes, traces of initiators or UV light are employed to start radical chain reactions.

The Mechanism of Bromination of Ethane

The bromination proceeds via a free radical chain mechanism comprising three main steps:

1. Initiation

In the initiation step, bromine molecules absorb energy (from UV light or heat), causing homolytic bond cleavage:

$Br_2 \rightarrow 2\ Br\bullet$

This produces bromine radicals (Br•), which are highly reactive and can abstract hydrogen atoms from ethane.

2. Propagation

This step involves a chain of radical reactions:

- Hydrogen abstraction:

$Br\bullet + C_2H_6 \rightarrow HBr + C_2H_5\bullet$

- Radical substitution:

$C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$

The process repeats, with radicals propagating the chain until termination occurs.

3. Termination

Radicals combine to terminate the chain:

- $Br\bullet + Br\bullet \rightarrow Br_2$

- $C_2H_5\bullet + Br\bullet \rightarrow C_2H_5Br$

- $C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ (butane, in some cases)

In limited bromine conditions, termination is more likely to occur before multiple substitutions happen, favoring mono-substituted products.

Effect of Limited Bromine Supply

When bromine is limited, the radical chain reaction is curtailed early, mainly leading to the formation of mono-brominated ethane (bromoethane). The key reasons include:

- Reduced availability of bromine radicals: Fewer radicals mean less likelihood of multiple substitutions.
- Kinetic control: The initial hydrogen abstraction occurs rapidly, but subsequent substitutions are less probable due to a shortage of bromine.
- Selectivity towards mono-substitution: The predominant product is the monobromo derivative.

This contrasts with excess bromine, which often results in dibromo- or tribromoethanes under prolonged reaction conditions.

Structural Analysis of the Organic Product

Drawing the Product: Bromoethane (Ethyl Bromide)

The primary organic product of bromination of ethane in limited bromine supply is bromoethane (ethyl bromide). Its structure features:

- A two-carbon chain (ethane backbone).
- One bromine atom attached to one of the carbons, replacing a hydrogen atom.

Structural Formula:

```
H H
| |
H—C—C—H
| |
Br H
```

Or more simply:

CH_3CH_2Br

Key Features:

- Mono-substitution: Only one hydrogen has been replaced by bromine.
- Stereochemistry: Ethane is symmetrical; substitution occurs randomly at either carbon, but typically at the

primary carbon for mono-substitution.
- Physical properties: Bromoethane is a colorless liquid with a sweet smell, similar to other haloalkanes.

Visual Guide to Drawing Bromoethane

1. Start with the ethane backbone: Two carbon atoms connected by a single bond.
2. Attach three hydrogen atoms to each carbon: The first carbon (left) has three hydrogens, and the second carbon (right) also has three hydrogens.
3. Replace one hydrogen on either carbon with bromine: Typically, the substitution occurs at the primary carbon (the methyl group), replacing a hydrogen with bromine.

Sample drawing:

```
H
|
H—C—H
|
Br
```

which represents CH_3CH_2Br.

Summary of Key Points

- The bromination of ethane proceeds via a free radical chain mechanism.
- Under limited bromine, the reaction predominantly yields mono-brominated ethane (bromoethane).
- The product is best represented as CH_3CH_2Br.
- The reaction is kinetically controlled, favoring mono-substitution due to limited bromine availability.
- The reaction conditions—such as UV light, temperature, and reagent quantity—significantly influence the product distribution.

Practical Applications and Considerations

Laboratory Synthesis

- When synthesizing bromoethane, controlling the amount of bromine ensures mono-substitution.

- Excess bromine and prolonged reaction times can lead to polybrominated products, which may be undesirable.

Organic Synthesis

- Bromoethane serves as an important intermediate in organic synthesis, enabling nucleophilic substitution reactions to produce various derivatives.

Environmental and Safety Notes

- Halogenated hydrocarbons like bromoethane are toxic and should be handled with appropriate safety precautions.
- Proper disposal methods are necessary to prevent environmental contamination.

Conclusion

Draw The Organic Product Of The Bromination Of Ethane In A Limited Supply Of Bromine. Ethane Reacts With bromine primarily to produce bromoethane. This mono-substituted product exemplifies how reaction conditions influence the extent of substitution in radical halogenation reactions. Recognizing the mechanism and the impact of reagent quantities allows chemists to steer reactions toward desired products, whether for research, synthesis, or industrial applications. Mastery of such fundamental reactions enhances understanding of organic reactivity and provides a foundation for more advanced synthetic strategies.

Draw The Organic Product Of The Bromination Of Ethane In A Limited Supply Of Bromine Ethane Reacts With

Draw The Organic Product Of The Bromination Of Ethane In A Limited Supply Of Bromine Ethane Reacts With

Related Articles

- Consider A Student Studying For A Biology Exam. Would You Expect Study Time To Be Subject To Diminishing
- Find The Future Value Of Each Annuity. 1. $750 Deposited At The Start Of Each Month For 15 Years At 5.9%
- Consider The Following Demand And Supply Curves: MC=20+0.90 WTP=300-0.3 0 Calculate The Consumer Surplus

Back to Home