Conjugated double bond systems can participate in a variety of reactions. The Diels-Alder reaction is one in which a conjugated diene bonds in with an alkene to produce a cyclohexene molecule.

**Introduction**

As aforementioned the *Diels-Alder* reaction forms a cyclohexene ring. The process by which the reaction occurs is by cycloaddition. This means that the electrons are transferred in a cyclic fashion between the diene and the alkene to for the cyclic structure. Although heat is not required in *Diels-Alder* reactions, heating up the reaction will improve yield. But again heat is not required for the reaction to go through.

**General Reaction.bmp**

To go into more detail, the alkene that reacts with the diene is commonly referred to as the *dienophile*. Although this reaction occurs readily, it doesn’t give a very good yield. This reaction tends to work best with dienes that are electron rich and dienophiles that are electron poor. To solve this problem we add an electron withdrawing group (EWG) to our dienophile. With the addition of these EWG’s, they pull the electrons away from the dienophile allowing the pi electrons from the diene to interact with those of the dienophile to bond with each other to form our product. Good EWG’s include keto groups, aldehyde, nitrile groups, nitro groups, trifluoromethyl groups, etc.

**EWGs.bmp**

**The Reaction**

Before we begin, there are a few things to consider when carrying out the reaction. Diels-Alder reactions are concerted, stereospecific, and follow the *endo rule*. The Diels-Alder reaction is a concerted reaction, this means it occurs in only one step. Moreover, all of the atoms that are participating in the reaction form bonds simultaneously.

**Electron Flow Diagram 2.bmp**
Secondly, Diels-Alder reactions are stereospecific. This means that the substituents attached to the both the diene and the dienophile retain their stereochemistry throughout the reaction. For example, if the functional groups on the dienophile are trans to each other in the reactants, they should remain trans to each other products. View the illustration below to clear up any confusion.

Stereospecific.bmp

Thirdly, Diels-Alder reactions are governed by the endorule. This means that whenever a bridged ring is formed, the substituents bonded to the dienophile are either trans or cis to the bridge. What if there are more than two things attached to the dienophile? Well, two of them will point towards the endo side and the other two will go towards the exo side. As common conventions have pointed out, the functional groups bonded on the right side of the dienophile go towards the endo side (meaning away from the bridge) and the groups attached to the left of the dienophile point towards the exo side (meaning towards the bridge).

Stereospecific2.bmp

The second part of the rule is that substituents on the left side of the dienophile are considered to be on the endo side in the product and that substituents bonded to the right side are considered to be exo. What this means is that endo substituents point down and exo substituents point up in the final product. An example of this can be seen below.

endoexo.bmp

References

Problems
Practice Problems.bmp
Answers

1. \[ \text{\text{\(\text{C}\)}} + \text{\(\text{\(\text{\(\text{C}\)}}\)}} \rightarrow \text{\(\text{\(\text{\(\text{C}\)}}\)}} \]

2. \[ \text{\(\text{\(\text{\(\text{C}\)}}\)}} + \text{\(\text{\(\text{\(\text{C}\)}}\)}} \rightarrow \text{\(\text{\(\text{\(\text{C}\)}}\)}} \]

3. \[ \text{\(\text{\(\text{\(\text{C}\)}}\)}} + \text{\(\text{\(\text{\(\text{C}\)}}\)}} \rightarrow \text{\(\text{\(\text{\(\text{C}\)}}\)}} \]

4. \[ \text{\(\text{\(\text{\(\text{C}\)}}\)}} + \text{\(\text{\(\text{\(\text{C}\)}}\)}} \rightarrow \text{\(\text{\(\text{\(\text{C}\)}}\)}} \]

5. \[ \text{\(\text{\(\text{\(\text{C}\)}}\)}} + \text{\(\text{\(\text{\(\text{C}\)}}\)}} \rightarrow \text{\(\text{\(\text{\(\text{C}\)}}\)}} \]

6. \[ \text{\(\text{\(\text{\(\text{C}\)}}\)}} + \text{\(\text{\(\text{\(\text{C}\)}}\)}} \rightarrow \text{\(\text{\(\text{\(\text{C}\)}}\)}} \]

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Further Reading

Wikipedia

The Diels-Alder Reaction

Khan Academy

Diels-Alder