4.11: Addition to Strained Rings - Epoxides

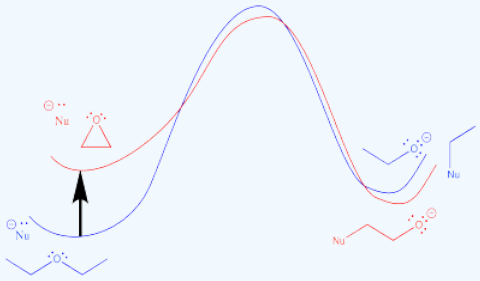
Oxygen is a very common element in all kinds of compounds, whether they are biological molecules, minerals from the earth or petrochemicals. Exploiting oxygen's electronegativity and giving it a little help to become a leaving group is a common way to make connections and build new molecules in nature, the laboratory or the production facility.

Sometimes oxygen doesn't need much help to become a leaving group. Epoxides, or oxiranes, are three-membered ring ethers. They are good electrophiles, and a C-O bond breaks easily when a nucleophile donates electrons to the carbon.

? Exercise 4.11.1

Explain why the C-O bond in an epoxide breaks easily.

Answer



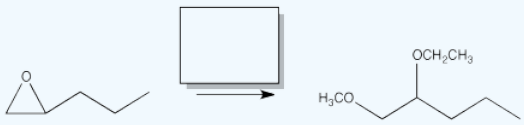
? Exercise 4.11.2

Use a potential energy diagram to show why epoxides are susceptible to react with nucleophiles, whereas other ethers are not.

Epoxides are very useful in the synthesis of important molecules. The Nu-C-C-O motif that is formed in nucleophilic addition to an epoxide is very valuable. Whereas other nucleophilic additions simply replace a halide or leaving group with a nucleophile, exchanging one reactive site with another, addition to an epoxide makes a product that has gone from having one reatcive site to two reactive sites. That can open the door to lots of useful strategies when trying to make a valuable commodity.

? Exercise 4.11.3

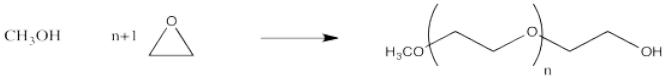
Show how you could carry out the following transformation. More than one step is involved.



? Exercise 4.11.4

One of the most widespread uses of epoxides is in making polymers. The polyethylene glycol produced in polymerization of an epoxide is frequently used in biomedical applications. Provide a mechanism with arrows for the following polymerization of ethylene oxide, in the presence of:

a. an acid catalyst
b. a basic catalyst.



Exercise 4.11.5

Tetrahydrofuran can also be polymerized, forming polytetramethylene glycol.

a. Compare the rate of polymerization of THF with that of ethylene oxide.
b. Polymerization of THF generally requires an acid catalyst, rather than a basic one. Why?