It is convenient to organize cyclization reactions on the basis of the locations of the reacting multiple bond and the radical center. These two can be either in the carbohydrate framework or in a substituent group. More information about radical cyclization is found in Chapter 19, which is devoted entirely to ring-forming reactions.

A. Addition of a Framework Radical to a Framework Multiple Bond

The reaction shown in Scheme 26 is one of several in which a framework radical adds to a framework double bond. In this reaction the open-chain radical passes through a chair-like transition state to form the radical, an intermediate with a new, five-membered ring. Hydrogen-atom abstraction and hydrolytic workup produce the lactone, the major reaction product.

Cyclization reactions also occur when framework unsaturation takes the form of a triple bond. As with reaction involving a double bond, the transition state for cyclization leading to a five-membered ring is, in most instances, less strained than that producing a ring with six members (eq 44). (Note that the two, five-membered rings in the product shown in eq 44 are cis-fused.) Among the structural features that can force reaction to form a larger ring, the most common is ring strain; thus, to avoid creating two, trans-fused, five-membered rings, the reaction shown in eq 45 produces a new six-membered ring.
The carbon–nitrogen double bond in an oxime represents another type of multiple bond that reacts with a properly positioned, carbon-centered radical to form a new ring system. As is illustrated by the reaction shown in eq 46, the carbon-centered radical adds to the carbon atom of the oxime to form a five-membered ring. Five-membered and six-membered rings both can be formed in this type of reaction.

B. Addition of a Framework Radical to a Substituent Multiple Bond

Many cyclization reactions of O-thiocarbonyl compounds involve a framework radical adding to a substituent multiple bond. In most such reactions the intermediate radicals are formed either at C-2 (eq 47) or C-3 (eq 48) in a furanoid ring. The multiple bond in this type of reaction is often part of an O-allyl or O-propargyl group. A typical cyclization is regioselective (e.g., forming a five-membered ring when both five- and six-membered ones are possible) and stereoselective (e.g., forming the stereoisomer with the least-strained ring fusion). Framework radicals also add to substituent carbon–nitrogen and carbon–oxygen double bonds.
C. Addition of a Substituent Radical to a Framework Multiple Bond

Other types of cyclization reaction of carbohydrates containing O-thiocarbonyl groups are rare. There is an example of addition of a substituent radical to a framework multiple bond (eq 49), but not one involving an O-thiocarbonyl carbohydrate in which a substituent radical adds to a substituent multiple bond.

D. Revisiting the Mechanism of the Barton-McCombie Reaction

The widely accepted mechanism for the Barton-McCombie reaction is shown in Scheme 2 (and discussed in Section II.B). A pivotal intermediate in this reaction is the radical 10, which must fragment rapidly if a deoxygenated product is to form. Support for the existence of 10 comes from reaction of the (thiocarbonyl)imidazolide 73 (Scheme 27). Formation of a product (75) with a new six-membered ring indicates that the radical 74 (analogous to 10 in Scheme 2) is formed but is diverted from the normal Barton-McCombie reaction pathway by internal radical addition. Formation of 75, therefore, provides indirect evidence for the intermediacy of 74 and, in so doing, supports the mechanism for the Barton-McCombie reaction shown in Scheme 2.
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