### 8.6.4 Epoxy Resins

Epoxy resins are produced by the reaction of low molar mass epoxy compounds with phenols (Fig. 8.58).

With a small excess of epichlorohydrin (epichlorhydrin:phenol < 2:1), higher molar mass epoxy resins are formed via multiple repetition of the reactions shown in Fig. 8.58 (Fig. 8.59).

These prepolymers can be converted into networks either by stoichiometric reactions with acid anhydrides (heat or latent curing) or with primary or secondary amines (cold curing), but also catalytically with tertiary amines.

The first step of the cross-linking of the prepolymers is an esterification of the –OH group with an acid anhydride (Fig. 8.60a). In the second step, the resulting –COOH function opens an epoxide ring and connects two chains together in the intermolecular course of the reaction (Fig. 8.60b).

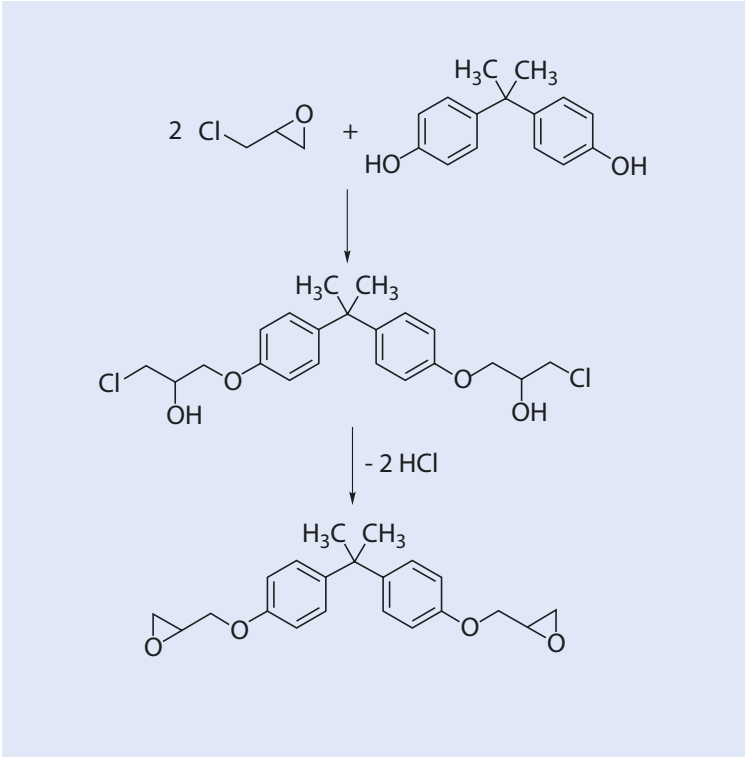


**Fig. 8.58** Condensation reaction of epichlorohydrin with bisphenol A

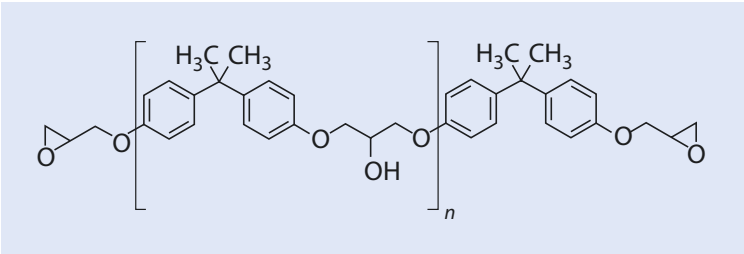


**Fig. 8.59** Structural formula of epoxy resin prepolymers

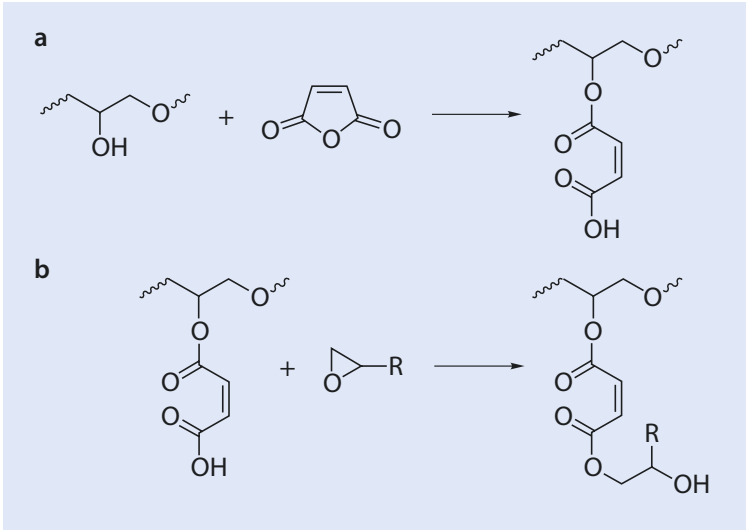


**Fig. 8.60** Mechanism of crosslinking of epoxy resin prepolymers with carboxylic acid anhydrides (heat curing)

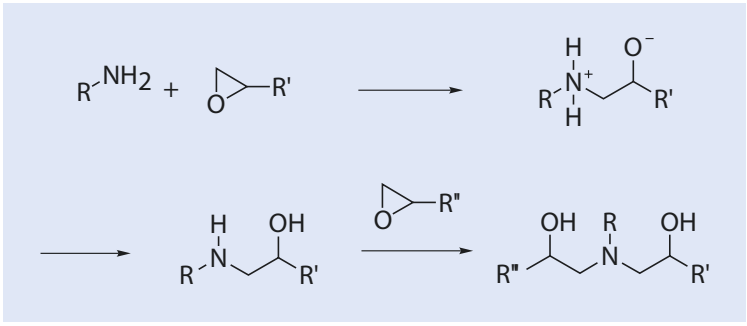

**Fig. 8.61** Reaction of epoxy resin prepolymers with primary amines (cold hardening); Cross-linking occurs when the components are multifunctional

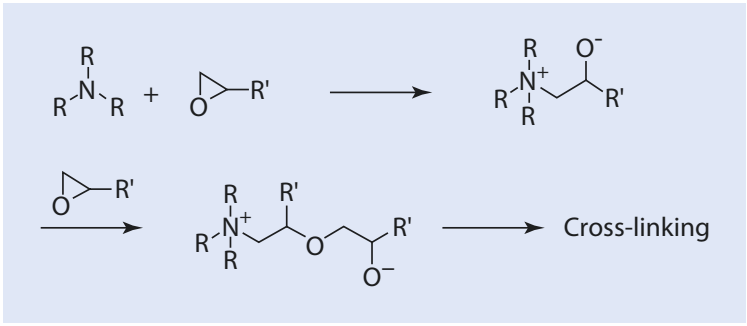


**Fig. 8.62** Catalytic curing of epoxy resin prepolymers with tertiary amines. Crosslinking occurs when the epoxy prepolymer is multifunctional, that is, at least two epoxy functional groups are present per molecule



The first step of the curing of the prepolymers with primary amines is the opening of the oxirane ring. In the second step, the resulting secondary amine opens another oxirane ring (most likely from another chain). As with acid hardening (Fig. 8.60), primary amine curing is a stoichiometric reaction (Fig. 8.61).

The curing of oxirane polymers with tertiary amines is a catalytic process. The basic steps of this curing are shown in Fig. 8.62.

Epoxy resins are high-quality, indispensable materials, which are often used in conjunction with reinforcing agents such as glass, carbon, or aramid fibers. The composites have tensile strengths and moduli greater than or equal to steel alloys. Areas of application are in electrical engineering (carrier material for printed circuit boards, printed circuits), the automotive industry (structural and body components), and sports articles (e.g., bicycle frames, skis, hockey, tennis rackets). By varying the starting components, the characteristic properties of these materials can be precisely adjusted to the particular requirements.