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Handbook of Adhesives and Sealants

Second Edition

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Edward M. Petrie

HANDBOOK OF ADHESIVES AND SEALANTS

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Second Edition



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Adhesion is distinctly different from *cohesion*, which involves only the intermolecular attractive forces *within* a single substance. Cohesion relates to the forces within the molecule itself or those that connect two or more molecules within a substance.

To better understand the difference between adhesion and cohesion, consider the failed joints illustrated in Fig. 1.2. Joints will fail either adhesively or cohesively or by some combination of the two. Adhesive failure is an interfacial bond failure between the adhesive and the adherend.

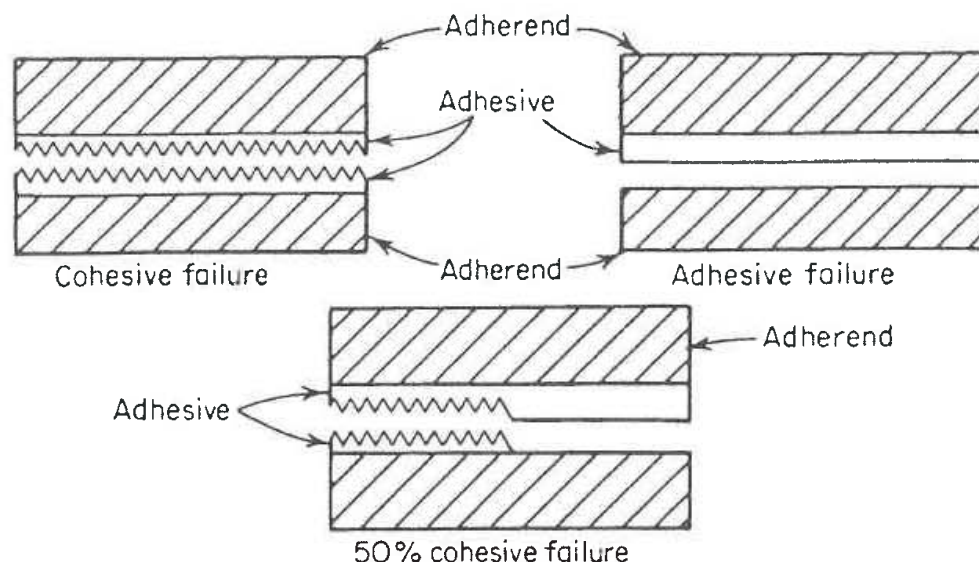


FIGURE 1.2 Examples of cohesive and adhesive failure.

Cohesion is determined by the inner strength of a material (i.e., by molecules in the bulk), and this is manifested mainly by chemical bonds between the molecules. Cohesive failures could exist within either the adhesive material or the adherend itself. Cohesive failure of the adhesive material occurs when stress fracture allows a layer of adhesive to remain on both substrates (i.e., the attachment of the adhesive to the substrate is stronger than the internal strength of the adhesive itself, and the adhesive fails within its bulk). When the adherend fails before the adhesive and the joint area remains intact, it is known as a cohesive failure of the adherend. Cohesive failure could also occur in a weak boundary layer that may exist between the adhesive and the substrate. Common weak boundary layers are shop contaminants (e.g., oil, grease, or dirt), oxide layers, and rust or corrosion.

Other important definitions can be made clear by considering the schematic of a bonded joint in Fig. 1.3. The *substrate* is the material to be bonded. After bonding, the substrate is often referred to as an *adherend* (although sometimes these two terms are used synonymously).

The three-dimensional volume of material between the adhesive and adherend is referred to as the *interphase region*. This interphase region is a thin region near the point of adhesive/adherend contact. The interphase region has different chemical and physical characteristics than either the bulk adhesive or the adherend. The physical and chemical nature of the interphase region critically influences the quality of an adhesive bond.

The structure, composition, and macroscopic properties of the adhesive or substrate can change in the interphase region. For example, there may be diffusion of small components out of the material or into the material (e.g., plasticizer egress or moisture ingress). The material in the interphase may be much different than the material in the bulk. These material differences could affect either the adhesive or cohesive strength of the joint.

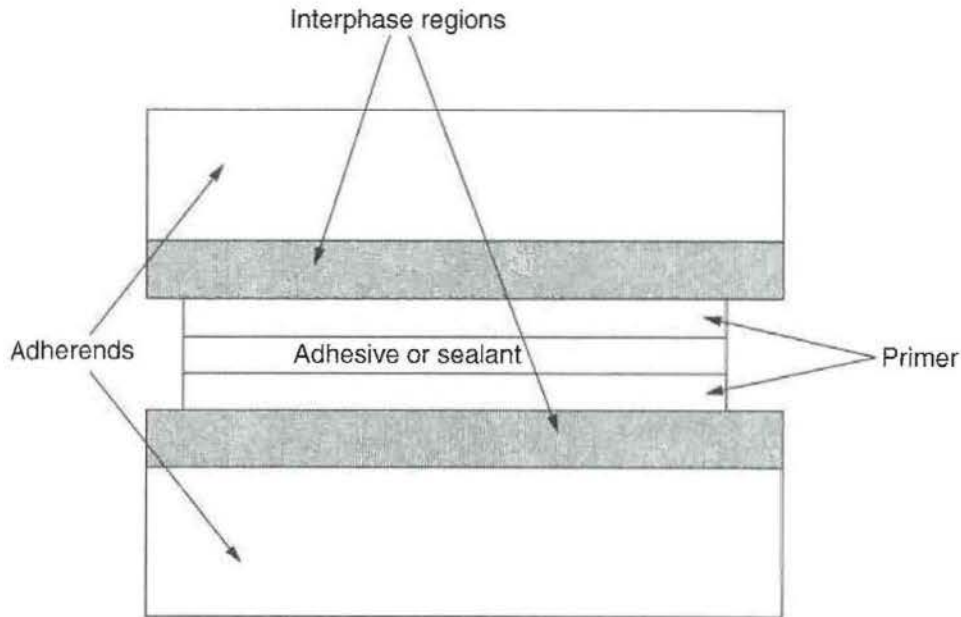


FIGURE 1.3 Components of a typical adhesive or sealant joint.

Within the interphase there can be several layers of materials, and these may be strongly or weakly attached to one another. These layers could also be cohesively strong or weak. When one of these layers is weak, it is sometimes referred to as a *weak boundary layer*. Just as in the weakest link of a chain, the weakest link in an adhesive joint is the most likely path to failure.

The *interface* is separate from the interphase but contained within it. The interface is the two-dimensional plane of contact between the surface of one material and the surface of another. The interface is often useful in describing surface energetics. Surface energetics control wetting or spreading of the adhesive on a substrate and the resulting adhesion forces that develop. The interphase and interface regions will be discussed in detail in following chapters.

Sometimes a *primer* is used with adhesives or sealants. A primer is a thin coating of material that is applied to a surface prior to the application of an adhesive or sealant. Generally, a primer is used to improve the performance of the bond or protect the surface until the adhesive or sealant can be applied. A primer is also used to protect the cured adhesive-adherend interface during environmental exposure.

The *joint* is the part of the assembly made up of adherends; adhesive or sealant; primers, if present; and interphase regions as shown in Fig. 1.3. However, the illustration in Fig. 1.3 is an extremely simplified one. In practice, the interphase region could have many different layers, including adsorbed water, corrosion, contamination (from internal or external sources), oxidation, and so on, depending on the type of substrate, how it was produced, and the storage conditions. This more detailed view of a substrate surface will be considered in Chap. 9.

1.2.3 Factors for Successfully Using Adhesives and Sealants

It should be apparent from the discussion above that joint quality will depend on many factors, some of which are rather entangled and complicated. The joint strength will depend on the nature of the adhesive as well as the substrate. However, the application of bonding