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Review of Alumina Adhesives and Weather Resistance

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Abstract

Adhesives have various application scenarios in alumina. Their high temperature resistance, chemical resistance and excellent bonding properties make them important in many industrial fields . This article discusses in detail the current research status of chemical and physical compatibility of bonding surfaces from the perspective of adhesives and alumina substrates , and analyzes how these factors of different adhesives affect the stability and durability of the overall adhesive structure . It is concluded that silicone rubber adhesive has better advantages in weather resistance. Its stable interface bonding ability, high temperature resistance, oxidation resistance and chemical resistance enable the bonding of alumina substrates to remain stable for a long time outdoors or in harsh environments, and is expected to meet the various complex bonding requirements of alumina substrates. Application demand prospects.

Keywords

Interface Chemistry; Weather Resistance; Adhesives.

1. Introduction

Adhesives are often used to seal aluminum oxide surfaces in high temperature environments. For example, in high-temperature equipment such as furnaces, heat exchangers, and piping systems, adhesives are needed to seal the aluminum oxide surface to prevent the leakage of high-temperature gases or liquids. In the ceramics industry, adhesives are often used to bond alumina ceramic pieces[1]. For example, when making stoves or ceramic crafts, adhesives are needed to hold alumina ceramic pieces together to form an overall structure. Adhesives are also widely used in the electronics industry, especially in the packaging process of alumina substrates. For example, adhesives often found in encapsulants used to manufacture electronic devices can firmly bond alumina substrates and other electronic components while having excellent high temperature and chemical resistance. Adhesives are also commonly used to protect aluminum oxide surfaces in the metalworking and coating industries. For example, in anti-corrosion paint or anti-corrosion coatings used to coat metal surfaces, adhesives may be added as binders to enhance the adhesion and weather resistance of the coating to the aluminum oxide surface[2].

High-temperature sealing , ceramic bonding , electronic component encapsulation , and metal coating protection illustrate the various application scenarios of adhesives in alumina. Its high temperature resistance, chemical resistance, and excellent bonding properties make it a popular choice in many industrial fields. one of the important materials.

2. Interfacial Reaction between Adhesive and Alumina

The surface of aluminum oxide is usually chemically reactive, but an oxide layer may also be present. Proper surface preparation can improve adhesive adhesion. For example, the use of surfactants, plasma treatment, chemical modification of the alumina surface and other methods can increase the

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activity of the surface and help the adhesive bond with the alumina surface. The adhesive chemistry should be compatible with the aluminum oxide surface to ensure a good bond. Silicone-based adhesives generally have good compatibility with alumina surfaces because they can react with silicon oxidation on the alumina surface to form stable chemical bonds. Some adhesives may have specific functional groups that interact with chemical groups on the alumina surface to increase bond strength. For example, adhesives containing functional groups such as carboxyl, amine or siloxane groups may form hydrogen bonds or covalent bonds with hydroxyl groups on the surface of alumina, thereby improving bonding properties. The size of the adhesive molecules and the structure of the alumina surface may also affect bonding performance[3]. Choosing an adhesive with appropriate molecular size can promote intermolecular interactions and improve the interface bonding effect.

In addition, some explanations of interface chemistry are obtained from a theoretical perspective. DLVO theory: can help understand the dual repulsive and attractive forces between the adhesive and the alumina surface to optimize the bonding effect.Lewis acid-base theory: helps to understand the chemical interaction between adhesives and alumina surfaces, thereby guiding the selection of adhesives with better compatibility.Interface energy theory: can be used to evaluate the match between the surface energy of the adhesive at the interface and the surface energy of the alumina surface to determine the best bonding material[4].

3. Types of Alumina Adhesives

3.1 Silicone Rubber Adhesives

In the fields of automobile manufacturing and aerospace, silicone rubber adhesives are needed to fix car bodies, aircraft alumina parts, etc. These parts usually need to withstand various harsh weather conditions such as sunlight, rain, wind, etc., but silicone rubber adhesives can resist the influence of factors such as ultraviolet rays, high temperature, and humidity, and maintain long-term and stable bonding performance.

The surface of alumina is usually rich in oxide groups (-OH), making it chemically active. These groups can form chemical bonds with the siloxane groups in the silicone rubber adhesive, thereby improving the adhesion of the adhesive to the alumina surface[5]. Silicone rubber adhesives usually contain siloxane groups, which can undergo silicon oxidation reactions with oxide groups on the surface of alumina to form stable chemical bonds, thereby improving the adhesion of the adhesive.

3.2 Epoxy Resin Adhesive

The application scenarios of epoxy resin adhesive in alumina include bonding ceramics, metals and composite materials. For example, in the ceramics industry, epoxy resin adhesives are used to secure alumina ceramic sheets or components[6]. In the electronics industry, epoxy resin adhesives are also commonly used to bond alumina substrates or packaged components.

The surface of alumina is usually rich in oxide groups (-OH), making it chemically active. A chemical reaction may occur between the epoxy group (-O-) in the epoxy resin adhesive and the oxide group on the aluminum oxide surface to form an aluminum oxide-epoxy resin chemical bond, thereby improving the bonding strength[7]. The formation of hydrogen bonds or covalent bonds can occur between the epoxy groups in the epoxy resin adhesive and the oxide groups on the aluminum oxide surface, thereby enhancing the bonding effect.

3.3 Acrylic Adhesive

The application scenarios of acrylic adhesive in alumina are mainly reflected in various assembly and bonding processes in industrial production[8]. For example, in automotive manufacturing, acrylic adhesives are used to bond aluminum oxide components, such as engine parts, exhaust systems, etc.

Acrylic adhesives contain acrylic monomers, which contain double bonds (C=C). These double bonds can chemically react with active groups on the surface of alumina to form covalent bonds, thereby enhancing bonding strength. The formation of hydrogen bonds or covalent bonds may occur between

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the acrylic groups in the acrylic adhesive and the oxide groups on the aluminum oxide surface, thereby improving the bonding effect.

3.4 Polyurethane Adhesive

The application scenarios of polyurethane adhesive in alumina include bonding, sealing and caulking[9]. For example, in the construction industry, polyurethane adhesives are used to bond structural components such as aluminum oxide window frames and door frames, as well as to caulk and seal cracks and gaps in aluminum oxide surfaces.

Functional groups such as isocyanate groups (-NCO) and hydroxyl groups (-OH) in polyurethane adhesives can interact with oxide groups on the surface of aluminum oxide to form hydrogen bonds, thereby improving bonding strength. In addition, van der Waals forces may also play a role in the adsorption between the polyurethane adhesive and the alumina surface. The isocyanate groups in polyurethane adhesives have the potential to react with the aluminum oxide surface, possibly reacting with the aluminum hydroxide or hydroxyl groups on the aluminum oxide surface to form more stable chemical bonds.

3.5 Silicone Adhesive

The application scenarios of silicone adhesive in alumina are mainly reflected in the fields of electronics, aerospace and chemical industry. For example, in the electronics industry[10], silicone adhesives can be used to bond alumina substrates, packaging components, etc.; in the aerospace field, silicone adhesives can be used to bond and seal aircraft parts made of alumina.

Silicone adhesives usually contain siloxane groups, such as methylsilyl group, methylvinylsilyl group, etc. These siloxane groups can chemically adsorb or react with active groups such as aluminum hydroxide or hydroxyl groups on the alumina surface to form chemical bonds, thereby enhancing the bonding effect. The siloxane groups in the silicone adhesive can also form hydrogen bonds with the aluminum hydroxide or hydroxyl groups on the aluminum oxide surface, and van der Waals forces may also play a role in their interaction, thereby enhancing the bonding strength.

4. Conclusion

In summary, from the perspective of interface chemistry, silicone rubber adhesives have better advantages in weather resistance. Its stable interface bonding ability, high temperature resistance, oxidation resistance and chemical resistance enable it to maintain a stable bonding effect for a long time outdoors or in harsh environments, and is expected to meet the needs of various complex applications for bonding alumina substrates. demand outlook.

Silicone rubber adhesives have the ability to form stable chemical bonds with the alumina surface because the siloxane groups chemically react with the aluminum hydroxide or hydroxyl groups on the alumina surface to form silicon oxide bonds. This chemical bond is very stable and can effectively resist erosion by external environmental factors, thereby maintaining the stability of the bonding interface.

The siloxane groups in silicone rubber adhesives have high thermal stability and can maintain stable chemical properties in high temperature environments. This allows the silicone rubber adhesive to be used in high-temperature outdoor environments for long periods of time without deterioration or failure.

Because the siloxane groups in silicone rubber adhesives have good oxidative stability, they can effectively resist the attack of oxygen and ultraviolet rays. This makes the silicone rubber adhesive less prone to oxidative aging or surface cracks when used outdoors , thereby maintaining good bonding performance.

Silicone rubber adhesives have good resistance to many chemicals and can resist the erosion of acids, alkalis, solvents and other chemical substances. This allows silicone rubber adhesives to maintain good bonding properties in environments that are contaminated by chemicals or corrosive.

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