

A Hybrid Technology: Static Dissipative / VpCI Films

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Introduction

Very few industries have packaging requirements that are as demanding as those of the electronics industry. Increasingly electronic components are made from numerous and exotic metals. The miniaturization of circuitry has resulted in components that are more sensitive than ever. Meanwhile the cost of these components skyrockets. In an industry that sees its products become obsolete in as little as a year, packaging materials need to be equally innovative.

Background

The principle of electrostatic dissipative films is quite well known. It is desired to increase the surface conductivity of the film. This can be accomplished by one of two means: bulk treatment or surface treatment. For bulk treatment an additive is mixed with the resin used to make the film. This additive increases the conductivity of the surface of the film. In surface treatment the film is made first, and then the surface is treated in a manner that increases the conductivity of the films surface. The increased conductivity allows localized charges to be dissipated.

Electrostatic dissipative packaging is not new to this industry. There have long been demands for static dissipative

packaging materials. The use of these materials proved to be of great advantage over plain packaging materials. These materials, however, leave their precious contents susceptible to damage from corrosion.

There are also packaging materials that are designed to control corrosion. These materials often employ the use of volatile corrosion inhibitors (VpCIs).

To better understand the concept of VpCIs, a review the concepts of corrosion and means of controlling it is needed.

Corrosion is caused by an electrochemical reaction. For this reaction to occur four components are needed, an anode, a cathode, an electrolyte and an electrical connection.

In a typical system these components are all present. Unless the metal is comprised of single crystal, some crystals of the metal serve as the anode and some as the cathode. Ambient moisture often plays the role of the electrolyte. Finally, there is an electrical connection because the crystals that comprise the metal are in contact and are conductive.

Corrosion inhibitors are used to control the electrochemical reaction. A corrosion inhibitor shifts the electrochemical potential of the metal in

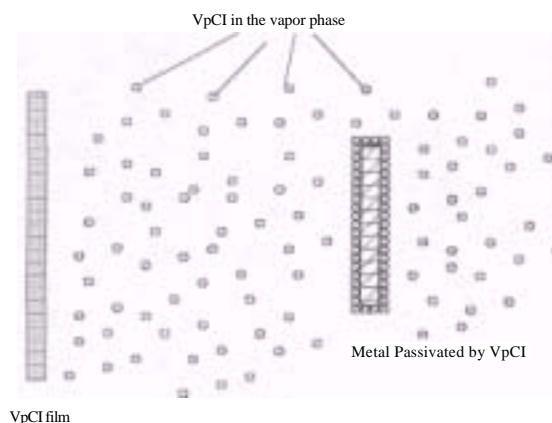
a way that makes the corrosion reaction unfavorable. This state of shifted electrochemical potential is known as passivation. A corrosion inhibitor also forms a barrier on the metal surface. In this way corrosion inhibitors slow down or stop the electrochemical reaction known as corrosion.

The principles of VpCIs are rather unique. VpCIs function similar to conventional inhibitors. The difference is that the inhibitor is volatile. Because the inhibitor is volatile it diffuses through the air to the metal surface. Components, therefore do not need to be in direct contact with the packaging material. This allows parts with large internal surface areas and void spaces to be protected. This makes VpCIs ideally suited for use with most packaging substrates.

To make a corrosion preventative film, VpCIs are loaded into the resin used to make the film. This resin is then extruded to form a film.

This film can now be used to protect metal from corrosion. The process is quite simple: The VpCI in the film volatilizes, filling the enclosed space with VpCIs. When a metal part is placed within this package the VpCIs condense onto all metal surfaces forming a thin layer. This layer passivates the metal. This passivation protects the metal from corrosion caused by a variety of agents such as moisture, H_2S , SO_2 and other contaminants. The VpCI mechanism is illustrated in figure 1.

Figure 1 The VpCI Mechanism



Conventional corrosion inhibiting packaging does not fully meet the demands of the electronics industry either. VpCI materials provide excellent protection from corrosion, however, these materials do not provide the static dissipative properties desired by the electronics industry.

The solution to this problem is a hybrid technology. A material that combines electrostatic dissipation properties with corrosion inhibition would be of great advantage for packaging of electronic components. The result would be a film that provides total protection to electronic components.

Methodology

To provide an objective evaluation of the performance of these materials it was desired to use established standards. It was necessary to choose test methods that would characterize the static dissipative properties as well as the corrosion inhibiting ability of the films.

The performance standards used for this study are those of the U.S. military. The static dissipative requirements were taken from military specification MIL-B-81705. The standard for VpCI performance comes from military specification MIL-B-22019. Thus by using standards from military specifications accepted performance requirements for electrostatic dissipation and VpCIs are utilized.

For this undertaking the effectiveness of electrostatic dissipative materials were evaluated using two requirements of MIL-B-81705. This is the U.S. military's specification for static dissipative materials.

The first test of static dissipative ability is the surface resistivity. A measurement of the surface resistivity verifies the effectiveness of the additive in increasing the conductivity of the films' surface.

The second static dissipation test is the static decay rate. This is a measure of how quickly a localized charge is dissipated. A charge is placed on a film. The time it takes for the film to dissipate this charge is then measured.

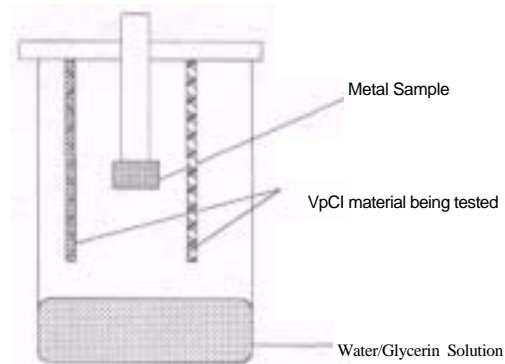
Therefore, an accurate assessment of the films' static dissipative qualities is obtained by use of these two tests.

There are very few established methods for testing the effectiveness of VpCI materials. The test used in MIL-B-22019 is called the Vapor Inhibiting Ability (VIA) test.

The concept of this test is fairly straightforward. The VpCI material (film, paper, etc.) is suspended inside a jar that

serves as a test chamber. In this jar there is a water-glycerin solution that results in a relative humidity of 90%. There is also a metal surface inside the jar. This surface is not allowed to contact the VpCI material. After a conditioning period the metal is chilled in a manner that causes condensation to occur on the surface. For non VpCI materials this condensation causes corrosion. For materials that contain an adequate amount of the VpCI, the metal surface will be passivated by the VpCI, preventing corrosion. This procedure is depicted in Figure 2. Thus it is possible to evaluate the VpCI properties of packaging material by use of the VIA test method,

Figure 2 The VIA Test Method



Experimental

Static decay rate

The static decay rate was tested in accordance with Federal Standard 101C method 4046.

The specimens to be tested were conditioned for twenty four hours in a chamber at 72 °F and 15% relative humidity

The specimens were mounted between the electrodes using wing nuts to secure intimate contact.

The voltage output was set a 5000 volts. The switch was closed, applying 5000 volts to the sample.

The time for the charge to be reduced to 99% of the original charge was recorded.

This was performed for both positive and negative charges.

Surface Resistivity

The specimens to be tested were conditioned for twenty four hours in a chamber at 72 °F and 15% relative humidity.

The surface resistivity was measured and recorded.

VIA Test

The VpCI properties were tested in accordance with Federal Standard 101 C method 4031 procedure B.

Ten milliliters of a water glycerin solution with a specific gravity of 1.076 was added to clean one quart glass jars.

Plugs made using QQ-S-698 low carbon steel were polished using 240 grit silicone-carbide abrasive. The plugs were then cleaned using methanol.

The plugs were fitted into the bottom of a tube that runs through the lid for the one quart glass jar. Two one inch by six inch strips of the material to be tested were suspended from the jar lids.

The jars containing the water-glycerin solution were then sealed using these lids.

The jars were allowed to condition for a period of twenty hours.

After twenty hours water at 12 °C was poured into the tubes causing condensation on the test surface.

After three hours the lids were removed and the test surface on the steel plugs were inspected for signs of corrosion.

In addition, a control must be used. For the control, the test was run identically, except no material was suspended from the lid.

For the test to be valid there must be signs of corrosion on the control.

Results

Three low density polyethylene films were tested for static dissipation and VpCI performance. The first film used was a standard static dissipative film using an amide based "antistat" agent. The second film was a VpCI film based on amine salts. The final film tested was a hybrid film containing the same static dissipative and VpCI additives that each of the first two films contained.

The requirements of MIL-B-81705 are simple. The surface resistivity is to be greater than or equal to 1×10^5 ohms per square but less than 1×10^{12} ohms per square. The static decay rate is to be less than 2 seconds.

The requirements from MIL-B-22019 is that the material must pass the VIA test. A material is considered to pass the VIA test if there is no visible sign of corrosion

Table 1 shows the results of the static dissipative and VIA testing. The values given for the surface resistivity and static decay rates are the maximum values obtained.

Table 1 Testing Results

Material	Surface Conductivity	Static Decay Rate	VIA
Static dissipative film	1×10^9	0.6	Fail
VpCI Film	$>1 \times 10^{12}$	>2	Pass
Hybrid Film	1×10^9	0.6	Pass

The static dissipative material was found to meet the surface conductivity and the static decay rate requirements. The VpCI film did not meet either requirement. The hybrid film met the requirements for the surface resistivity and static decay rate. Therefore, only the static dissipative film and the hybrid film met the static dissipation requirements of MIL-B-81705.

These same materials were also tested for VpCI properties using the VIA test method. The static dissipative film was found to provide no corrosion protection. The VpCI film passed the VIA test. The hybrid film also passed the VIA test and it was determined that it provides vapor phase corrosion protection. Thus the VpCI and hybrid films pass the VIA test while the static dissipative film fails the VIA test.

In summary, the static dissipative film provides static dissipative qualities but no corrosion control properties. The VpCI film has no static dissipative properties but provides corrosion protection. Finally the hybrid film provide both static dissipation and corrosion control.

Conclusions

Each material is limited only by its design. Each film provides the type of protection that it was intended to provide.

Static dissipative films provide only electrostatic discharge (ESD) protection. These materials are suitable for packaging applications in which ESD is a concern and corrosion is not. In applications that involve metals susceptible to corrosion, these materials are a poor choice as they offer no corrosion protection.

VpCI films have been successfully used in a wide variety of industries to solve various corrosion problems, but they are not recommended for packaging of ESD sensitive materials.

The VpCI/static dissipative film provides total protection. If ESD damage is a concern, the static dissipative properties accommodate this need, while the corrosion protection is not compromised. This allows sensitive components that may be damaged by ESD to be stored in an area that would otherwise not be possible due to corrosion. The VpCI in the hybrid protects parts from corrosion caused by moisture and industrial pollutants. Since the VpCIs in the hybrid are formulated for multimetal protection, copper, aluminum, solder, nickel, and

silver are protected as well. Thus making it an ideal choice for the protection of electronic components.

References

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