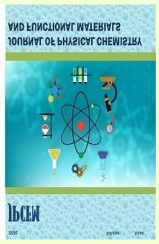
Journal of Physical Chemistry and Functional Materials 2,1 (2019) 1-4

Journal of Physical Chemistry and Functional Materials

Home Page of Journal: https://dergipark.org.tr/jphcfum



Effect of Epoxy Resin in Synthesis of Rubber-Metal Adhesive

[a,b]Ümit Sevinç ,[a]Ali Kara*

[a]Uludag University, Institute of Science, Department of Chemistry, 16059 Bursa, Turkey

[b]SKT Yedek Parca ve Mak. San. Ve Tic. AS, 16140 Bursa, Turkey

Received: 8-May-2019, **Accepted**: 24-May-2019
ISSN: 2651-3080

ABSTRACT

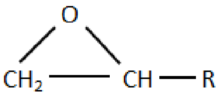
The appropriate solvent for the dissolution of the NBR (Nitrile Rubber) Polymer, the fillers, the crosslinking chemicals and the epoxy resin was investigated. As a result of the research, the best effect was seen in toluene. Dissolution was effected by means of a mechanical stirrer. The prepared solution was applied to a zinc phosphate coated metal plate with a pressure spray gun. Adhesive applied metal was vulcanized in hot press with NBR (Nitrile Rubber). The adhesive applied metal plate was vulcanized in hot press with NBR rubber. The vulcanized rubber was peeled off with a tensometer and the adhesion was examined.

ARTICLE INFO

Keywords: Nitrile Rubber, Epoxy Resins, Bonding, Vulcanization.

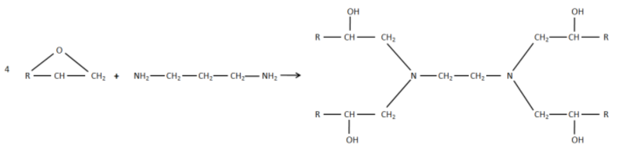
1. Introduction

Epoxy resins were discovered in 1909 by Prileschajew. Epoxy resins are defined as low-molecular-weight pre-polymers containing more than one epoxide group of the form.



(1)

Epoxy resins are thermosetting resins, which are cured using a wide variety of curing agents via curing reactions. Their properties depend on the specific combination of the type of epoxy resins and curing agents used. Because of their excellent mechanical properties, high adhesiveness to many substrates, and good heat and chemical resistances, currently epoxy resins are intensively used across a wide range of fields, where they act as fiber reinforced materials, general-purpose adhesives, high-performance coatings, and encapsulating materials. In this paper, the synthesis and curing process of epoxy resins are reviewed in detail. In addition, the preparation and application of epoxy-based composites are discussed [1].



Chemical reaction of four epoxy resins with a curing agent

(2)

2. Rubber to Metal Bonding

Rubber finds use in many applications as a means of isolating vibration and reducing shock or as a way to seal in solids, liquids and gases. For many of these applications, it is desirable or even imperative that the rubber be attached to a metal substrate in a reliable manner. There is a fundamental difference between bonding of rubber to metal involving crosslinking mechanisms and the physical 'sticking' of rubber to metal using a non-vulcanizing adhesive. The former involves a chemical reaction (generally during cure) while the latter generally relates to a physical surface tension phenomenon. Bonded rubber parts have found use in a myriad of dynamic applications such as engine mounts, suspension bushings, body mounts, torsional dampers, helicopter rotor bearings, seismic bearings, transmission and axle seals, and as flexible couplings. These parts are usually made by vulcanizing the rubber and bonding it to the metal component in a single-stage press operation.

* Corresponding author:
E-mail (umitsevinc@hotmail.com)

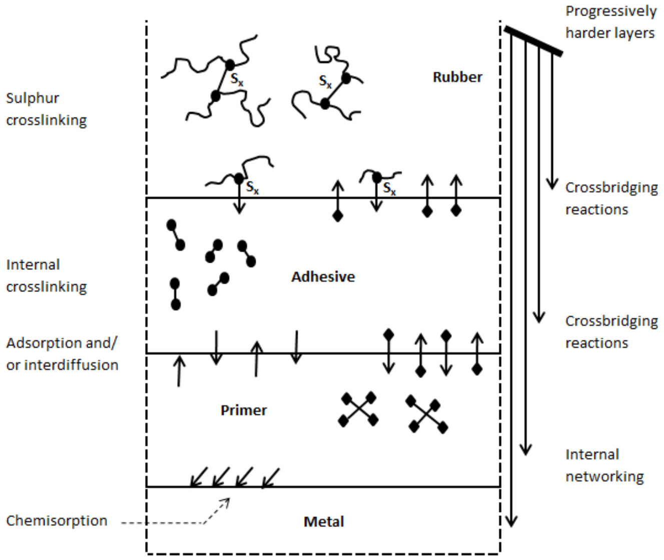


Figure 1. Schematic of vulcanization bonding process.

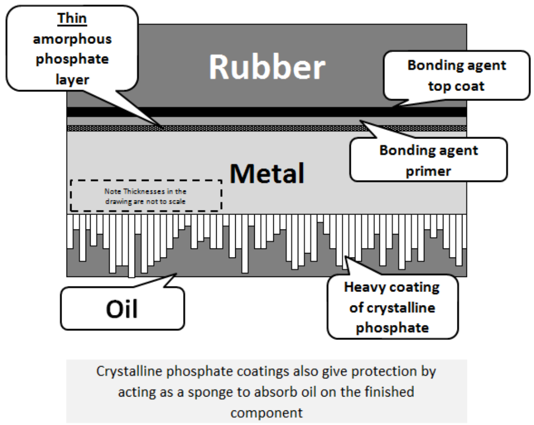


Figure 2. Diagram showing component with bonded layer and oil soaked crystalline phosphate protective coating

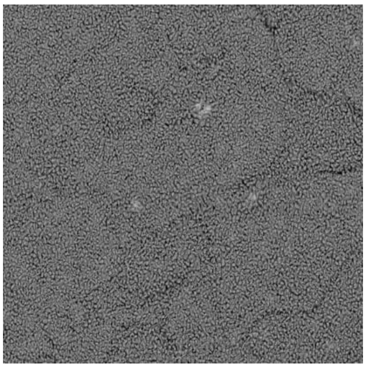


Figure 3. Phosphate coating crystalline structure

3. Method and Surface Preparation

3.1. ASTM D429-14 / Method B

This test is intended to determine the adhesive strength of rubber-to-metal bonding agents. The results are obtained by measuring the force necessary to separate a rubber from a metal surface. The data obtained indicates the strength of adhesion along a line across the width of the rubber strip being separated from a metal plate at a 90° angle. The test provides valuable data for development and control of rubber compounds and test methods of bonding. It also serves as a screening test for the evaluation of various bonding agents, techniques, or both.

3.2. Metal Surface Preperation

Steel is often phosphate coated for use within the engineering and decorative laminate industries to reduce corrosion. Iron or zinc phosphate can be used. However, although used for some years as a corrosion protection technique for rubber to steel bonding, it can be difficult to control the process, with a resultant variable thickness of phosphate deposit of varying crystalline structure. If too thick a phosphate layer is obtained it becomes too friable and lacking in the cohesive integrity required to maintain a rubber to metal bond under load during service.

The phosphating process usually involves cleaning of the metal, rinsing, surface activation, and phosphate conversion producing an amorphous layer before a finalrinse and seal.This sequence is:

i. Alkaline degrease,
ii. Rinse,
iii. (Surface activation),
iv. Phosphate,
v. Rinse,
vi. Seal (Passivation),
vii. Rinse,
viii. Dry.

Surface Reactions:

Etching Reaction : $Fe^0 + 2H^+ \longrightarrow Fe^{2+} + 2[H^0]$

Depolarization: $2[H^0] + [O] \longrightarrow H_2O$

Coating Occurrence:
$3Zn^{2+} + 6H_2PO_4^- + 4H_2O \longrightarrow \underline{Zn_3(PO_4)_2x4H_2O} + 4H_3PO_4$

Hopeite

$2Zn^{2+} + Fe^{2+} + 6H_2PO_4^- + 4H_2O \longrightarrow \underline{Zn_2Fe(PO_4)_2x4H_2O} + 4H_3PO_4$

Phosphophyllite

Ingredients	Weight of adhesive
Polymer	8,50 g
Activator	0,34 g
Accelerator	0,25 g
Carbon Black	2,03 g
Resin (Epoxy Resin)	12,75 g
Antioxidant	1,00 g
Insoluble sulphur	0,13 g
Solvent	75,00 g

Table 1. Formulation-1 (with epoxy resin)

Ingredients	Weight of adhesive
Polymer	8,50 g
Activator	0,34 g
Accelerator	0,25 g
Carbon Black	2,03 g
Antioxidant	1,00 g
Insoluble sulphur	0,13 g
Solvent	75,00 g

Table 2. Formulation-2 (without epoxy resin)

3.3. Adhesive Preparation

Weighing of Chemicals

Mixing of Chemicals

Control of solids determination

Application of adhesive to metal plate

Vulcanizationtogetherwithrubber

Determination of adhesion force in tensometer

Results

(a) (b)

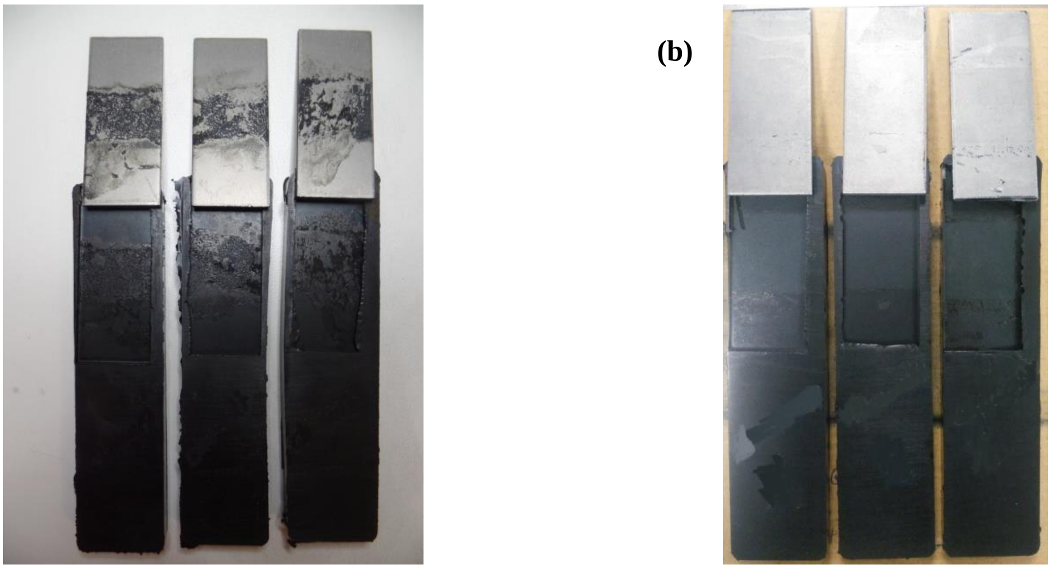


Figure 4. (a) Formulation-1, and (b) Formulation-2.

4. Results and Discussion

In this study, the effect of epoxy resin on rubber-metal adhesive was investigated. In order to see the effect of the resin, two different formula rubber-metal adhesives were prepared. In formula 1 epoxy resin was added to the solution. No epoxy resin was added in formula 2. Two adhesives were applied to the metal plate coated with zinc phosphate. Then vulcanized with the same rubber and in the same process conditions. It was tested by tensometer device. As can be seen in Figure 4, the formulation in which epoxy resin was added gave better results.

5. Conclusion

Rubber-Metal bonding agent prepared with epoxy resin provides better adhesion than without epoxy resin.

REFERENCES

[1] Synthesis and application of epoxy resins
[2] Molecular dynamics study on the tensile deformation of cross-linking epoxy resin
[3] Adhesive formulations for rubber to metal bonding systems
[4] Henkel Design Guide for Bonding Rubbers and TPEs, vol. 2, dt 2/05.
[5] J.F.E. Ruffel, Durham Raw Materials Ltd; Paper, Elastomer to Metal Bonding read at West England Section Conference at Trowbridge 5th March 1968, Journal of the IRI vol. 3 (4) (August 1969).
[6] E.M. Petrie, Handbook of Adhesives and Sealants, second ed., McGraw-Hill Professional, 2006. ISBN: 0071479163, 9780071479165.
[7] F. Gage, Dayton Chemical Products Laboratory, Rubber to metal bonding, Journal of the IRI 2 (1) (February 1968).
[8] Bryan Crowther, Revised and Reprinted 2003, The Handbook of Rubber Bonding
[9] Kevin Violette, The Delta Rubber Company, Rubber-to-Metal Bonding
[10] Murat Ovalı, Türk HENKEL A.Ş., Boya Öncesi Yüzey İşlem Eğitimi
[11] LORD Corporation, Preparation of Chemosil primers And Adhesives
[12] Sina Ebnesajjad - Adhesives Tecnology Handbook (2. edition)
[13] ASTM D429-14 Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
[14] Dr. Hans-Joachim Graf, Europe Rubber Processing Education 2016
[15] Effect of Silane in the Rubber-Metal Bonding Agent, Journal of Physical Chemistry and Functional Materials, 1(1), (2018), 73-81