Investigation of Filiform Corrosion of Coated Aluminium

Andrea Rudolf, Wolf-Dieter Kaiser

Institut für Korrosionsschutz Dresden GmbH, Gostritzer Straße 61-63, 01217 Dresden, Germany

Summary: Filiform corrosion on different aluminium alloys, coated with a clear varnish has been studied. Image analysis and metallographics were used to characterize the corrosion. It has been shown, that filiform corrosion consists of a lateral propagation of filaments and an attack on the aluminium under the filaments. The extent of filiform corrosion is dependent on the sort of alloy and the pretreatment of metall surfaces.

Keywords: Aluminium alloys, filiform corrosion, pretreatment, image analysis, coating

Introduction

Filiform corrosion is a particular type of localized corrosion of coated aluminium and occurs by the following conditions:

- at a wet environment with relative humidity of 40-90 %
- at the presence of ionic substances, for instance chlorides
- at the presence of defects in the coating [1-8].

Filiform corrosion is characterized by a lateral propagation of filaments and an attack under the filaments on the substrat [9,10]. Figure 1 and 2 show two examples.

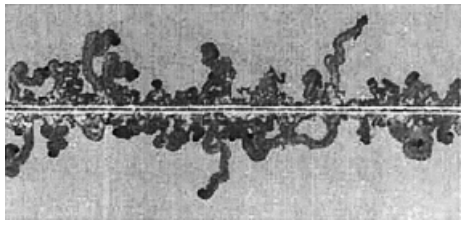


Figure 1. Lateral propagation of filaments of EN AW 2024, T42, coated with a 2K-PUR-AY coating

The aim of this work was to investigate the influence of the substrat material and the treatment of surfaces of the filiform corrosion of coated aluminium alloys. Different pretreatments of surfaces were used: alkaline degreasing, etching, yellow chromating, treatment with zirconiumfluoride

 CCC 1022-1360/00/$ 17.50+.50/0

and anodizing. It was used a clear coating material and many aluminium alloys used in industrial manufacturing.

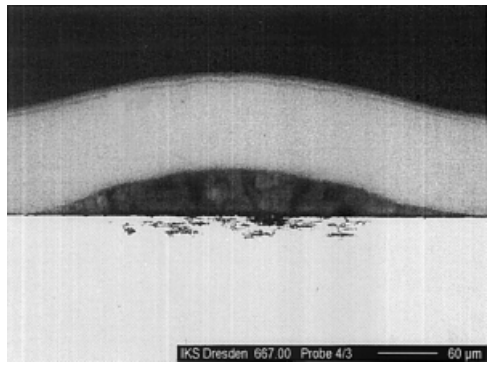


Figure 2. Attack under a filament of EN AW 6082, T4, coated with a polyester powder coating

Experimental

Substrates: Aluminium alloys used for this investigations are shown in table 1.

Table 1. Aluminium alloys

aluminium with high purity	Al99,999
EN AW 2XXX	EN AW 2017A, O EN AW 2017A, T42 EN AW 2024A, O EN AW 2024, T42 EN AW 2024, T62
EN AW 5XXX	EN AW 5005, H14 EN AW 5754, O EN AW 5754, F22 EN AW 5754, H22 EN AW 5182, O EN AW 5182, H19
EN AW 6XXX	EN AW 6060, extruded EN AW 6016, T4 EN AW 6082, T4 EN AW 6082, T651
EN AW 7XXX	EN AW 7020, T6 EN AW 7075, T76

Pretretment of metall surfaces [10]:

alkaline degreasing:	P3 almeco 20/HNO_3
etching:	P3 almeco 20/P3 almeco 40, NaOH/ HNO_3
yellow chromating:	P3 almeco 20/P3 almeco 40, NaOH/ HNO_3/Alodine C6100
Zr-F-Polymer:	P3 almeco 20/P3 almeco 40, NaOH/ HNO_3/Alodine 4830/31
anodizing:	P3 almeco 20/P3 almeco 40, NaOH/ HNO_3/H_2SO_4 (GS)

Rinsing processes were carried out, but they are not mentioned.

Coating:	2K-PUR-AY (clear varnish)
Loading:	Filiform corrosion was initiated by one-hour treatment with hydrochloric acid in according to DIN EN 3665 and following storage at 40°C and 82% relative humidity.
Exposure time:	2000 hours
Test procedure:	Image analysis of propagation of corrosion filaments and metallografical analysis of the attack on the substrat were carried out.

Results

Both phenomena - lateral propagation and appearence of corrosion within the substrat - are dependent on the pretreatment of metall surfaces and on the metal itself. The following figures 3 - 7 shows the lateral propagation of filaments.

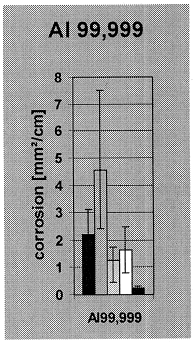


Figure 3. Al99,999

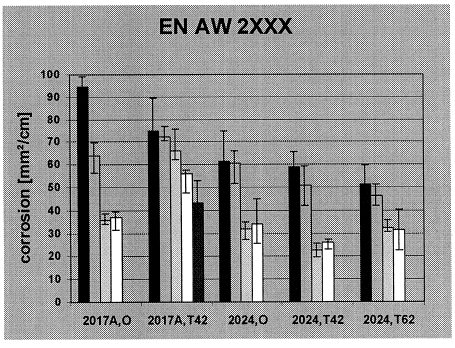


Figure 4. EN AW 2XXX

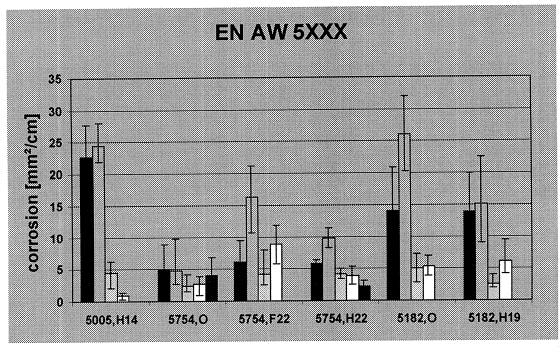


Figure 5. EN AW 5XXX

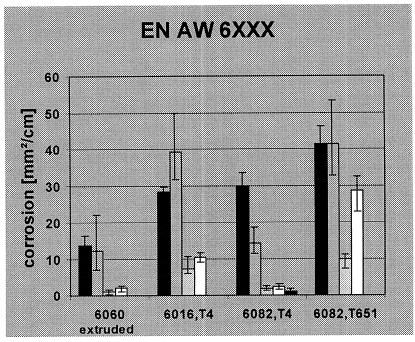


Figure 6. EN AW 6XXX

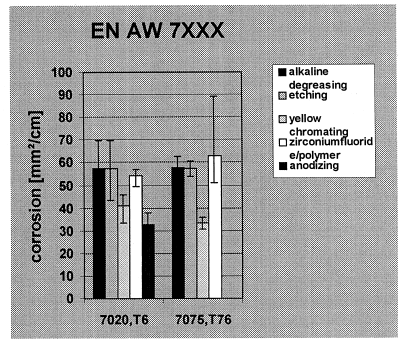


Figure 7. EN AW 7XXX

The formation of filiform corrosion is dependent on the pretreatment of metall surfaces. The best method to reduce filiform corrosion is to anodize, following by yellow chromating or treatment with zirconiumfluorides. Extensive filiform corrosion was also found when metal surface was only degreased or etched.

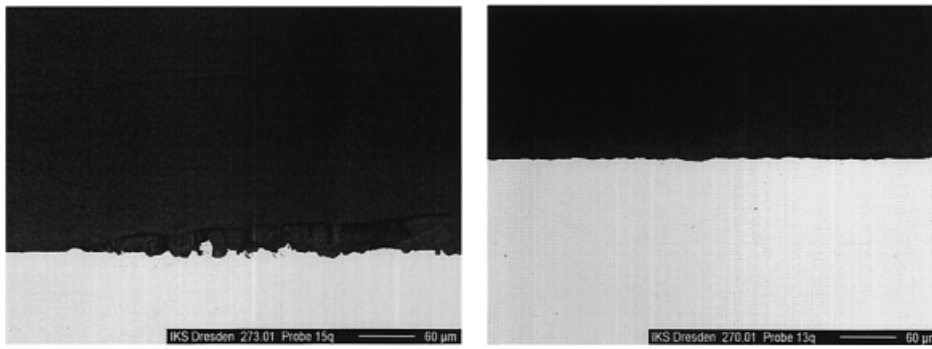
Lateral filiform corrosion and depth of the filiform corrosion attack are dependent on the metal. The chemical composition of the alloy plays an important role.

Alloys with copper and zinc have a high susceptibility to filiform corrosion. Aluminium with high purity shows a high filiform corrosion resistance.

The attack within the substrat has a special appearance. There are some alloys, they show intergranular attack (EN AW 2017, EN AW 6016), some alloys show roughening of the surface (EN AW 5005, EN AW 6006) and other show only even uniform corrosion (Al99,999). In some cases shallow pit building occurs (EN AW 5182, EN AW 7020). In the first case of intergranular attack precipitations on grain bonderies are important (table 2, figure 8-10).

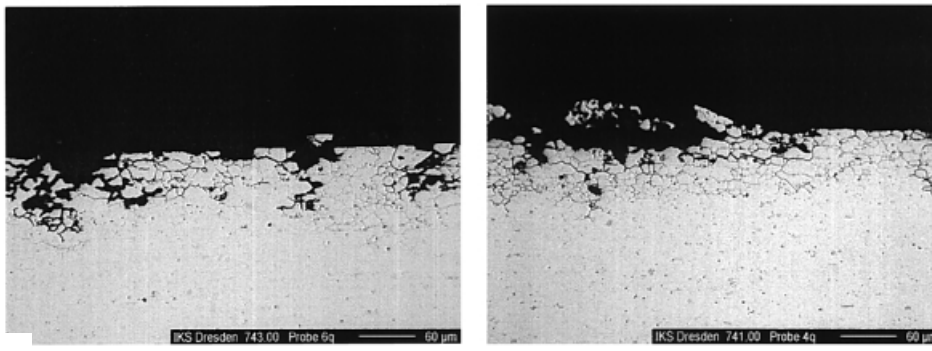
Table 2.Examples of corrosion attack under the filaments

substrat	pretreatment of metall surfaces	attack under the filament	
		Appearance image of attack	max. depth [µm]
Al99,999	etching	uniform attack	<5
	yellow chromating		
	Zr-F-polymer		
	anodizing		
EN AW 2017A T42	etching	intergranular attack with grain disintegration	120
	yellow chromating		120
	Zr-F-polymer		130
	anodizing		140
EN AW 5182 H19	etching	shallow pit formation	35
	yellow chromating	intergranular attack and pitting	100
	Zr-F-polymer		100
EN AW 6016 T4	etching	intergranular with formation of pits	110
	yellow chromating		110
	Zr-F-polymer		130
EN AW 6060 extruded	etching	roughening	10
	yellow chromating		5
	Zr-F-polymer		10
EN AW 7020 T6	etching	roughening, shallow pit formation	25
	yellow chromating		25
	Zr-F-polymer		25
	anodizing		55
EN AW 7075 T76	etching	intergranular with grain disintegration	50
	yellow chromating		60
	Zr-F-polymer		55
	anodizing		80



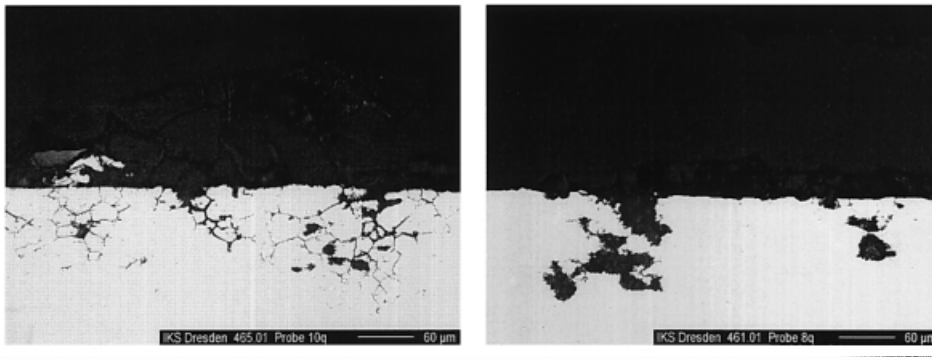
a) b)

Figure 8. Attack under the filament on EN AW 5005, H14
a: etching
b: Zr-F-polymer



b) b)

Figure 9. Attack under the filament on EN AW 2017, T42
a: etching
b: Zr-F-polymer



a) b)

Figure 10: Attack under the filament on EN AW 6016, T4
a: etching
b: Zr-F-polymer

Acknowledgements

This projekt was suported by the department of economy in Germany and the AiF (project number 11804B) . The autors are grateful to FPL, Stuttgart for performing image analysis.

References

[1] Kaesche, H.: Werkstoffe und Korrosion 11(1959), S. 668 - 681
[2] Ruggeri, R.T.; Beck, T. R.: Corrosion-Nace 39(1983), S. 452 - 465
[3] Boutista, A.: Prog. Org. Coat. 28(1996), S. 49 - 58
[4] Schmidt, W.; Stratmann, M.: Corrosion Science, 40(1998)8, S. 1441 - 1443
[5] Haagen, H.; Rihm, K.-H.: Farbe + Lack 96(1990), S. 509 - 513
[6] Haagen, H.; Gaszner, K.; Scheck, K.: Farbe + Lack 97(1991), S. 306 - 310
[7] Pietschmann, J. E.: JOT (1993)11, S. 74 - 79
[8] Defrancq, J. N.: Estal Eurocoat Symposion, Cannes 16.09.1994.
[9] Rudolf, A.; Kaiser, W.-D.: Aluminium 72(1996)10, S. 726 - 733
Aluminium 72(1996)11, S. 832 - 835
[10] Rudolf, A., Kaiser, W.-D.: JOT 42(2002)4, S.98 – 103