NaCl induced corrosion of Zn-0.2Al, Zn-5Al and Zn-55Al coated steel was investigated at low and ambient CO₂ levels. Weight loss measurements revealed an enhancement of the corrosion of Zn-0.2Al and particularly Zn-5Al in low CO₂. This was connected to an increase of surface pH in a low CO₂ atmosphere promoting the formation of ZnO and layered double hydroxide for Zn-5Al. For Zn-55Al, CO₂ depletion did not affect the surface pH due to the acidification effect of Al₃⁺. Preferential dissolution of zinc rich phase was observed on cross-sections, particularly in depleted CO₂ experiments. Different sequences of corrosion product formation were proposed for the different Zn-Al coatings.

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The X-ray diffraction (XRD) measurements were performed at 5° angle of incidence using a Bruker AXS D8 Discover with a Cu-anoode and a SolX detector with energy window for Cu Kα and a Göbel mirror on the detector side.33

Results

Microstructure.—The microstructure of Zn-5Al and Zn-55Al may be observed from the surface in Figure 1 while cross-sections and EDX analysis are given in Figure 2 and Figure 3 for Zn-5Al and Zn-55Al respectively. Zn-5Al coating has a relatively complex microstructure. During solidification, the η-zinc (pro-eutectic) phase containing about 1% aluminum crystallizes first, followed by the crystallization of a eutectic of zinc containing about 5% aluminum. The microstructure of Zn-5Al is thus characterized by a two-phase structure, a zinc-rich eta (η) proeutectic phase surrounded by a eutectic type phase consisting of beta (β) aluminum and eta (η) zinc lamellae as described elsewhere.34 It should be noticed that the beta aluminum phase contains more aluminum than the eta zinc phase. The microstructure of Zn-55Al shows aluminum-rich dendrites, zinc-rich interdendritic areas interspersed with occasional silicon particles and a thin intermetallic layer which binds the coating to the steel as highlighted in the cross section of Figure 3 and in agreement with1 and 35.

The microstructure of the binary alloys is documented in Figure 4 with SEM images and XRD diagrams. Zn-0.7Al samples showed a grain size of about 100 μm. XRD as well as EDS did not show any other phase than the η-Zn phase. Zn-22Al contains grains of random sizes. Primary dendrites of dark α-Al phase have dimensions of about 10–20 μm. Light η-Zn phase solidified from melt as long precipitates on the grain boundaries. Fine eutectoid solidified between those phases as the consequence of decomposition of metastable β-Al phase into α-Al and η-Zn phase. The grain size of Zn-68Al was much larger i.e. about 500 μm. XRD shows α-Al phase and residues of η-Zn phase (under the detection limit e.g. less than 1 vol.%). These residues are small light spots at the grain boundary of the α-Al phase (not visible in the SEM picture).

Corrosion kinetics.—Figure 5 compares the mass loss of the three metallic coatings and the three Zn-Al binary alloys after 4 weeks exposure at 20°C and 90% R.H. in the presence of sodium chloride, in air and in low CO2 atmosphere. In good agreement with previous data on comparable coatings, lowering the carbon dioxide in the atmosphere resulted in an enhancement of the corrosion of Zn-0.2 Al and Zn-5Al coatings.28 Such results were also observed on pure zinc by Lindström and co-workers.25 In the present low CO2 conditions, the mass loss was multiplied by 1.4 for Zn-0.2Al coating compared to air and rather similar enhancement was observed on pure phase Zn-0.7Al; the composition of which is indeed close to Zn-0.2Al coating. It is interesting to note that the reduction of CO2 content has a more detrimental effect on Zn-5Al coating where an enhancement of 4 was observed on the corrosion rate compared to normal CO2 level in agreement with previous work which also pointed out a similar negative effect on ZM coating.26 On the other hand, no effect of CO2 content was observed on the mass loss of the coating with the highest aluminum content e.g. Zn-55Al coating and Zn-68Al cast binary alloy. In the case of Zn-55Al coating, the surface pH remains rather neutral (yellow-green color) with no increase of the pH in depleted CO2 conditions contrarily to Zn-0.2Al and Zn-5Al where the surface became alkaline (blue color) as shown on the photographs of Figure 6 which present the surface pH measured using an agar containing pH indicator applied on the corroded surface of the three zinc coatings in low CO2 conditions. The surface pH was further estimated using an image analysis and plotted in Figure 7 which compares the data with normal and low CO2 concentration. The surface pH on corroded Zn-55Al was indeed almost entirely neutral and rather similar in air and low CO2 atmosphere, in agreement with the mass loss. Similar results were also observed on Zn-Al pure phases containing the highest aluminum content i.e. Zn-68Al as shown in Figure 8. In contrast, about 90% of the surface of corroded Zn-0.2Al and Zn-5Al

| Alloy    | Zn  | Al  |
|----------|-----|-----|
| Zn-0.7Al | 99.3| 0.7 |
| Zn-22Al  | 77.8| 22.2|
| Zn-68Al  | 32.4| 67.6|

Table II. Composition of pure phases (estimated by atomic absorption spectroscopy).

+ 0.8 g Na2SO4 + 100 ml H2O/ laboratory temperature /5 s; and for Zn-22Al and Zn-68Al alloys, 10 g NaOH + 100 ml H2O/ 70°C/ 1–5 min.

Exposure conditions.—The samples were contaminated by spraying even a given volume of solution of NaCl containing NaCl, resulting in a surface concentration of approximately 2 g/m2 of chloride (Cl−), which was verified by weighing the samples. Four parallel samples contaminated by NaCl were exposed, among which 3 were used for the metal loss calculations and 1 for the analyses of corrosion products. The samples were exposed horizontally in a climatic chamber “Voitsch VCC 0060” regulated at a temperature of 20°C and a relative humidity of 90%. A concentration of maximum 8 ppm of CO2 was achieved by purifying the inlet air through filters before entering the climatic chamber while it was about 350–400 ppm of CO2 in the experiments conducted in normal air concentration of CO2. The concentration of CO2 was measured using an infrared gas analyzer WMA-4 from PP-Systems. The exposure duration was 4 weeks. At the end of the exposure, the samples were dried in the exposure cell for about 2 days by introducing dry air or low CO2 (R.H. < 10%).

Methods of evaluation.—In order to remove the corrosion products, the samples were pickled in saturated glycine for coatings or alloys with low amount of Al, while chromic acid solution (100 g/L CrO3, 10 g/L AgNO3) was used for Zn-55Al coated steel, Zn-22Al and Zn-68Al alloys. This was done according to ISO 8407. The weight loss of the metallic coating or alloy was gravimetrically calculated. On one sample, the surface pH was visually mapped by placing a thin layer of agar containing a wide range of pH indicator (WRI). Details on the preparation of the WRI agar may be found elsewhere.17 This allowed a visualization of the surface pH for different material and exposure conditions. Image analysis software (LUCIA) was then used to estimate the percentage of surface with alkaline, neutral or more acidic pH by measuring the total surface with blue, green-yellow and red color, respectively.

A Scanning Electron Microscope (SEM) Hitashi SU3500 was used for surface and cross section analysis of the coatings. Cross-sections were embedded in epoxy resin and polished down to 1 μm with water free products. In addition, the distribution of elements on cross sections of corroded panels was obtained using Energy Dispersive X-Ray Spectrometer (EDX) from Thermo Scientific Ultradry NSS 312.

Analysis of corrosion products.—Fourier transform infrared – Attenuated total reflection (FTIR-ATR) spectroscopy measurements on corrosion products formed on the Zn-Al coated steel were performed using a Bruker Vertex 70 spectrometer equipped with a wide band beamsplitter and a Harrick’s single bounce ATR accessory (Splitpea) with a Si internal reflection element. The FTIR-ATR spectra were recorded in the region 80 – 6000 cm−1 with a resolution of 8 cm−1 on corrosion products removed from the samples. FTIR micro spectroscopy measurements were performed using a Bruker Vertex 70 spectrometer with a Hyperion 3000 microscope and a broad band MCT detector in the region 400 – 6000 cm−1. The peaks in the FTIR spectra of the corrosion products were assigned by comparing with reference FTIR spectra.

The samples were contaminated by spraying evenly a given volume of solution of methanol containing NaCl, resulting in a surface concentration of approximately 2 g/m2 of chloride (Cl−), which was verified by weighing the samples. Four parallel samples contaminated by NaCl were exposed, among which 3 were used for the metal loss calculations and 1 for the analyses of corrosion products. The samples were exposed horizontally in a climatic chamber “Voitsch VCC 0060” regulated at a temperature of 20°C and a relative humidity of 90%. A concentration of maximum 8 ppm of CO2 was achieved by purifying the inlet air through filters before entering the climatic chamber while it was about 350–400 ppm of CO2 in the experiments conducted in normal air concentration of CO2. The concentration of CO2 was measured using an infrared gas analyzer WMA-4 from PP-Systems. The exposure duration was 4 weeks. At the end of the exposure, the samples were dried in the exposure cell for about 2 days by introducing dry air or low CO2 (R.H. < 10%).

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coatings showed an alkaline pH in low CO₂ condition. It is interesting to underline that the surface at high pH is about 4 times larger for Zn-5Al coating and 1.5 for Zn-0.2Al when comparing the surface pH in low and normal CO₂ conditions. This corresponds also to the ratio of mass loss in low CO₂ atmosphere versus in air.

In order to visualize the corrosion attacks, cross sections of corroded Zn-5Al and Zn-55Al coatings were observed in SEM for both low and normal CO₂ content. The images are shown in Figure 9. Zn-5Al coating was rather homogenously degraded in low CO₂ atmosphere down to the full coating thickness and a significant layer of corrosion products may be observed (Figure 9b). This is in agreement with the high mass loss measured. In normal CO₂ atmosphere, the amount of corrosion was less and also more localized, zinc phases being preferentially attacked (see Figures 9a). Concerning Zn-55Al coating for which SEM images are presented in Figures 9c and 9d, the attack is localized in both CO₂ conditions. The cross sections indicate a preferential attack of zinc rich phases as expected and the attack is clearly more pronounced in low CO₂ conditions. The average mass loss obtained by the gravimetric method after removal of corrosion products by chemical pickling is not accurate when such localized corrosion takes place. Such observations have already been pointed out by Thierry and co-workers on HDG coated steel exposed to natural environments. As shown in Figure 10, the elemental distribution from a cross section of corroded Zn-55Al in low CO₂ conditions confirms the preferential attack of zinc rich phase with chlorides ions.

Composition of the corrosion products.—Analysis of the composition of the corrosion products formed on Zn-0.2Al and Zn-5AI coatings exposed in air and in low CO₂ conditions was performed with FTIR-ATR spectroscopy and XRD. Figure 11a presents FTIR-ATR spectra obtained on Zn-5Al in air and low CO₂ atmosphere while reference spectra for Zn and Zn-Al compounds are shown in Figure 11b. In air, the main corrosion products on these coatings are zinc hydroxy chloride, Zn₅(OH)₈Cl₂·H₂O (Simonkolleite,
SC), which have three characteristic IR-bands at 715, 905 and 1041 cm$^{-1}$ and zinc hydroxy carbonate, Zn$_5$(OH)$_6$(CO$_3$)$_2$ (HC), with carbonate bands at 830, 1384 and 1500 cm$^{-1}$. ZnO is a large component in low CO$_2$ conditions, which has a single band with a maximum at 373 cm$^{-1}$ in the FTIR-ATR spectra. On Zn-5Al, layered double hydroxide (LDH), Zn$_3$Al(OH)$_8$(CO$_3$)$_{1/2}$·xH$_2$O (ZA) was also present in low CO$_2$ conditions, as inferred from both XRD and FTIR-spectra, which have a characteristic band at 1360 cm$^{-1}$ due to carbonate ions. However, it cannot be ruled out that small amounts of this compound are formed also on Zn-0.2Al. These results are consistent with previous results for Zn-0.2Al and ZM coatings in low CO$_2$ conditions were ZnO was a main corrosion product on both coatings and with

![Figure 3. Cross-section SEM images of Zn-55Al including EDX analysis.](image)

![Figure 4. Surface SEM images (left) of Zn-0.7Al (a), Zn-22Al (b) and Zn-68Al (c) and XRD diagrams (right).](image)

![Figure 5. Influence of CO$_2$ on the mass loss of metallic coated steel (a) and Zn-Al cast binary alloys (b) after 4 weeks of exposure at 20°C and 90% R.H in presence of 2 g/m$^2$ Cl$^-$. The ratio of mass loss low CO$_2$/Air is indicated.](image)
Photograph of surface pH from WRI containing agar on corroded Zn-0.2Al, Zn-5Al and Zn-55Al metallic coating after 4 weeks exposure in low CO₂ conditions at 20°C and 90% R.H. with 2 g/m² Cl⁻. The pH is given by the color scale. The white mark is 10 mm.

The formation of Zn-Al LDH on ZM.28 The formation of ZnO and Zn-Al LDH is connected with the high pH on the surface electrolyte on Zn-0.2Al and Zn-5Al when the CO₂-content is low. The formation of LDH also indicates that aluminum is dissolved. The results of the FTIR and XRD analysis for Zn-0.2Al and Zn-5Al coatings are summarized in Tables I and IV, respectively.

FTIR spectra obtained on Zn-55Al surface after exposure in normal and low CO₂ conditions are shown in Figure 12. The assignments of the spectra were based on reference spectra in Figure 11b and from spectra published in the literature.36,37 The spectra show clearly the presence of NaAl(OH)₂CO₃ (dawsonite, DW) with characteristic bands at 1390 and 1570 cm⁻¹ as well as the typical stretching band of OH around 3300 cm⁻¹ for this compound. Both zinc hydroxy chloride, SC, and zinc hydroxy carbonate, HC are zinc corrosion products which are present both in air and in low CO₂ conditions. There are also the Al-based corrosion products which were detected by FTIR spectroscopy such as aluminum hydroxide gel containing carbonate, Al(OH)₃·(CO₃)₃ (AC) or aluminum hydroxyl chloride, Al(OH)₃·(Cl)₃ (ACl), the latter mainly in low CO₂ conditions. These have typically FTIR spectra with very broad bands due to hydroxyl groups and water in the gel-like structure of these compounds. Similar spectra have been observed for aluminum in connection with filiform corrosion on aluminum.37 There are no distinct differences observed between samples exposed in air and in low CO₂ conditions as seen from the FTIR and XRD results in Tables III and IV. The XRD and FTIR results also indicate that some Zn₃Al(OH)₆(CO₃)₁₂·xH₂O might have been formed.

**Discussion**

The results obtained by weight loss on Zn-0.2Al and Zn-5Al are consistent with previous results and highlight the importance of CO₂ in the formation of protective corrosion products on Zn.28 It should be noticed that uniform corrosion was observed for both coatings in low CO₂ conditions, due to the presence of only the η-Zn phase for Zn-0.2Al and, a very fine microstructure and a large amount of zinc grains at the surface for the Zn-5Al as displayed in Figures 1 and 2. The results obtained on Zn-0.2Al are fully consistent with those obtained on the pure η-Zn phase. Hence, the results clearly indicate that the corrosion of zinc is enhanced in depleted CO₂ environments compared to air exposure. This is linked to the increase of the surface pH as shown in Figure 7 with the formation of ZnO. The formation of different corrosion products is related to the solubility of the products, which is dependent on parameters such as

![Figure 6](image1)

![Figure 7](image2)

![Figure 8](image3)
**Figure 9.** SEM cross section of Zn-5Al (a, b) and Zn-55Al (c, d) coated steel after 4 weeks exposure at 20°C and 90% R.H. in air (a, c) and in low CO₂ conditions (b, d) in presence of 2 g/m² Cl⁻. The corrosion products are in dark color as shown in a).

**Figure 10.** EDX maps of a cross-section of corroded Zn-55Al in low CO₂ atmosphere shown in Figure 8d.
**Figure 11.** FTIR-ATR spectra corrosion products from Zn-5Al after exposure in low CO2 conditions, in air and spectrum of corrosion product in low CO2 conditions subtracted by the reference spectrum of Zn5(OH)8Cl2·H2O (a). FTIR-ATR reference spectra of SC: Zn5(OH)8Cl2·H2O, ZA: Zn3Al(OH)8(CO3)1/2·xH2O, HC: Zn5(OH)6(CO3)2, and ZnO (b). * artifact from Si ATR element.

The formation of ZnO is favored at high pH values and low CO2 content, while Zn5(OH)8Cl2·H2O is formed at higher CO2 content. It is known that the formation of ZnO is favored at high pH values and low CO2 content, while Zn5(OH)8Cl2·H2O is formed at higher CO2 content. It was the lowest in moderately basic pH and increased at both low and high pH values. Solubility experiments indicated that optimum conditions for the formation of dawsonite, NaAl(OH)2CO3, is moderately basic solutions. It was the lowest in moderately basic pH and increased at both low and high pH values. Solubility experiments indicated that optimum conditions for the formation of dawsonite, NaAl(OH)2CO3, is moderately basic solutions. It was the lowest in moderately basic pH and increased at both low and high pH values. Solubility experiments indicated that optimum conditions for the formation of dawsonite, NaAl(OH)2CO3, is moderately basic solutions. It was the lowest in moderately basic pH and increased at both low and high pH values. Solubility experiments indicated that optimum conditions for the formation of dawsonite, NaAl(OH)2CO3, is moderately basic solutions. It was the lowest in moderately basic pH and increased at both low and high pH values. Solubility experiments indicated that optimum conditions for the formation of dawsonite, NaAl(OH)2CO3, is moderately basic solutions.
leading to an increase in the surface electrolyte pH. The pH increase promotes the formation of ZnO on the surface. The ZnO surfaces can be sites for the oxygen reduction reaction which can lead to higher corrosion rates for the samples exposed in low CO₂ conditions. For Zn-5Al, the results are similar to Zn-0.2Al. In addition, the pH increase will dissolve Al-oxide and thus release aluminate ions. Further dissolution of Al at high pH conditions leads to more aluminate which reacts with Zn²⁺ ions and form Zn-Al LDH as shown in Figure 13b.

As shown in Figure 9, the corrosion of Zn-55Al remained localized both in air and in low CO₂ environments with a preferential dissolution of the zinc rich phase. From the micrographs of Figure
Table III. Major compounds identified by FTIR spectroscopy in the corrosion products formed on Zn-0.2Al, Zn-5Al and Zn-55Al in air and low CO2 conditions.

| Zn-Al coating | Exposition conditions | Detected phase |
|---------------|-----------------------|----------------|
| Zn-0.2Al      | Low CO2               | Zn5(OH)6(CO3)2 · H2O, Zn5(OH)8Cl2 · xH2O, Zn5(OH)6(CO3)2 · xH2O |
|               | Air                   | Zn5(OH)6(CO3)2 · H2O, Zn5(OH)8Cl2 · xH2O, Zn5(OH)6(CO3)2 · xH2O |
| Zn-5Al        | Low CO2               | Zn5(OH)6(CO3)2 · H2O, Zn5(OH)8Cl2 · xH2O, Zn5(OH)6(CO3)2 · xH2O |
|               | Air                   | Zn5(OH)6(CO3)2 · H2O, Zn5(OH)8Cl2 · xH2O, Zn5(OH)6(CO3)2 · xH2O |
| Zn-55Al       | Low CO2               | NaAl(OH)2CO3, Al(OH)3 · xH2O, NaAl(OH)2CO3, Al(OH)3 · xH2O |
|               | Air                   | NaAl(OH)2CO3, Al(OH)3 · xH2O, NaAl(OH)2CO3, Al(OH)3 · xH2O |

*Maybe unknown carbonate compound.
**AI hydroxide gel.

9, the surface of the corroded area was estimated by image analyses, representing about 10 and 40% after exposure in air and in depleted CO2 environments, respectively. This indicates that a 4X increase in corrosion rate was observed in low CO2 environments, a value close to that observed for Zn-5Al under the same conditions. In addition, converting the corroded area measured from Zn-55Al cross section of Figure 9 to a uniform corrosion gives about 2.2 μm and 7.7 μm in air and in low CO2 environments, respectively. This clearly indicates that the corrosion of the zinc phase is initially at the same rate as that measured for the η-Zn phase in air. However, in depleted CO2 conditions, a higher rate was observed for Zn-55Al compared to the η-Zn phase indicating that the aluminum phase is linked to the increase of the corrosion rate compared to pure zinc or to the η-Zn phase. A similar effect was observed for Zn-5Al and ZM.25 This seems to indicate that the aluminum phase acts as the cathode and the zinc rich phase as the anode as suggested by Zhang and co-workers,26 resulting in a higher dissolution of the zinc rich phase in low CO2 environment. A similar mechanism is expected for Zn-5Al with the β-Al phase being more noble than the η-Zn phase. From the results obtained above and the nature of the corrosion products, some mechanisms of corrosion are proposed for Zn-55Al in Figure 13c. It is suggested that dissolution of both Zn and Al occurs at the anodic areas, which are located mainly at the zinc rich phases on the coating. Ramus Moreira et al. identified two different phases in the interdendritic areas, one of the phases is aluminum-rich containing zinc while the other is zinc-rich containing aluminum.25 It was concluded that the atmospheric corrosion process begins in an aluminum rich phase present in the interdendritic areas. As indicated in Figure 3, the Al content measured by SEM-EDS in zinc rich phase ranges between 3% up to 29% at some locations such as close to the surface. Thus, Al1+ ions can be dissolved as a result of anodic dissolution of interdendritic phases. Hydrolysis of Al1+ ions in the anodic areas leads to the release of hydronium ions. This lowers the pH in the surface electrolyte. Further hydrolysis of the Al1+ ions leads to the formation of aluminum hydroxide gels containing carbonate or chloride as well as more well defined compounds such as dawsonite, NaAl(OH)2CO3. The Zn2+ ions combine with hydroxide ions and chloride ions resulting in the formation of Zn(OH)2Cl, H2O and some Zn2(OH)6Cl2. Small amounts of Zn-Al LDH are formed by reaction of Zn2+ and Al1+ with hydroxyl and carbonate ions. The hydrolysis of the Al3+ ions formed in the anodic process leads to an overall lowering of the pH of the surface electrolyte, as observed experimentally. In this case, the alkalinization of the surface electrolyte at low CO2 contents is small, due to the strong acidification effect of the Al3+ ions.

As seen from the SEM micrographs in Figure 9 and the EDX maps of Figure 10, the zinc rich interdendritic areas are preferentially attacked, which leads to the anodic dissolution of this phase and formation of Zn2+ and Al3+ ions. The Al-rich phases are quite unattacked and are probably passivated. This is well in line with the results obtained for the pure phase of Zn-68Al showing low mass loss and uniform corrosion. Since the pH could not increase due to the acidification by Al3+ ions, cathodic dissolution of Al could not occur in this case. It should be mentioned that the conditions during field exposure differs from the laboratory conditions in this work and that the mechanism suggested here may not be fully applicable to material exposed in real field conditions.

Finally, it should be pointed that for coatings displaying a complex microstructure, weight loss is not accurate to determine the corrosion rate as the corrosion occurs mostly at one of the phases. Hence, in those cases, only cross sections after exposure can reveal the exact corrosion behavior of the coating.

Conclusions

The influence of CO2 concentration on the atmospheric corrosion of hot dip Zn-0.2Al, Zn-5Al and Zn-55Al coated steel in presence of NaCl was investigated at 20°C and 90% R.H. The following conclusions were drawn:

- Zn-0.2Al and Zn-5Al coated steel showed an increase of the uniform corrosion in depleted CO2 environments compared to exposure at normal CO2 concentration.
- The increase in the corrosion for Zn-5Al was significantly higher in low CO2 environments than that measured for Zn-0.2Al coating.
- In the case of Zn-55Al, the corrosion was highly localized with a preferential attack of the zinc rich interdendritic areas, the Al-rich phases being quite unattacked and probably passivated. The corrosion rate of the zinc rich interdendritic phase was higher in low CO2 environments.

Table IV. Major compounds identified by XRD in the corrosion products formed on Zn-0.2Al, Zn-5Al and Zn-55Al in air and low CO2 conditions.

| Zn-Al coating | Exposition conditions | Detected phase |
|---------------|-----------------------|----------------|
| Zn-0.2Al      | Low CO2               | Zn5(OH)6(Cl2) · H2O, Zn5(OH)8(Cl2) · xH2O |
|               | Air                   | Zn5(OH)6(Cl2) · H2O, Zn5(OH)8(Cl2) · xH2O |
| Zn-5Al        | Low CO2               | Zn5(OH)6(Cl2) · H2O, Zn5(OH)8(Cl2) · xH2O, Zn5(OH)6(Cl2) · xH2O |
|               | Air                   | Zn5(OH)6(Cl2) · H2O, Zn5(OH)8(Cl2) · xH2O, Zn5(OH)6(Cl2) · xH2O |
| Zn-55Al       | Low CO2               | Zn5(OH)6(Cl2) · H2O, Zn5(OH)8(Cl2) · xH2O, Zn5(OH)6(Cl2) · xH2O |
|               | Air                   | Zn5(OH)6(Cl2) · H2O, Zn5(OH)8(Cl2) · xH2O, Zn5(OH)6(Cl2) · xH2O |

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Different sequences of formation of corrosion products have been proposed for Zn-0.2Al, Zn-5Al and Zn-55Al. For Zn-0.2Al and Zn-5Al, the pH increase in low CO₂ environments promotes the formation of ZnO on the surface resulting in a higher corrosion rate. In the case of Zn-5Al, the pH increase also dissolves Al-oxide resulting in the formation of LDH. In the case of Zn-55Al, the effect of a low CO₂ content is small on the pH, due to the strong acidification effect of Al³⁺ ions.

For coatings displaying a complex microstructure, the average weight loss obtained by gravimetric method after removal of corrosion products by chemical pickling is not accurate to determine the corrosion rate as the corrosion occurs mostly at one of the interfaces.
phase. Hence, in those cases, only cross sections after exposure can reveal the exact corrosion behavior of the coating.

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