3.5 wt.% NaCl로 오염된 콘크리트 기공 용액에서 아크 용사 Al 및 Al/에폭시 이중 금속 고분자 코팅의 내식성 성능

Corrosion resistance performance of arc thermal sprayed Al and Al/epoxy dual metal polymeric coating in 3.5 wt.% NaCl-contaminated concrete pore solution

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Abstract : Corrosion of the steel rebar in coastal environment caused huge economical loss of the globe. Therefore, coating on the steel rebar being used to mitigate the corrosion. In the present study, we have applied epoxy coating on arc thermal sprayed Al coating (a dual metal/polymeric coating) vis-à-vis compared with as coated one (Al coating). The corrosion studies were performed in simulated concrete pore solution with 3.5 wt. % NaCl solution. The morphology of the dual epoxy/Al coating is smooth while Al coating shows rankle and defects. Due to defects, Al coating is susceptible to corrosion while dual epoxy/Al coating has performed excellent compared to as coated one at extended period of immersion.

키워드 : 강재, 부식, 코팅, SEM, EIS.
Keywords : steel, corrosion, coating, SEM, EIS

1. Introduction

Due to corrosion, in the USA alone it cost around $276 billion only for carbon steel. The corrosion is the biggest challenge for the materials scientist. Therefore, it is utmost important to monitor the corrosion in building and infrastructure as well as consider a suitable protective schemes to reduce or mitigate the corrosion. The use of coating, electroplating, hot dip galvanizing and thermal spray [1] are the popular methods for corrosion protection. However, the electroplating is very thin coating, which can not sustain long time in aggressive environment. Since hot dip galvanizing and thermal spray can provide long-term corrosion resistance but they cause embrittlement in the coating when applied on steel rebar and immersed in alkaline condition. Therefore, a polymeric coating is recommended over the metal coating. In the present study, firstly a 100 μm thick Al coating was deposited by arc thermal spray process on steel substrate thereafter an epoxy coating was applied on Al coating. The corrosion resistance properties of Al and dual metal/polymeric coating was assessed in the simulated concrete pore solution contaminated with 3.5 wt.% NaCl solution over the immersion time.

2. Materials and Method

A 1.6 mm diameter twin wires of Al (99.95%) was considered to deposit 100 μm thick coating on plain carbon steel by arc thermal spray process. The coatings were deposited by arc thermal spray process where the twin wires of each metal melted at arcing point and the molten metal particles were propelled by the compressed air and hit the steel substrate resulting deposition of the coatings [2]. An epoxy coating was applied on Al coating to act as barrier and stop the penetration of aggressive ions.

The surface morphology of the coatings was characterized by Scanning Electron Microscopy (SEM). The corrosion performance was assessed in 3.5 wt. % NaCl contaminated concrete pore (CP) solution with immersion periods.

3. Results and Discussion

The surface morphology of the Al and epoxy/Al dual metal polymeric coating is shown in Figure 1(a) and (b), respectively. After

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deposition of the Al coating, it can be clearly seen from Figure 1(a) that rankles are formed on the surface with broken layer. It is attributed to the deposition of semi-molten metal particles during coating process where all Al particles are not properly melt and early deposit on the surface resulting cause the defects in the coating. To reduce the defects and porosity of the coating, a barrier layer of epoxide on the Al coating is applied and the morphology of this dual epoxy/Al coating is shown in Figure 1(b). After application of epoxide, the coating is smooth. The corrosion resistance properties of the coating is assessed in CP solution and the results are shown in Figure 1(c). It is very interesting to see the total impedance plots of the coating in CP solution that epoxy/Al dual coating exhibits around 700 times higher impedance compared to Al coating after 1 d of exposure. It is attributed to the epoxide, which act as barrier for penetration of aggressive ions. However, it is decreased as the immersion periods increased due to presence of nano-sized pores in the coating, which allow to penetrate the smaller size Cl- ions and cause the corrosion. Alternatively, in the case of Al coating, it is increased with time and again decrease after 27 days of immersion might be attributed to the formation of unstable corrosion products. Although, again the total impedance of dual epoxy/Al coating is increased after 20 days of immersion due to filling of nano pores by the corrosion products formed at epoxide/Al coating interface.

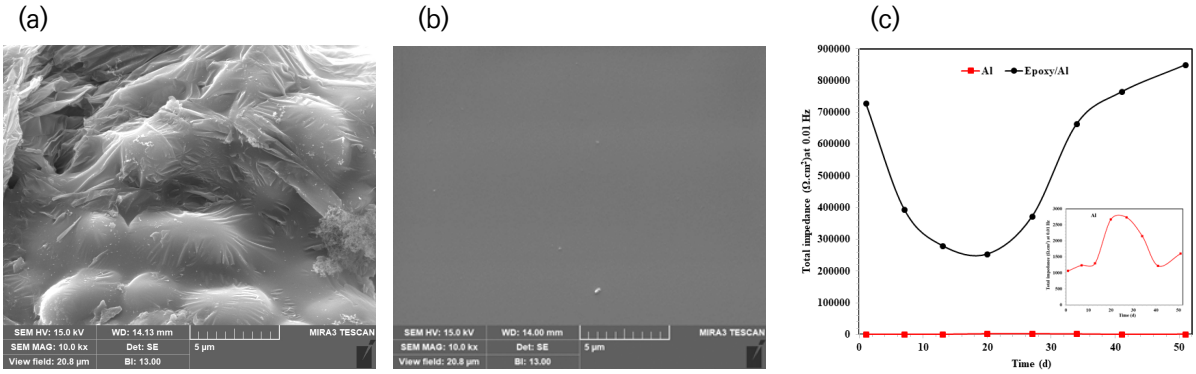

Figure 1. SEM of (a) Al, (b) Epoxy/Al dual metal polymeric coating, and (c) total impedance of coatings immersed in CP solution

4. Conclusions

The dual epoxy/Al coating exhibits smooth and uniform morphology while Al coating shows rankle and broken layer of coating, which cause the corrosion. Therefore, Al coating exhibit very less impedance but it is increased as the duration extended until 27 day due to formation of corrosion products but it again decreased caused by presence of loose, porous and unstable corrosion products. Initially dual epoxy/Al coating exhibits around 700 times higher impedance attributed to the barrier protection caused by epoxide. But it is decreased until 20 d and again increased caused by self filling ability of the corrosion products at epoxide/Al coating interface.

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