CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Epoxy systems composed of epoxy/m-XDA were proven to be effective in providing protection to the carbon steel. However, results have shown that better corrosion protections were achieved when adding an appropriate amount of Polyaniline to the epoxy/m-XDA systems compared to the epoxy systems without the addition of PANI.

In this study, epoxy systems with 0.5 wt.% of PANI were determined to be the most effective systems by means of providing protection to the steels from corroding. This is probably because of the miscibility of polyaniline in the epoxy mixture. It is assumed that when higher amount of polyaniline is used in the epoxy, polyaniline became immiscible, phase separation occurred. Therefore, lower PANI loaded coatings provided better corrosion protection towards the substrate than higher PANI loaded coatings. Curing temperature also plays an important role in which samples that are fully cured have been proven to be providing better thermal and inhibition properties than samples that are partially cured. Basically, epoxy systems which were fully cured (curing at 120°c) provided better corrosion protection than epoxy systems that were cured at room temperature.

Generally, within the range of PANI concentration studied, the addition of PANI has increased the Tg in which this restricts the movements of chain. Therefore, no plasticizers effects were observed. However, as the concentration of PANI is increased, Tg dropped but still higher than the unmodified epoxy. It is due to the similar structure of PANI to epoxy in which the molecules were more miscible at low content. These findings are in agreement with the results obtained from the corrosion analysis test: salt spray test, pull-off test, water absorption test, impedance measurement (EIS).

The impedance measurement also confirmed that coating system with 0.5 %PANI/epoxy was the most effective system compared to other coating systems in which it produced the highest coating resistance, Rp, the lowest coating capacitance, Cc, the highest charge transfer, Rct, the lowest double layer capacitance, Cdl and the lowest corrosion rate after 30 days immersion in 3% NaCl. All the coatings exhibit corrosion stability for the first 15 days of immersion time but started to degrade for the next 15 days. Although corrosion have initiated at all the samples and the corrosion rates increased after 30 days of exposure to the environment (NaCl), it can be claimed that the coating systems are stable towards corrosion as the corrosion rates were small ($x10^{-9}$ Ω).

In addition, all corrosion analysis results were found to be in correlation with the EIS results. This proves that not only EIS but other corrosion analysis tests are also reliable methods in predicting the corrosion behavior of the substrates.

Finally, it can be concluded that the application of PANI as one-coat systems were reliable towards protecting metals from corrosion though no other layer (secondary, top coat) were applied.

5.2 Recommendation

The cleanliness of the metal surface is one of the most critical factors in determining the durability of the coating. Cleanliness refers to the degree of which rusts, mill scales, surface debris and others have been removed. Since most of the cleaning methods will result in the increase of cost, only standard procedure of surface cleaning (grinding) was implemented for the current work. It is recommended that other surface cleaning and treatments will be implemented in future works, for instance: blasting, acid pickling, surface pre-treatment using phosphates and others.

It has been stated by many researchers that different dopants (phosphoric acid, sulfonic acid) used in synthesizing Polyaniline will result in different performance of the coatings in protecting the metal substrates from corrosion. In this current work, PANI purchased was doped with sulfonic acid Therefore, it is recommended that PANI is synthesized (not purchased) and different dopants will be used to determine the effects of each dopant.

Other than that, different types of epoxy and hardener could also influence the coating properties thus affecting the corrosion inhibition properties. In this work, the epoxy resin used was based on diglycidyl ether of bisphenol A and amine. Different combination of epoxy and hardener needs to be done in future works to evaluate the effects of epoxy properties towards the corrosion inhibition performance.

In this work, PANI/epoxy coating was applied as one-coat coating system to the metal substrates. No additional layer (secondary or top coat) layers were applied. Since PANI was proven to effectively inhibit corrosion even without the application of other layers, it is suggested that next time, secondary or top coat layers will be applied to the substrates as these combinations of layers may produce better corrosion inhibition properties of the coatings. For instance, Zn-rich coating can be combined with PANI as it is the most commonly used system that was claimed to be effective in preventing corrosion.

In the salt spray test, the delamination of coatings were evaluated by measuring the values of delamination occurred. No further works were done to characterize the delamination and other phenomena (blisters, rusting, etc) in the current study. So, it is suggested that Scanning Acoustic Microscopy (SAM) will be used to characterize the images (particularly blisters, delamination) seen after exposure to the salt spray chamber.