Chapter 7
Developing Deeper Understanding of Green Inhibitors for Corrosion of Reinforcing Steel in Concrete

Mohammad Ismail
Universiti Teknologi Malaysia, Malaysia

Pandian Bothi Raja
Universiti Teknologi Malaysia, Malaysia

Abdulrahman Asipita Salawu
Federal University of Technology, Nigeria

ABSTRACT

Corrosion of reinforcing steel in concrete is a very serious and significant problem in the construction industry. The primary cause of corrosion of reinforcing steel is chloride attack or carbonation. Among several protection measures for concrete corrosion, the usage of corrosion inhibitors is very attractive from the view of cost and ease of application. Though there are numerous organic and inorganic compounds that have been tested and applied industrially as corrosion inhibitors, restrictive environmental regulations have compelled and motivated researchers towards the development of cheap, non-toxic and environmentally benign natural or green corrosion inhibitors. Recent studies on green inhibitors have shown that they are more effective and highly environmentally benign compared to synthetic inhibitors used in the industries. This chapter contributes to developing awareness, understanding and innovative involvement of materials and engineering students in this area that is vital to reduce expenditure related to corrosion problems when they serve in the industries.

INTRODUCTION

The development and building of large concrete structures for offshore oil and gas production in the 1970s had led to increased attention on corrosion of steel reinforcement. Worldwide, reinforced concrete is the most durable, versatile, and widely used construction material which has a wide range of applications from making small posts to vast bridges and tall buildings. The corrosion of reinforcing steel has the same basis as any other steel, but in this case, the occurrence of corrosion is associated with concrete. Thus, it is essential to consider the concrete's properties as well.

Concrete is a composite material which mainly consists of Cement, Aggregate (Fine and Coarse) and Water. Additionally, other materials called admixtures may be added to modify the properties of the concrete. Ordinary concrete is good in compressive strength but weak in tensile, flexural or shear forces. In addition, all concrete structures suffer from volume changes resulting from shrinkage, creep and thermal changes, producing cracks that are detrimental to the performance of the structure. To impart ductility to structures, ordinary concrete is reinforced with high tensile material such as steel. Steel in concrete is protected from corrosion by passivation, due to high alkalinity of concrete. However, one of the huge challenges facing the concrete industry is the corrosion of reinforcing bars in concrete. Over time, reinforcing steel bars may undergo various types of degradation or corrosion depending on composition, structure and the environment.

The content of this chapter can be used for developing deeper understanding by Materials Science and Engineering (MSE) students on various aspects of corrosion of reinforcement in concrete. The discussion starts with the mechanism of corrosion, followed by corrosion testing and corrosion protection using inhibitor. The emphasis placed on green corrosion inhibitors for reinforcement protection is in line with the current educational and industry trends towards sustainable development.

BACKGROUND

In general, corrosion does not damage the concrete structures. The reason is that the pores in concrete contain high levels of calcium, sodium, and potassium hydroxide, which maintain a pH between 12 and 13. This high level of alkalinity passivates the steel inside the concrete, forming a dense gamma ferric oxide ($\gamma-Fe_2O_3.H_2O$) that is self-maintaining which prevents rapid corrosion. But, since concrete is porous, both moisture and oxygen can easily penetrate through the pores and micro cracks in the concrete which subsequently create the basic requirements for corrosion of reinforcing steels.

Corrosion issues on reinforcing steel in concrete have significance in both structural integrity and in economic aspects. Corrosion can cause potholes, spalls, and delamination of reinforced highway structures such as bridge decks. Parking garages and support pillars also face damage because automobiles carry salt-bearing snow and ice through the garages, which melt further and permit aggressive chloride ions to permeate through the concrete. Similarly, coastal structures are subjected to corrosion when exposed to seawater containing high amounts of chloride.

A survey in the United States revealed that the cost of damage due to deicing salts alone is estimated between \$325 to \$1,000 million / year for reinforced concrete bridges and car parks. In North Africa, near coastal zones, and in the Middle East Arabian Gulf area, a few buildings were completely destroyed due to deterioration of the structures as a result of corrosion of reinforced concrete (El – Reedy, 2008). The cost can be considerably reduced by mitigating the

Related Content

Visualization Skills in Engineering Education: Issues, Developments, and Enhancement

Dayana Farzeeha Ali, Arun Patiland Mohd Safarin Nordin (2012). *New Media Communication Skills for Engineers and IT Professionals: Trans-National and Trans-Cultural Demands (pp. 175-203).*

www.irma-international.org/chapter/visualization-skills-engineering-education/64013

Strategies to Remove Barriers and Increase Motivation to Use the Tablet PC in Formative Assessment

Antony Dekkers, Prue Howard, Nadine Adamsand Fae Martin (2015). *International Journal of Quality Assurance in Engineering and Technology Education (pp. 44-55).*

www.irma-international.org/article/strategies-to-remove-barriers-and-increase-motivation-to-use-the-tablet-pc-in-formative-assessment/147416

Math-Related Problems in Russian Engineering Education: Possible Solutions Based on Best Practices in European and Russian Universities

Ilia Soldatenko, Irina Zakharova, Oleg Kuzenkovand Alexander Yazenin (2019). *Handbook of Research on Engineering Education in a Global Context (pp. 166-175).*

www.irma-international.org/chapter/math-related-problems-in-russian-engineering-education/210317

Teaching with a Tablet PC

Matthew Joordens (2016). *International Journal of Quality Assurance in Engineering and Technology Education (pp. 1-15).*

www.irma-international.org/article/teaching-with-a-tablet-pc/173760

Qualification Frameworks and Field-specific Approaches to Quality Assurance: Initiatives in Engineering and Technical Education

Giuliano Augustiand Sebastião Feyo de Azevedo (2011). *International Journal of Quality Assurance in Engineering and Technology Education (pp. 44-57).*

www.irma-international.org/article/qualification-frameworks-field-specific-approaches/49559