Investigation of a novel self-immunity system in cementitious materials with calcium oxide microcapsules

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Keywords: cementitious materials; microcapsules; self-immubity system; smart release; PH adjustment

Abstract ID No : 45

ABSTRACT

This paper presents work toward the studying of a new family of self-immunity material that hold promise for cementitious material, expecially for reinfrocement concrete. This innovative material features the design of chemical self-immunity system for preventing the steel corrosion in reinforcement concrete. A novel type of microcapsule was successfully synthesized, which is feature with calcium oxide as the healing agent. The aim of this research is to study the releasing behavior of microcapsule and the PH regulating process of self-immunity system. In the research, the simulated solution was designed carefully for studying the releasing behavior of healing agent and regulating procedure of alkaline environment. The releasing behavior of microcapsule was characterized by the SEM (Scanning Electron Microscope) and EDX (Energy Dispersive X-ray Analysis). The regulating process of alkaline environment was monitored by means of digital PH-meter. The experimental results show that the releasing rate of healing agent increases as the decrease of alkalinity; the microapsule based chemical self-immunity system can smartly adjust and control the alkaline environment of simulated concrete solution which is exposed to a natural carbonization encironment.

1. INTRODUCTION

Steel in cementitious material (e.g. concrete) is protected from corrosion by passive film which is formed under a high alkali environment. However, the passive film will be broken when the PH value is lower than 10 due to some environmental effect, such as carbonization. The steel corrosion will then start when the film is broken or depassivated. Thus, it is very necessary to develop a novel chemical self-immunity system which is not just sensitive to the alkaline environment of concrete but can adjust and control it. The microcapsule based chemical self-immunity system seems to be a promising solution to adjust and control the alkaline environment for protecting the passive film and embedded steel [1, 2]. In this paper, a novel chemical self-immunity system with microcapsule for reinforcement concrete was designed and studied. The experimental results show that the system can intelligently adjust and control the PH value of simulated solution when it was under different alkaline environment.

2. MATERIALS AND METHODS

A novel kind of microcapsule was designed and synthesized in the research，in which calcium oxide was selected as curing agent. In order to study the releasing behavior of microcapsule, two different simualted alkaline environment (with PH=10 and PH=11, rsepectively) were designed and applied in the research. What more, the PH regulating progress was investigated based on the simulated concrete solution which was exposed to a natural carbonization environment.

SEM (Scanning Electron Microscope) and EDX (Energy Dispersive X-ray Analysis) were used to monitor the releasing behavior of microcapsule in different alkaline environment at different time. The digital PH-meter was applied to monitor the variation of PH value of different simulated concrete solutions (including solution with microcapsules and without microcapsules) at different natural carbonization time.

3. RESULTS AND DISCUSSION

As shown in Fig. 1, microcapsule with calcium oxide was successfully synthesized in this study. It exhibits some favorable physical properties, including rough surface, suitable size, and a good sphericity. These mechanical properties shows that the microcapsules studied in this research satisfy the self-immunity system for reinforcement concrete.

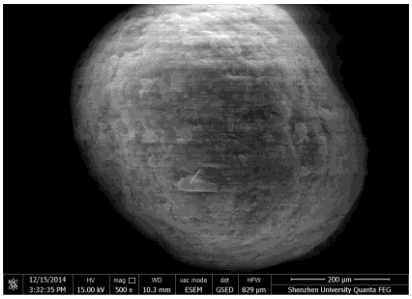

Fig. 1 SEM image of microcapsule

The releasing behavior of microcapsule was successfully analyzed in the research as shown in Fig. 2. The experimental result illustrates that the releasing efficiency of healing agent is increased as time. What more, the releasing rate would be increased with the decrease of PH values. Based on the results, we can make a conclusion that the microcapsule has a sensibility for critical alkaline environment of reinforcement concrete (PH=10). Thus, based on this point, the microcapsules based self-immunity system could releasing healing agent and adjust the chemical environment according different alkaline condition within concrete or other cementitious materials.

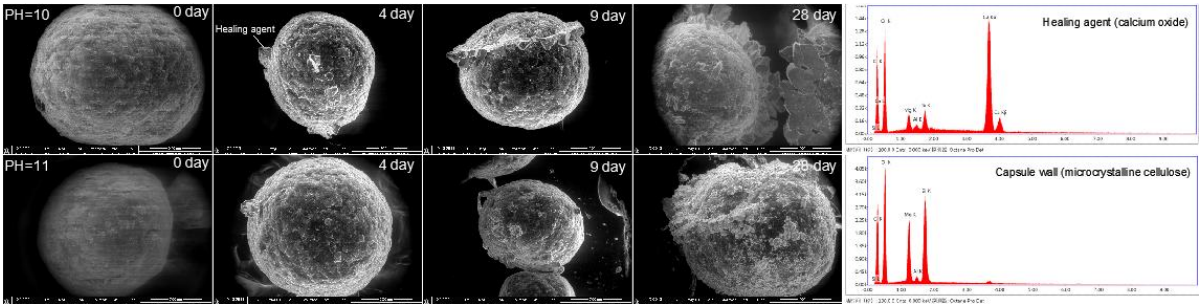

Fig. 2 SEM/EDX result of microcapsules at different time in different simulated solutions

Theoratically, the PH value of the simulated concrete solution would keep reducing until the level of neutralization (i.e. PH=7.0) under the natural carbonization environment. As shown in Fig. 3, the PH of simulated concrete solution without microcapsule has a similar reducing trend as the theoratical result. However, the simulated solution with microcapsule (chemical self-immunity solution) shows different developing trend. Initially, its PH value was also decreased as time just like the control solution. However, the reducting rate of PH value become much slower when it reach the critical alkaline level between 10 and 11. This is because the microcapsules began to release and adjust the PH value of solution. Furthermore, with the release of healing agent, the PH value of simulated solution has become stable and has an increasing trend with the increase of time. The expermental results show us that the self-immunity can automatically adjust the PH value of simulated solution. In other words, this microcapsules based chemical self-immunity system can automatically adjust and control the chemical environment of reinforcement concrete to protect the passive film and prevent the corrosion of embedded steel. However, the further study must be carried out in the real environment of reinforcement concrete or other cementitious materials.

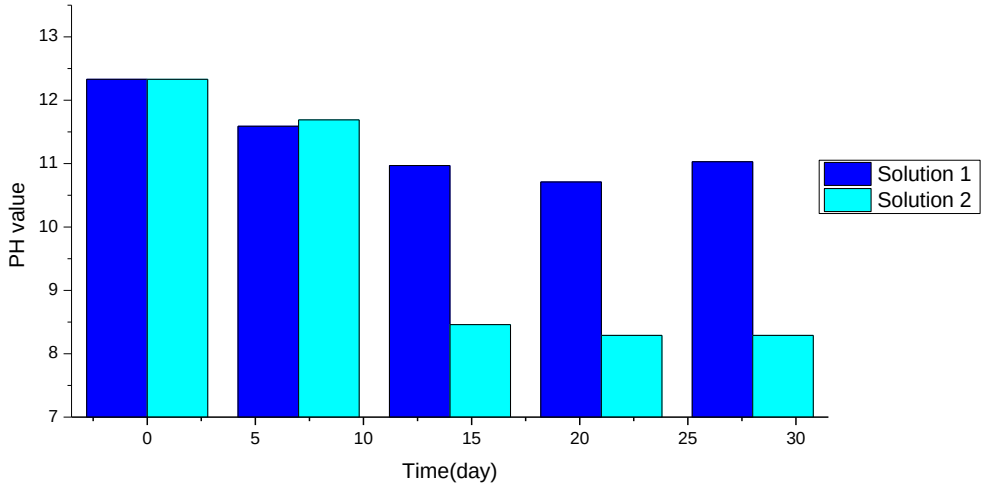

Fig. 3 The variation of PH value of different simulated solution at different carbonization time
(Solution 1 = simulated solution with microcapsules; Solution 2 = simulated solution without microcapsules)

4. CONCLUSIONS

A new family of chemical self-immunity system with special microcapsule was successfully designed and studied in the research. The microcapsule can smartly release in different alkaline simulated solution and automatically adjust the releasing rate under different alkaline environments. What more, the self-immunity system can automatically adjust and control the PH value of simulated concrete solution under natural carbonization encironment. It shows us that the chemical self-immunity system has a strong potential value, which can be chosen as a smart protecting measure to prevent steel corrosion in reinforcement concrete or other cementitious materials.

ACKNOWLEDGEMENTS

The authors would like to acknowledge financial support provided by National Natural Science Foundation of China (No.51120185002/51272160/U1301241); Natural Science Foundation of Guangdong Province (No. S2013010013089) and Collaborative Innovation Center for Advanced Civil Engineering Materials, Nanjing, P. R. China.

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