The application of chloride ions trigger capsules in cementitious matrials

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ABSTRACT
We have successfully fabricated smart chloride ions responsive capsules with the narrow size distribution, and the diameter is 2.5mm. The capsules can be responsive to different concentrations of chloride ions. The capsules responsive behavior in concrete will be studied with the characterization of X-ray computed tomography (XCT).

1. INTRODUCTION

In 2001 year, S. R. White and his co-workers introduced microcapsules into the healing of polymer matrixes[1], the healing microcapsules are broken by mechanical strength when cracks appear, especially in the healing of cementitious matrials. However, these mechanical trigger capsules cannot make a satisfactory work when embedded into concrete to protect the reinforcement from being induced corroded by chloride ion. Because when cracks form, it is not possible to make sure all capsules will be broken for the wall materials and the interface between capsules and matrix properties, so this will show low healing efficiency. Moreover, chloride ions can spread through many nano-channels existed in the concrete matrix without significant cracks, when the reinforced concrete has been corroded, maybe the capsules still do not begin to work.

2. MATERIALS AND METHODS

2.1 Materials

Sodium alginate was purchased from Qing Dao Hai Zhilin chemical corporation (viscosity, 100mpa·s). $AgNO_3$ (Aladdin-reagent, Shanghai, China) is the solid agent. NaCl (Tianjin Chemical Plant, China) is the trigger agent. Methyl methacrylate (Aladdin-reagent, Shanghai, China) is the oil core. Sodium dodecyl benzene sulfonate (Tianjin Chemical Plant, China) is the emulsifier. All materials are analytical pure.

2.2 Concrete specimen embedded with capsules

10 g cement was added 4g water, the ratio of water to cement is 0.4. The slurry was added 1g (10wt% of cement) Ag-alginate capsules. After 7days, one concrete specimen was tested by X-ray CT, the other concrete specimen was soaked into 20wt% NaCl (high concentration of NaCl is adopted for saving experiment time) solution for 15days, and then the soaked specimen was tested by X-ray CT.

3. RESULTS AND DISCUSSION

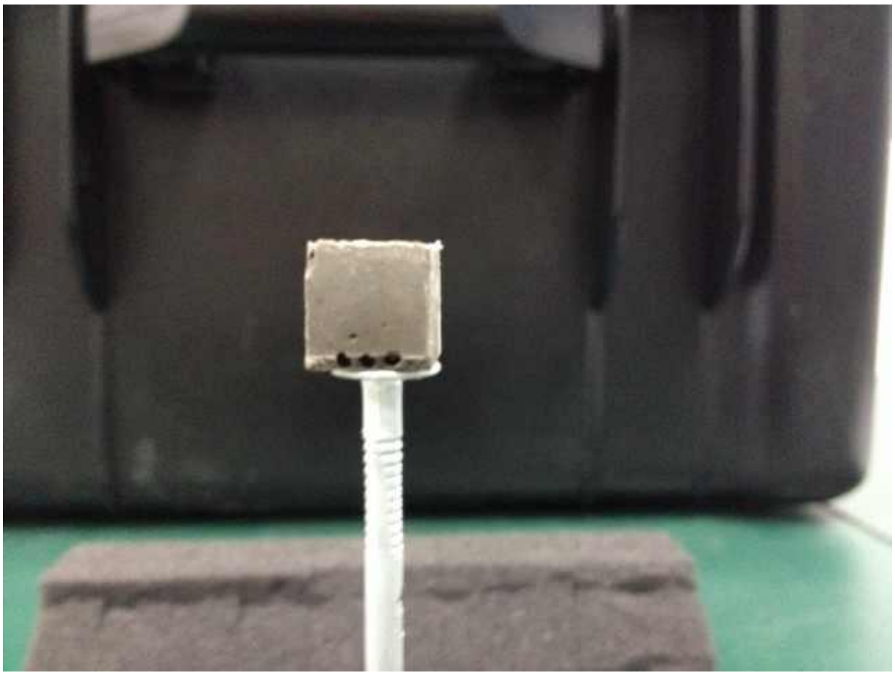

Fig.1 The concrete specimen embedded with Cl^-- responsive Ag-alg capsules

X-ray computed tomography (X-ray CT) is a promising non-destructive technique to demonstrate the inner morphology within non-optically transparent materials, moreover, this versatile characterization approach can offer reconstructing modeling of spatial characteristics and volume fraction in 3D[2]. X-ray CT was employed to detect concrete specimen embedded with chloride ions responsive Ag-alg capsules (Figure 1). For much more visualized contrast, Ag-alg capsules were not freeze dried. The Ag-alginate capsules became smaller during the concrete specimen hydrated process for the loss of water molecules in the framework of Ag-alginate hydrogel. Figure 2a shows the concrete specimen embedded with Ag-alginate capsules, but not be soaked with NaCl solution, it is observable to identify the shrinkage hydrogel. Figure 2b was the concrete specimen exposed to chloride ions environment. It is clearly that the capsules near the surface of concrete specimen have disappeared, left with hollow pores. In X-ray CT 3D model, heavy metals like Ag have strong absorbency to X-ray, they look shining in 3D images. Compared with X-ray CT 3D images (Figure 2c and Figure 2d), the capsules near the surface of concrete specimen also have disappeared, the contrast is much more observable.

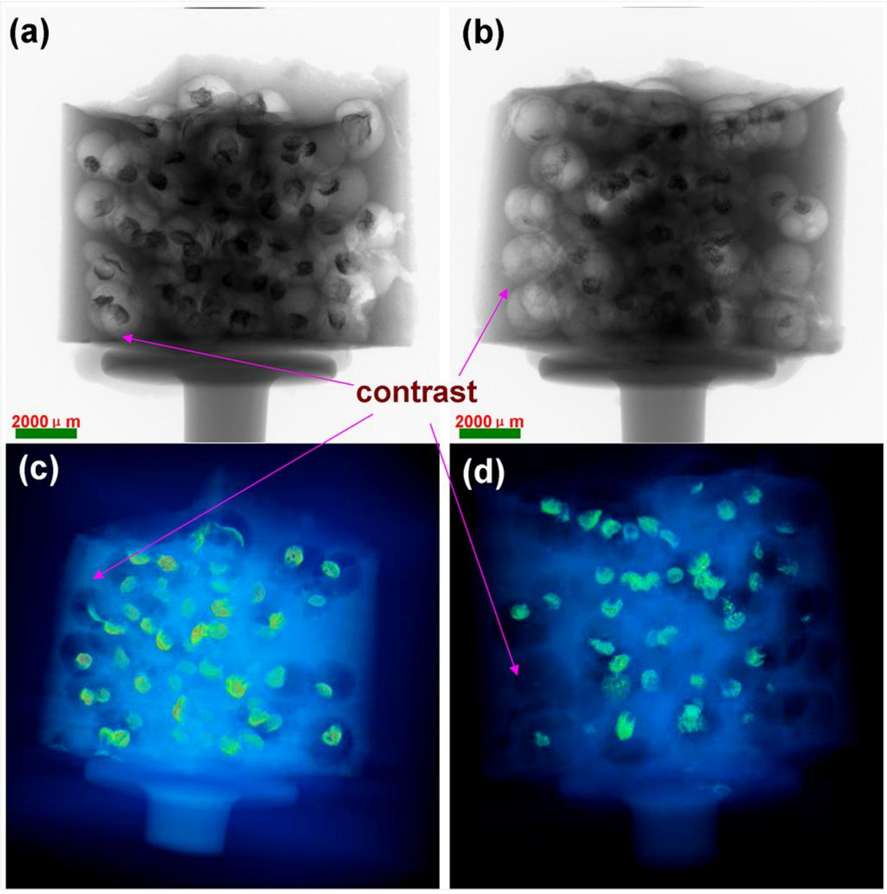

Figure 2: X-ray CT images of: (a) concrete specimen and X-ray CT test specimen in the inset, (b) concrete specimen soaked into NaCl solution; X-ray CT 3D images of: (c) concrete specimen, (d) concrete specimen soaked into NaCl solution

4. CONCLUSION

In summary, we have successfully fabricated smart chloride ions responsive capsules, first introduce them into cementitious materials, and prove the capsules still can be responsive to chloride ions in concrete matrix. This new self-recovery system will reduce deleterious effect of chloride-attack and possesses high broken efficiency and sensitivity advantages. Therefore, we anticipate that this novel self-recovery system will be a promising candidate for building materials and prolong the life of construction and building materials, especially in marine environment.

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