Fabrication and characterization of chloridion-triggered capsules

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Keywords: capsules, trigger, chloride ion, alginate

Abstract ID No : 103

ABSTRACT

In this article, We choose silver alginate (Ag-alg) to form the responsive wall material, the uniform smart chloride ions responsive capsules are successfully fabricated, the size distribution is narrow and the average diameters is around 2.5mm. Optical microscopy (OM) is adopted to characterize the capsules.

1. INTRODUCTION

Microencapsulation as an increasing important technique has been widespread applied in many fields, such as self-healing materials[1-3], drug delivery[4], food preservation[5], phase change materials[6] and fragrance release[7].

Encapsulation technology is a promising candidate for self-healing materials, it can heal some cracks which are difficult to repair due to inaccessibility and the cost is very low. It is believed that this technology will play an important role in automatic healing field. It is well known steel of reinforcement in concrete is prone to be induced corrosion by chloride ions, the direct solution is to mix corrosion inhibitor into concrete structure, unfortunately, during the fabrication process of concrete, much of them will lost. It is a feasible method to embed capsules encapsulated to solve the problem, many literature have reported capsules broken by mechanical strength. However, when cracks appear, it is difficult to make sure all capsules will be broken for the wall materials and the interface between capsules and matrix properties, so the healing efficiency will be not high. Furthermore, chloride ions can spread through

many nano-channels existed in the concrete matrix without significant cracks, when the steel has been corroded, the capsules may still not start to work. So it is necessary to fabricate a kind of capsule which is responsive to chloride ions, to the best of our knowledge, there is no paper to report relative research.

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 Preparation of microcapsules

1.5wt% alginate solution emulsified with methyl methacrylate (MMA) and sodium dodecyl benzene sulfonate (SDBS), MMA is the oil core, SDBS is surfactant, we use a syringe to squeeze the emulsion out drop by drop into solid bath - 1 $mol \cdot L^{-1}$ $AgNO_3$. After 10h, and then to filter the solution to obtain the capsules, washed with deionized water for several times.

3. RESULTS AND DISCUSSION

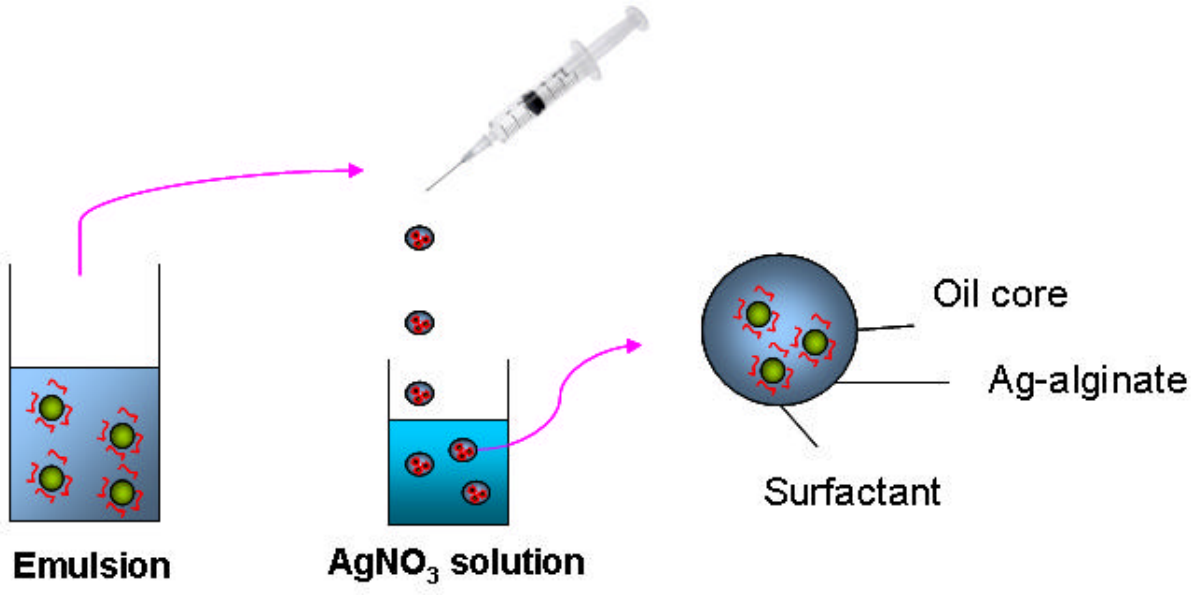

Fig.1 Schematic of Ag-alginate capsules encapsulated oil cores.

A range of methods have utilized to fabricate alginate capsules including microfluid[8], internal gelation[9] and orifice solid bath. In this work, Ag-alginate capsules are fabricated by orifice solid bath method (Figure 1)[10]. This approach is a facile synthesis and low cost technique. We just need to mix core materials with sodium alginate solution, in addition to encapsulating aqueous substances. if the core materials are oil, surfactant is needed, after stirring, a syringe is used to extract the emulsion, and then squeeze the emulsion out drop by drop, the droplets will form capsules gelled by AgNO3 solution, the Ag-alginate capsules with oil cores are fabricated.

Figure 2a shows the images of the Ag-alginate capsules. Figure 2b illustrates the magnified microscopic image of Ag-alginate capsules. The average size of capsules is around 2.5mm. When the Ag-alginate capsules were added several drops of NaCl 3.5wt% (the concentration of NaCl in seawater) aqueous solution, the capsules were collapsed entirely in around 1 minute (Fig. 2c).

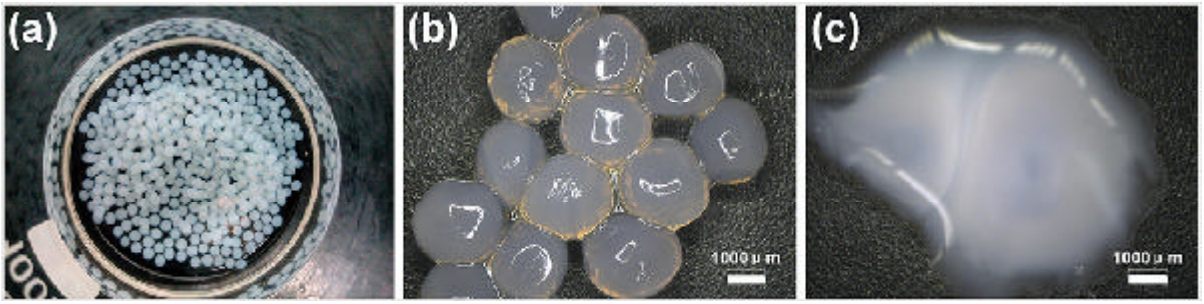

Fig. 2 (a) Ag-alg capsules, (b) Optical image of Ag-alg capsules, (c) disintegrated Ag-alginate capsule when exposed to chloride ions

4. CONCLUSION

In summary, we have successfully fabricated smart chloride ions responsive capsules, the size distribution is narrow and the average diameter is around 2.5mm. We also proved the capsules can be responsive to chloride ions, the capsules were added with 3.5wt% NaCl solution, and the capsules collapsed entirely after about 2 minutes.

ACKNOWLEGDEMENTS

The authors would like to acknowledge financial support provided by National Natural Science Foundation of China (No.51120185002/U1301241), Science and

Technology Project of Shenzhen City (JCYJ20140418091413518), and Collaborative Innovation Center for Advanced Civil Engineering Materials, Nanjing, P. R. China.

REFERENCE

[1] White, S. R. et al. Autonomic healing of polymer composites, Nature 409 (2001) 794-797.

[2] Jin, H. H. et al. Thermally Stable Autonomic Healing in Epoxy using a Dual-Microcapsule System, Advanced Materials 26 (2014) 282-287.

[3] Yuan, Y. C. et al. Self-healing polymeric materials using epoxy/mercaptan as the healant, Macromolecules 41 (2008) 5197-5202.

[4] Abbaspourrad, A., Datta, S. S. & Weitz, D. A. Controlling Release From pH-Responsive Microcapsules, Langmuir 29 (2013) 12697-12702.

[5] Filippidi, E., Patel, A. R., Bouwens, E. C. M., Voudouris, P. & Velikov, K. P. All-Natural Oil-Filled Microcapsules from Water-Insoluble Proteins, Advanced Functional Materials 24 (2014) 5962-5968.

[6] Jin, Z. G., Wang, Y. D., Liu, J. G. & Yang, Z. Z. Synthesis and properties of paraffin capsules as phase change materials, Polymer 49 (2008) 2903-2910.

[7] Hofmeister, I., Landfester, K. & Taden, A. pH-Sensitive Nanocapsules with Barrier Properties: Fragrance Encapsulation and Controlled Release, Macromolecules 47 (2014) 5768-5773.

[8] Yang, C. H. et al. Core-shell structure microcapsules with dual pH-responsive drug release function, Electrophoresis 35 (2014) 2673-2680.

[9] Puguan, J. M. C., Yu, X. H. & Kim, H. Characterization of structure, physico-chemical properties and diffusion behavior of Ca-Alginate gel beads prepared by different gelation methods. J. Colloid Interface Science, 432 (2014) 109-116.

[10] Dowling, M. B., Bagal, A. S. & Raghavan, S. R. Self-Destructing "Mothership" Capsules for Timed Release of Encapsulated Contents, Langmuir 29 (2013) 7993-7998.