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Preparation and characterization of self-healing microcapsules embedding waterborne epoxy resin and curing agent for asphalt materials

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HIGHLIGHTS

- WER and CA microcapsules are well synthesized by interfacial polymerization.
- Optimal synthesis process is determined via SEM, FT-IR, and TG-DSC analysis.
- The microcapsule particles are uniform, well-dispersed and regular in shape.

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ABSTRACT

In this paper study, two kinds of self-healing microcapsules embedding waterborne epoxy resin (WER) and curing agent (CA) are synthesized by using the interfacial polymerization method, which could be incorporated into asphalt binders to prepare the novel self-healing materials and have the potential application to repair the micro-damage and micro-crack in asphalt materials. The two capsule-core materials were emulsified by using different emulsifier dosage and emulsification time, and the normal distribution characteristics of the particle size and quantity were statistically analyzed to determine the optimal emulsification solution. Then, ethylene glycol and toluene diisocyanate (TDI) were selected as the capsule-wall raw materials, and the microcapsules were prepared by using different core-wall materials ratio. The particle dispersion, surface morphology and coating properties were statistically analyzed to determine the optimal synthetization. FT-IR analysis results demonstrated that the microcapsules were successfully prepared by suing those optimized schemes. The optimal synthetization of WER microcapsules that 0.5% emulsifier dosage, emulsification for 16 min, core-wall materials ratio of 1.3:1, and the optimal synthetization of CA microcapsules is that 0.7% emulsifier dosage, emulsification for 16 min, core-wall materials ratio of 1:1. SEM and TG-DSC analysis results showed that the microcapsule particles were uniform, well-dispersed and regular in shape, and the capsule-wall thickness was about 1.0 µm. The thermal stability of the WER microcapsules is better than the CA microcapsules.

1. Introduction

In the process of road service, the long-term effects of traffic load and temperature can easily lead to pavement fatigue damage, resulting in cracks on the road [1–3]. Once the cracks develop, water damage to the road surface will occur under load and rain water [4]. Many studies have found that after the asphalt pavement materials are damaged, it can recover some of its performance after curing for a period of time. This phenomenon of asphalt materials is called self-healing [5,6]. In recent years, in order to improve the life of roads and reduce the cost of later-stage conservation, many scholars have conducted relevant researches on self-healing mechanism, materials selection, and preparation processes [7–9].

Ehsan et al. Prepared polyurethane/urea-formaldehyde (PU/UF) double-walled microcapsules by in-situ polymerization. It was found that the lower the pH, the higher the stirring rate, and the higher the curing temperature is, the more homogeneous the wall [10]. Leyang et al. Prepared PF microcapsules and studied their properties by optical microscopy, SEM and TGA. It was found that the average particle size of microcapsules increases and the wall

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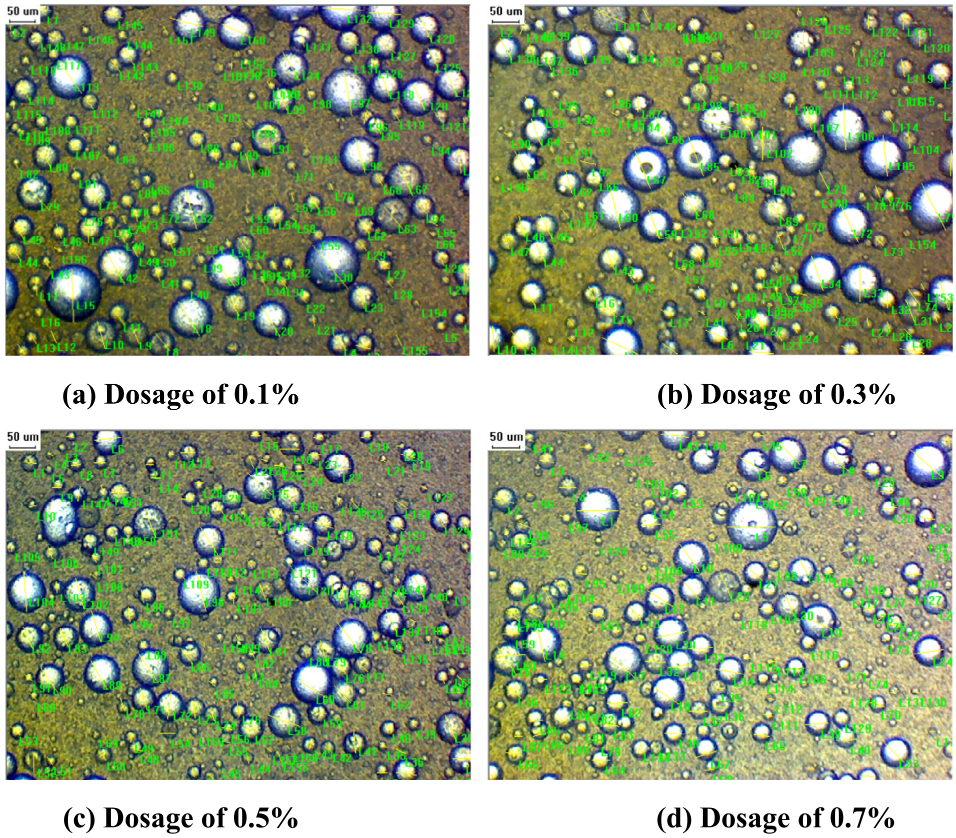

Fig. 1. Data collection of droplet of WER.

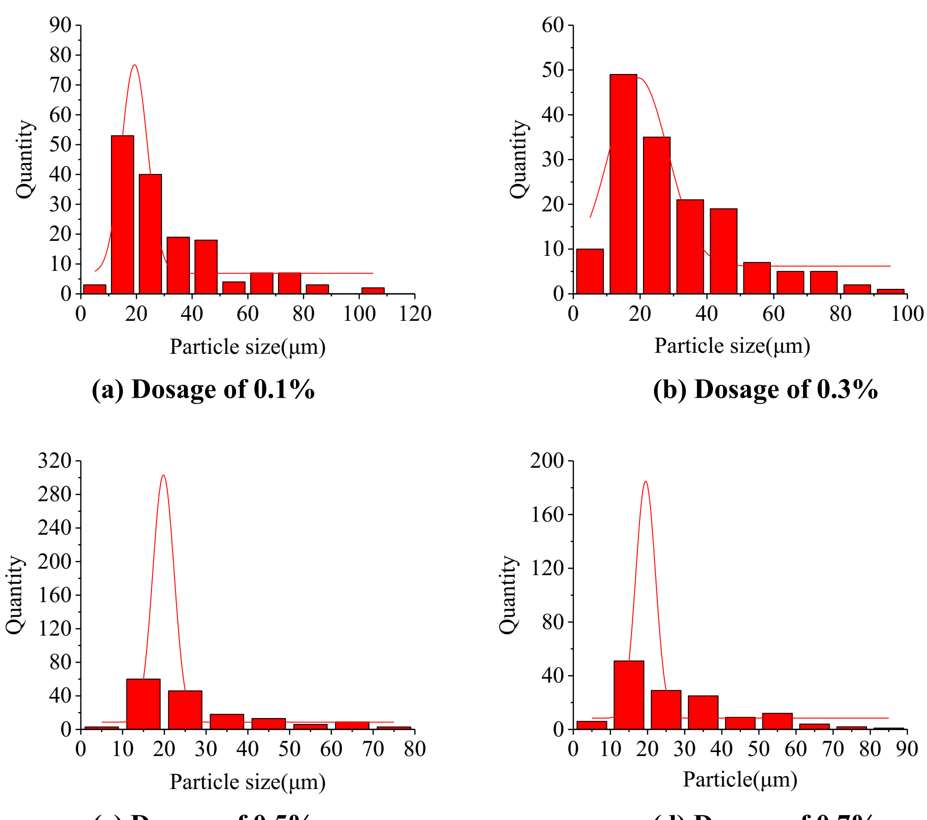

Fig. 2. Particle size distribution of droplet of WER.