Advanced Powder Technology 23 (2012) 845–849

Contents lists available at SciVerse ScienceDirect

Advanced Powder Technology

journal homepage: www.elsevier.com/locate/apt

Original Research Paper

Study on the breaking behavior of self-bursting microcapsules

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ARTICLE INFO

Article history:
Received 8 October 2011
Accepted 27 November 2011
Available online 27 December 2011

Keywords:
Microcapsule
Interfacial polymerization
Polyurethane
Self-bursting

ABSTRACT

We have successfully prepared "self-bursting" microcapsule. The microcapsule retains its shape when suspended in water but breaks open quickly after the water evaporates. In this report, the breaking behavior of MC, which encapsulated insecticide (pyriproxyfen) with polyurethane via an interfacial polymerization method, was studied. In order to investigate the self-bursting phenomenon more detail, we studied the relationships between the self-burst ratio and the self-weight of the microcapsule, capillary force, and critical buckling stress. As a result, it was found that wall thickness affected the self-bursting phenomenon.

1. Introduction

Microcapsules (MCs) are small containers whose wall material is mainly comprised of natural polymers, synthetic polymers, or inorganic compounds [1,2]. Therefore, the core material is protected from the external environment by the wall material. MCs offer a number of other interesting advantages to the cores they encapsulate including their protection, shelf life-enhancement, and controlled release. For this reason, numerous researchers are actively studying MC formulations in the pharmaceutical, printing, agricultural, and food industries [3–15].

In addition, there are numerous methods for preparing MCs such as interfacial polymerization [6], in situ polymerization [7], coacervation [3], and spray-drying [4].

As just described, numerous researchers have taken note of the controlled release of active ingredients (AIs) by microencapsulation. However, many of the studies have primarily concentrated on the slow and "long-duration release" profile of the AIs. For a number of years, we have studied polyurethane MC formulations prepared with interfacial polymerization to improve the residual efficacy, fish toxicity, and safe/convenient handling of AIs [16–18]. Interfacial polymerization is highly suited for microencapsulation [19–22] because of its simplicity, its high loading capacity, and the relative ease with which its scale of production is increased. In a previous study employing this technique, we reported a breaking-type MC that is destroyed upon application of an external force [18]. This breaking-type MC is an example of a MC with a "long-duration release" profile.

In contrast, a quick-release MC is demanded in certain areas of agriculture. For example, when a farmer prepares pesticide, the AI is preferably coated by a material for safe handling. However, when applying the pesticide to a target, the coating becomes a hindrance for quick efficacy. Though there are some reports about the quick-release MC [23–27] at present, these techniques are very complicated so that it is not commercially acceptable in the field of crop protection specially. Therefore, we focused on experienced interfacial polymerization in order to prepare the quick-release MC.

In this study, a self-bursting MC was prepared by following a previous study [28]. The MC contains pyriproxyfen, which is a widely used insect growth regulator. We investigated the relationship between the self-burst ratio and potential factors underlying the spontaneous bursting of the MC after the water in which it is dispersed evaporates. The factors such as the self-weight of the MC, capillary force, and critical buckling stress were examined as key determinants of this behavior. The results point to critical buckling stress, and more specifically, the wall thickness of the MCs, as a key factor for self-bursting.

2. Materials and methods

2.1. Materials

Pyriproxyfen was supplied by Sumitomo Chemical Co., Ltd. Nisseki Hisol SAS 296® (Phenyl xylyl ethane) was purchased from Nippon Oil Corporation. Vinycizer 40® (Di-isobutyl adipate = DIBA) was purchased from Kao Corporation. Sumidur N-3300 shown

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0921-8831/$ - see front matter
doi:10.1016/j.apt.2011.11.006