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Original Research Paper

Preparation of self-bursting microcapsules by interfacial polymerization

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ABSTRACT

Here, we describe a new technique for microencapsulating pyriproxyfen, a widely used insect growth regulator. Using interfacial polymerization, we successfully prepared self-bursting microcapsules that retained their shape when suspended in water but break open quickly after the water evaporates. In order to investigate the self-bursting phenomenon, we studied the relationship between formulation factors such as volume median diameter (D) or wall thickness (T) and the physical strength of the obtained polyurethane films. As a result, it was found that T and the structure of isocyanate affected the self-bursting phenomenon.

1. Introduction

Microcapsules (MCs) are minim containers whose wall material is mainly comprised of natural polymers, synthetic polymers, or inorganic compounds [1,2]. Their particle sizes of MCs can vary widely between the nano and micron levels depending on their use. The core material is protected by the wall material from the external environment, and the release rate of the core material is controlled by the wall material. So numerous manufacturing methods for preparing MCs have emerged including interfacial polymerization [3–5], in situ polymerization [6–8], the coacervation method [9], and the spray-drying method [10] among others.

MCs offer a number of interesting advantages to the active ingredients (AIs) they encapsulate including their protection, shelf life-enhancement, controlled release, and odor-masking. For this reason, numerous researchers are actively studying MCs in the pharmaceutical, printing, agricultural, and food industries [11–23]. Mainly studied in the pharmaceutical industry, nanoparticles (NPs) [23–26] are colloidal particles consisting of polymer and AIs and range in size between 10 and 1000 nm. For example, Kawashima et al. [25] successfully prepared controlled-release NPs by the emulsion–solvent diffusion method. Here, the polymer functioned to confer NPs with biodegradability as well as controlled drug release. In the food industry, Bertolini et al. [27] reported the spray-drying method for preparing MCs of monoterpenes to stabilize them against oxidation. In the agricultural domain, Lowell [28] and Scher [4] reported commercial pesticide MCs based on crosslinked nylon-type polymers or polyurea, produced by interfacial polymerization of isocyanate with amine and/or acid chlorides. In this case, MCs functioned to reduce mammalian toxicity and extend insecticidal activity.

As just described, numerous researchers have taken note of the controlled release of AIs by microencapsulation. However, many of the studies have primarily concentrated on the slow and "long-duration release" profile of the AI. 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 [29–32]. Interfacial polymerization is highly suited for microencapsulation 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 [33]. 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 sprays 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 [34–38] 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 a series of studies, we have found a new type of MC with the intriguing property of spontaneously bursting after the water in which it is dispersed evaporates. Unlike a long-duration controlled-release MC, it quickly releases the core material. We refer to this new type of MC as a "self-bursting MC."

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