SELF-HEALING POLYMERS: MICROCAPSULES FILLED WITH MONOMERS

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ABSTRACT

Polymeric microcapsules have already a wide range of applications in medicine as transport vectors for drugs and contrast substances [1] and potential future applications in materials science as component of the autonomous self-healing process [2-5]. Two types of polymeric microcapsules filled with dicyclopentadiene and cyclooctadiene have been synthesized and analyzed. Microscopy and spectroscopic methods have been used to characterize the microcapsules and quantify the amount of confined monomer.

I. INTRODUCTION

"The classical" self-healing (SH) concept has been successfully proved [2-4] by dispersing microcapsules (MCs) filled with

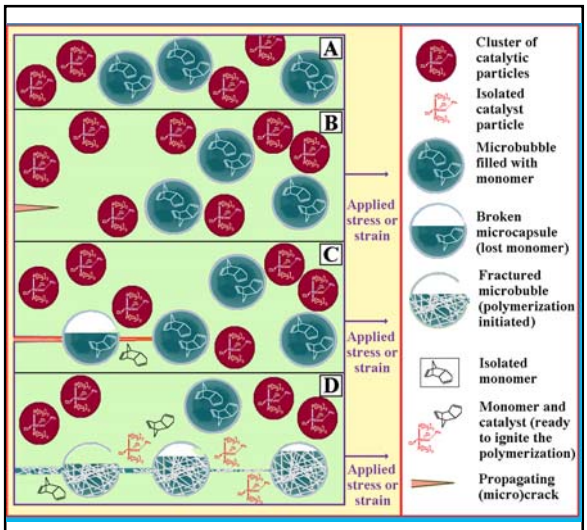

Figure 1

dicyclopentadiene (DCPD) within epoxy resins loaded with first generation Grubbs catalyst (FGGC) [2-4]. Mechanical stresses sufficiently large are required to initiate the rupture of MCs and the subsequent release of DCPD. The diffusion of DCPD within the epoxy resin ends on a FGGC cluster, where a ring opening polymerization reaction is initiated. This mechanism adds self-healing features triggered by crack propagation to epoxy resins [2-4], as shown in Fig. 1. Hence, a new polymer (resulted from the reaction of DCPD with Grubbs catalyst) is synthesized within the propagating microcracks of the polymeric matrix. This "new polymer" (polydicyclopentadiene-PDCPD) heals the epoxy resin and adds "SH capabilities" to the epoxy resin. Later, this concept was demostrated for laminate composite materials [3] and rubbers [5].

Up to now [1 - 4] successful micron-scale SH was reported mainly for the system epoxy resin (matrix), polyureea-formaldehyde (PUF) MCs filled with DCPD, and FGGC. Tentative to replace DCPD by other monomers such as norbornene, to use other catalysts, and to reinforce other polymeric matrices have been reported [5].

2. PUF microcapsules filled with monomers

PUF microcapsules filled with DCPD and cyclooctadiene (COD) have been prepared as reported elsewhere [2-4].

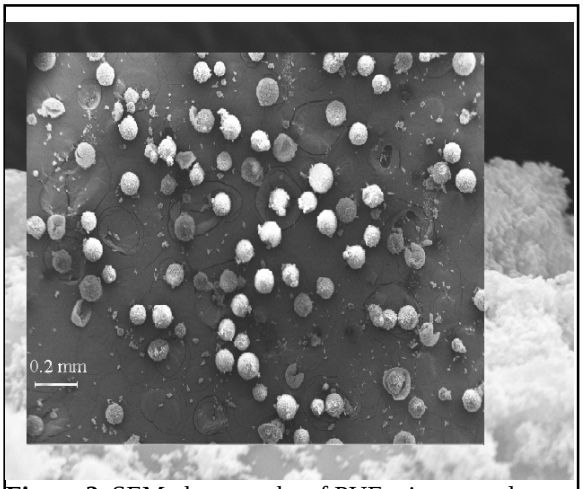

Figure 2. SEM photographs of PUF microcapsules filled with DCPD

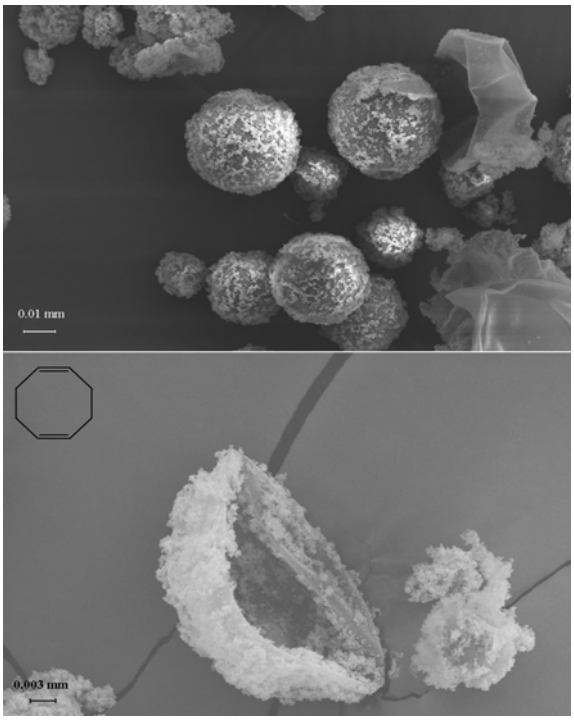

Figure 4. SEM photographs of PUF microcapsules filled with COD.

As seen from Figs. 2 and 3, the as-obtained whitish powder is actually a collection of almost perfectly MCs filled with monomer and broken MCs. The diameter of MCs decreases from about 1 mm to few microns as the spinning rate is increased from 200 to 2000 rpm. Additional

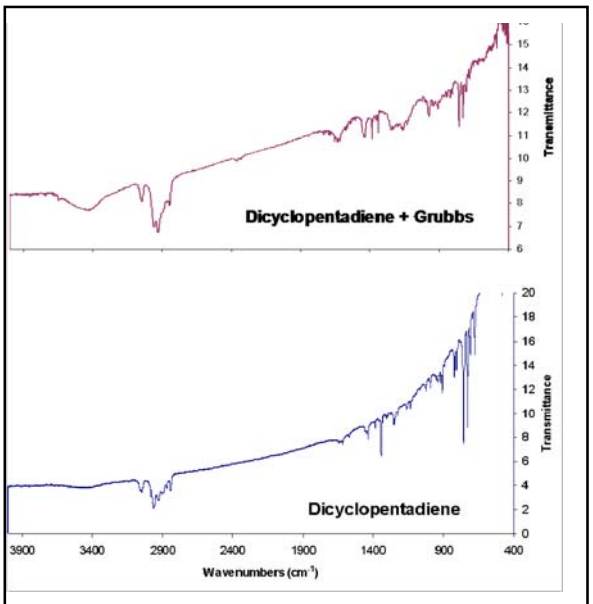

Figure 5. FTIR spectrum of DCPD (bottom) and DCPD and FGGC (top spectrum)

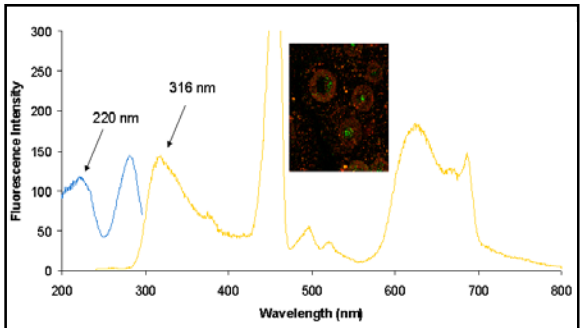

Figure 3. Fluorescence of DCPD

factors [2-5] such as pH, temperature, nature of the confined monomer, and amount of water are also affecting the diameter of MC and the thickness of the MC's wall. The wall of MC's has a thickness of the order of 10^2 nm (see Fig. 3, bottom panel). FTIR spectroscopy has been used to identify and quantify the amount of monomer (DCPD and COD) confined within MCs (see for example Fig. 4). Fluorescence was also found to be capable of sensing and quantifying the amount of monomer. For DCPD, the excitation at 250 to 320 nm is responsible for an emission line located at about 360 nm (see Fig.5).

CONCLUSIONS

The synthesis of MCs filled with monomers (DCPD and COD) was reported. Experimental techniques capable of identifying and quantifying the amount of monomer confined within MC have been identified**.** Scanning Electron Microscopy data confirmed the synthesis of MCs.

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