

BURNING CHARACTERISTICS OF MICROCELLULAR COMBUSTIBLE OBJECTS

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Extended Abstract

Application of porous combustible objects containing combustible cartridge cases, caseless ammunition and combustible detonator-holding tubes in weapons is to save metal, ensure light weight ammunition, eliminate the disposal of spent metal case, simplify automatic firing device and add energy to propulsion system [1-3]. Generally, the combustible objects were fabricated from a mixture of nitrocellulose, fibers and binder. Various methods have been employed, such as felt-moulding [4, 5], winding [6] or impregnation of resin in the felted combustible components [7, 8] to achieve the desired properties. While, these objects were judged to be unsafe due to an increased sensitivity to friction, heat and static electricity, resulting in nitrocellulose ingredient. Hence, foamed combustible objects using heat-resistant nitramines become a potential replacement of NC-based ones. In recent years, a reaction injection moulding (RIM) process was used to fabricate foamed polymer bonded RDX propellants [9].

In our study, supercritical CO_2 (SC- CO_2) was used as foaming agent to fabricate microcellular combustible objects, which were presented in detail in Reference 10. SC- CO_2 as foaming agent offers many superiorities including enhanced diffusion rates [11, 12], effective plasticization [13] and an critical temperature and critical pressure of 31.1°C and 7.38 MPa [14]. The combustible objects were composed of RDX as energetic ingredient and poly methyl methacrylate (PMMA) as inert binder. As shown in Figure 1, firstly, the objects absorbed SC- CO_2 in the high pressure vessel at certain foaming conditions and then self-foamed after venting the pressure in the vessel to atmosphere pressure.

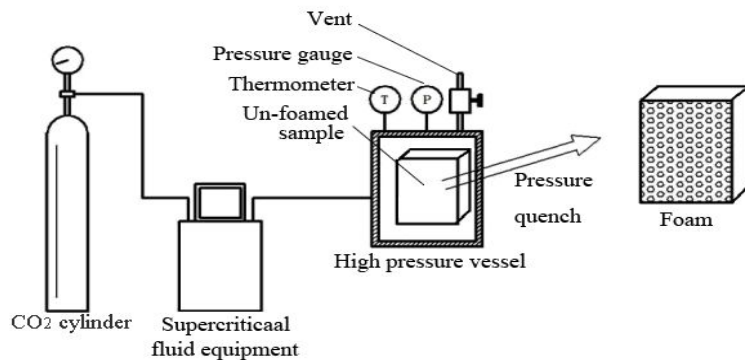


Figure 1. Schematic illustration of foaming process in SC- CO_2 .

The typical inner structures of unfoamed and microfoamed combustible objects are Figure 2. The inner porous structure presents a unimodal or bimodal distribution of pores foamed at different foaming conditions.

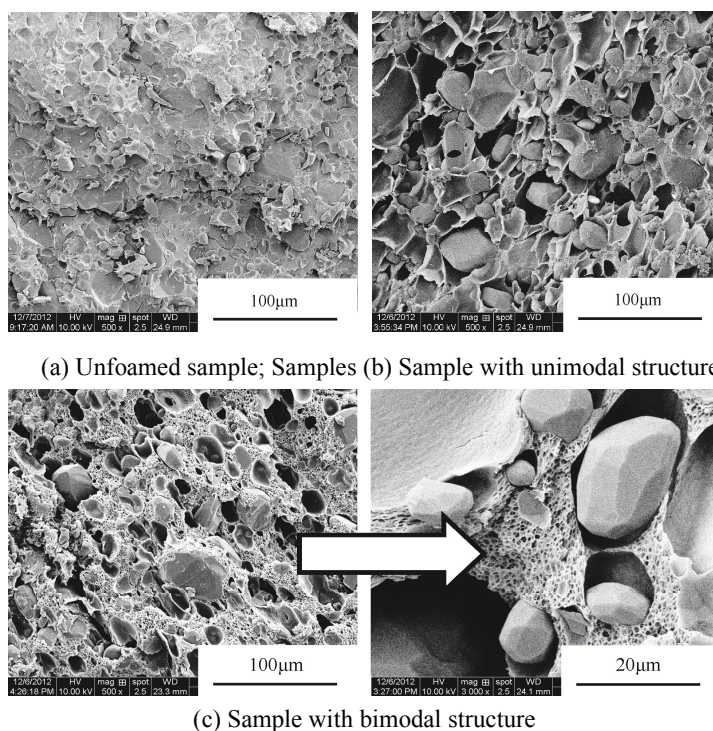


Figure 2. Inner structures of unfoamed and microcellular objects.

A series closed bomb experiments were conducted to investigate the influence of both porous structure style and RDX content on the burning behaviors of these objects. Details of closed bomb tests are listed in Table 1.

Table 1. Details of samples tested in closed bomb.

Sample	1	2	3	4	5
Formulation (weight percent)	60 / 40	50 / 50	60 / 40	60 / 40	70 / 30
Cell size distribution style	solid	unimodal	unimodal	bimodal	unimodal

Figure 3 presents the closed bomb pressure histories of un-foamed and foamed samples. As Figure 3 shows, the pressure histories consisted of an initial pressure rose from combustion of the ignition powder, a subsequent slight pressure decrease due to ignition delay and heat transfer losses, and, finally, combustion of the microcellular sample. Figure 4 shows the curves of apparent burning rate vs. pressure. The sample with bimodal distribution of cell sizes burns faster than that with unimodal distribution, and simultaneously, the concentration of RDX can influence the burning characteristics in a positive manner.

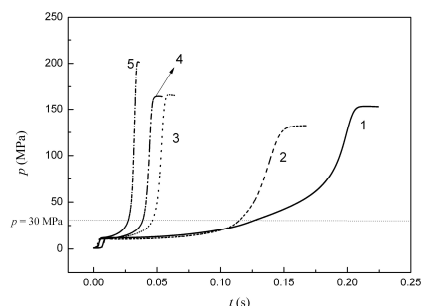


Figure 3. Closed bomb pressure histories.

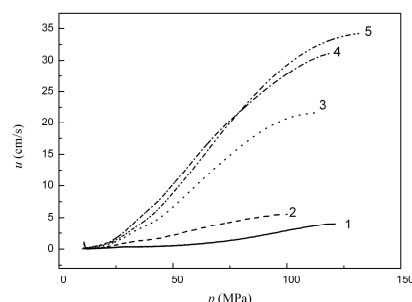


Figure 4. Curves of apparent burning rate vs. pressure.

The translation of laminar burning to convective burning is determined by burning rate versus pressure curves of samples at two different loading densities (Figure 5). Below a certain pressure ($p \approx 30$ MPa), samples burned as non-porous propellants, and burning rate is independence from loading density. While the pressure in chamber is high enough ($p \geq 30$ MPa) to drive hot combustion gases into the microcells of unburned zone through in the samples, which in turn convectively heats the propellant to ignition. This process usually results in a ragged flame front, making the burning rate curves separated.

The size dependence of burning rate on samples size was also investigated. Two samples with different sizes were tested. Figure 6 shows the u - p curves of samples with different sizes. The results indicated that the bigger sample could provide deeper convective depth and burned faster than the smaller sample.

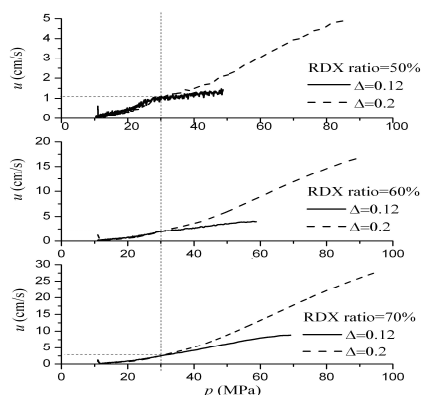


Figure 5. Burning rate vs. pressure at different loading densities (Δ)

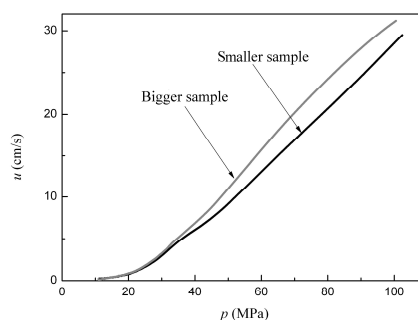
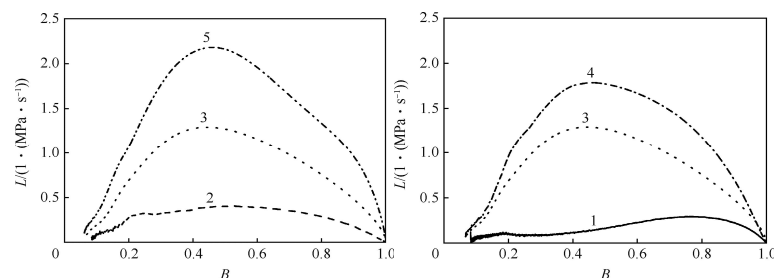


Figure 6. u - p curves of samples with different sizes.

Dynamic vivacity curves of samples are shown in Figure 7. The results show that the vivacity increases with RDX content and varies with inner structure. Meanwhile, the remarkable differences between L - B profiles of un-foamed and foamed objects indicated that different combustion modes were followed when the samples were burned in the closed vessel.



(a) Samples with various RDX contents (b) Samples with different inner structures

Figure 7. Dynamic vivacities of samples.

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