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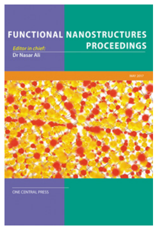

Preparation of PTFE / Al core - shell structure and its reaction characteristics

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ABSTRACT

Polytetrafluoroethylene (PTFE) and active metal are a new kind of energetic materials. At present, the PTFE and aluminum are widely used in solid propellants, thermite and fuel cells. For PTFE / Al-based active materials, nano-aluminum has a greater specific surface area than micron aluminum, which can greatly improve combustion efficiency.
However, nano-aluminum is easily oxidized to form Al_2O_3. The Al_2O_3 has a high melting point, which hinders the reaction of PTFE and aluminum. In this paper, PTFE is used to replace alumina to form core-shell structure. The PTFE shell not only prevents nano-Al oxide, but reduces the mass transfer distanceas well, greatly improving the buring rate. This method provide a general approach to the preparation of other high-energy fuel.
Furthermore, the reaction characteristics were studied systematically.

I. INTRODUCTION

Metal / fluoropolymer reaction material is a new type of metastable energetic composite materials. The theoretical energy of 70%PTFE-30%Al (wt%) can reach 14800 J/g, and the emission energy per unit mass is more than 3 times of TNT (4200 J/g). [1] At present, PTFE-Al active material is mainly used in solid propellants, thermite and fuel cells. However, the reaction process limited by the reaction rate and mass transfer rate between the oxidant and the reducing agent. [2] How to improve the contact area of materials and reduce the transmission distance is the main research direction. [3] Preparation the coreshell structure of Al-PTFE composites is an effective way to solve this problem. R. R. Naik et al. used proteins to adjust the oxidizer and Al. This method can inhibit the oxidation of aluminum. [4] Wang Jun et al. Designed and fabricated a nano-Al / PTFE core-shell structure by vapor-depositing PTFE on Al surface. [5] However, the majority of the preparation process is complex and the preparation cost is high, which is not suitable for industrial production.

In the present work, the core- shell structure of Al-PTFE is prepared by high energy agitation and ball milling. The reaction energy of the material under oxygen and inert atmosphere has been studied. Besides, the burning rate of core–shell Al–PTFE composites has been revealed. Furthermore, when the materials explode in the 300 ml reaction kettle, the specific volume of explosion is tested.

II. EXPERIMENTAL MATERIALS AND PROCEDURES

Fig. 1 and b are the schematic and process flow diagram for preparation of the core-shell PTFE-Al composites. First, the PTFE nanoemulsion is prepared by high energy stirring. After that, aluminum powder is added to the emulsion so that the PTFE nanosheets deposite on the surface of the aluminum particles. Finally, PTFE forms a uniform coated shell by ball milling. Fig. 2a and b are the SEM of core-shell Al–PTFE composites, and Fig. 2c and d are the TEM of core-shell PTFE-Al composites. The pictures show that a complete core-shell PTFE-Al structure has been successfully prepared by using this method.

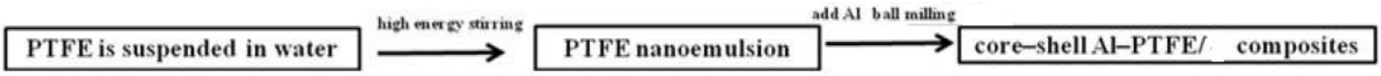

Figure 1a the process diagram for preparation of the core-shell structure.

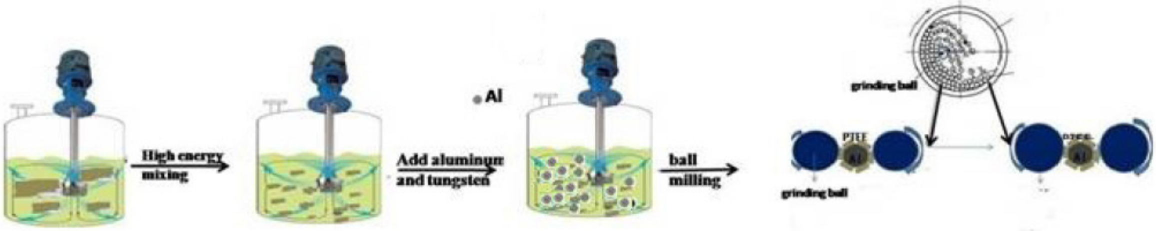

Figure 1b the schematic for preparation of the core-shell PTFE-Al composites.

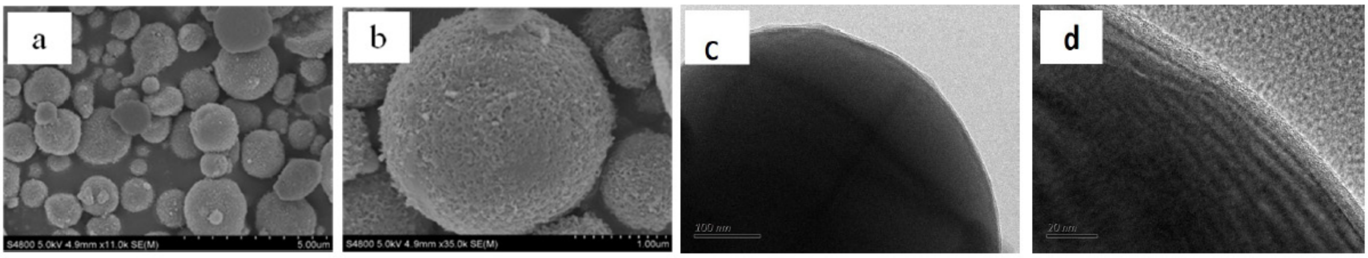

Figure 2a,b the SEM of core-shell Al–PTFE composites; c, d is the TEM of core-shell Al–PTFE composites.

In the course of the reaction, Al is oxidized by fluorine from PTFE, and the stoichiometric weight percentage ratio of Al:PTFE is 3:7 for complete reaction. Therefore, in this study, two kinds of composites were studied: core–shell 70PTFE–30Al (wt.%), and non-covered structure 70PTFE–30Al (wt.%). Table 1 shows the reaction energy of the two components in oxygen and argon. The reaction energy of core–shell 70PTFE-30Al composites is 14160J/g, and the emission energy per unit mass is more than 3 times of TNT (4200 J/g).

Table 1 Reaction energy of the W–PTFE–Al composites in oxygen and argon.

W–PTFE–Al composite (W%)	oxygen (J/g)
core–shell 70PTFE-30Al composites	14160

Figure 3a is the burning rate of 70PTFE–30Al composites, and the burning rate is 0.3m/s.. Figure 3d is the burning rate of core–shell 30Al–70PTFE composites, and the burning rate is 2m/s. It can be seen that the core–shell 30Al–70PTFE composites has a faster buring rate and the flame is more obvious. This is mainly because the core–shell PTFE/Al make the mass transfer faster and improves the reaction rate of the material.

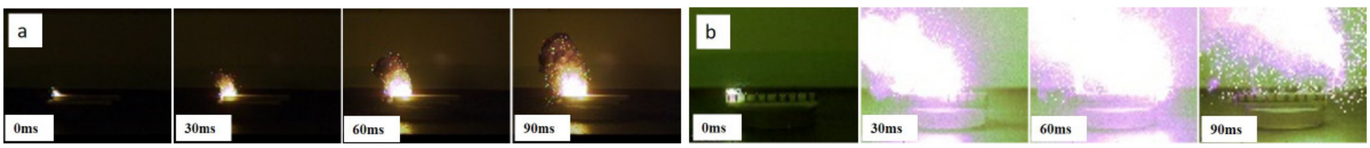

Figure 3 a is the burning rate of the burning rate of 70PTFE–30Al composites; **(b)** is the burning rate of core–shell 30Al–70PTFE composites.

Fig. 4a is the explosive test device schematic diagram. Fig. 4b is the the stress - time curves of the two kinds of composites. When the materials explode in the 300 ml reaction kettle, the specific volume of explosion is tested. It can be seen from the figure, the specific volume of explosion of core–shell 30Al–70PTFE composites is 6.2×10^5Pa. This is because the core–shell 30Al–70PTFE composites produce AlF_3, which is gaseous at the moment of reaction.

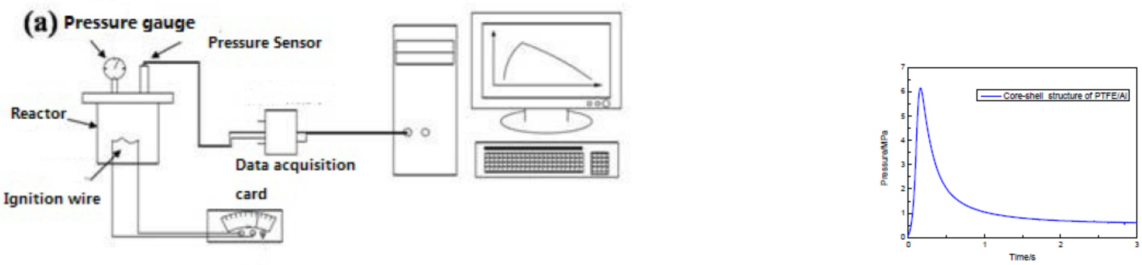

Figure 4a is the specific volume of explosion test schematic; b is the the stress - time curves of the two kinds of composites.

III. CONCLUSION

First, the core-shell structure PTFE-Al can be successfully prepared by high-energy agitation-ball milling. Second, the core–shell 30Al–70PTFE composites have a faster buring rate and the flame is more obvious than 30Al–70PTFE composites. Moreover, the reaction energy and the reaction pressure reveal that the core-shell structure burns more fully.

IV. REFERENCES

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