НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ ТОМСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
РОССИЙСКИЙ ФОНД ФУНДАМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ
ИНСТИТУТ ПРОБЛЕМ ХИМИКО-ЭНЕРГЕТИЧЕСКИХ ТЕХНОЛОГИЙ СО РАН
АО «ФЕДЕРАЛЬНЫЙ НАУЧНО-ПРОИЗВОДСТВЕННЫЙ ЦЕНТР «АЛТАЙ»
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ВЫСОКОЭНЕРГЕТИЧЕСКИЕ И СПЕЦИАЛЬНЫЕ МАТЕРИАЛЫ: ДЕМИЛИТАРИЗАЦИЯ, АНТИТЕРРОРИЗМ И ГРАЖДАНСКОЕ ПРИМЕНЕНИЕ

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A STUDY ON ADVANCED PYROTECNICS USING NANO-METAL POWDERS

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Firework industry is a big one in Japan and several countries, and expanding with solid steps in the world. However, large fireworks are restricted in terms of safety more and more, and the demand of the small firework usage in closed area such as amusement facilities and stadiums becomes stronger in big cities. Smoke emission from Potassium nitrate, Potassium perchlorate and ammonium perchlorate which are used as oxidizers of firework pyrotechnics have been the problem in many situations, and the development of advanced firework pyrotechnics to solve the problem is strongly required.

One of the solutions is the replacement of these oxidizers with ammonium nitrate. However, it is well known that ammonium nitrate has a poor combustion characteristics and some technical approaches are necessary to overcome them. In the past studies, MgAl alloy was found to be effective to enhance the burning rate and lower the PDL (pressure deflagration limit) of ammonium nitrate based rocket propellant[1, 2]. And ALEX (nano Aluminum powders produced by electric explosion of wire method) has been used in many applications in pyrotechnics and rocket propellants to improve their combustion characteristics[3–6]. The combination of MgAl and ALEX is used to replace typical oxidizers of firework compositions with ammonium nitrate, and we found it is possible to reduce the smoke at least 50% (Fig. 1), and this composition can be the base composition for firework applications with the addition of other color-producing compounds. The mechanism of the role of ALEX was also investigated with the measurement of the temperature profile during the combustion and DTA/TG device, and we found ALEX promotes the gasification of AN and gaseous products chemical reaction.

Fig. 1. Burn of AN/AP/MgAl/L-ALEX

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EVALUATION OF BISPYRAZOLYLMETHANES ES ENERGETIC MATERIALS

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The synthesis of a novel class of functionalized pyrazoles is presented. The linking of nitrated pyrazoles by methylene bridges has been explored and provided energetic materials with interesting characteristics. For other functionalized pyrazoles this has been proven to be more challenging. Possible approaches for the synthesis will be discussed.

The reaction of diiodomethane with the sodium salt of 4-amino-3,5-dinitropyrazolate afforded bis(4-amino-3,5-dinitropyrazolyl)methane which can be used as a heat resistant secondary explosive. This compound shows a good thermal stability ($T_{dec.}$: 310 °C) as well as good calculated detonation performances with values of 8332 m s^{-1} for V_D and 29.6 GPa for $p_{C\text{-}J}$, both of which are higher than the ones of HNS (V_D: 7629 m s^{-1}; $p_{C\text{-}J}$: 24.5 GPa).

Further oxidation of the amino-compound towards nitro groups yielded bis(3,4,5-trinitropyrazolyl)methane, which combines high nitrogen and oxygen content. This compound shows a higher theoretical (V_D: 9304 m s^{-1}) and estimated (LASEM) (V_D: 9910 m s^{-1}) detonation velocity than RDX (V_D: 8803 m s^{-1}) and in the range of CL-20.

Diazotation or nitration of bis(4-amino-3,5-dinitropyrazolyl)methane, using nitric acid/sulfuric acid mixtures, afforded the primary explosive bis(4-diazo-5-nitro-3-oxopyrazolyl)methane with a high thermal stability ($T_{dec.}$: 226 °C, T_m: 194 °C). The energetic values and sensitivities (*IS*: 1.5 J; *FS*: 40 N) are comparable to those of DDNP (*IS*: 1 J, *FS*: 5 N).