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LASER INITIATION OF PRESSED LIGHT-SENSITIVE EXPLOSIVE AND SHEETS

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ABSTRACT The laser initiation characteristics of light-sensitive explosive charges and sheets was investigated because they are of interest as possible objects for study of the mechanism of fast reactions in condensed explosives. The complex salts of *d*-metals, i.e., the transition elements with *d*-electron in their outer electron-shell, were taken as examples in the study. It was found that this class of salts is extremely sensitive to laser beam radiation, and the sensitivity of explosive sheets is clearly dependent on their thickness, which supposes that there must exist some mechanism for localization of the laser energy inside the explosive sheets.

KEYWORDS laser initiation, light-sensitive explosive, threshould of initiation, *d*-metal, critical thickness.

1 INTRODUCTION

Pressed explosives and explosive sheets with high sensitivity to laser beam radiation are of interest as possible objects for the study of the mechanism of fast reactions in condensed explosives. For example, the threshold of initiation of pressed lead azide by Nd-laser beam (wavelength 1060 nm) is near 0.5 J/cm^2, whereas $Pb(N_3)_2$ monocrystals are more sensitive, having the threshold of initiation about 2 mJ/cm^2[1,2].

It is generally believed that the conception of laser initiation of explosives is based on the idea of ignition at hot spots. Hot spots are structural defects or chemical impurities of a substance. The theory of hot spots gives the possibility to outline the process of secondary explosive initiation. The critical energy of initiation of these compounds is above ten times higher than that of primary explosives[1]. Unfortunately, this idea can not explain the existence of low-threshold ignition of explosives ($E<0.1$ J/cm^2), because the absorbed energy is unsufficient for heating explosives up to the ignition temperature. Some authors suggested to take into consideration the effect of radiation

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amplification of explosive particles in the charge. This point of view, however, fails to explain the results of the investigation of Hagan and Chaudhri[1], where single crystals of lead azide revealed no increase of radiation in the crystals.

Consequently, it seems important to search for new highly light-sensitive explosives and to study their laser initiation.

2 LASER INITIATION OF PRESSED LIGHT-SENSITIVE EXPLOSIVES

2.1 Charges

Complex salts of *d*-metals are a very interesting class of light-sensitive explosives. Our investigations have shown that it is necessary to solve several problems in order to find novel highly light-sensitive explosives among complex salts of *d*-metals. These problems are as follows:

(1) Choice of the central ion. We used cations of *d*-metals with high ionization potentials.

(2) The nature of the outer sphere anion-oxidizer. We used perchlorate anion as an effective oxidizing agent for inner sphere ligands as well as a new oxidizer for the complexes, perchlorylamide-dianion.

(3) The type of inner-sphere ligands. Azoles have been used as ligands because they have positive formation enthalpies and readily oxidized products of primary decomposition.

(4) The preferred colour of the complexes. Complexes must have a weak absorption at the wavelength of Nd-laser. The explanation of this demand when using short pulses of Nd-laser is given in the paper[3].

Accordingly, a complex of copper perchlorate with 3(5)-amino-4-hydrazino-1,2,4-triazole (Ⅰ) as a ligand has been synthesized as a result of solving these problems[4,5]. Complex (Ⅰ) has the initiation threshold about 40 mJ/cm² by Nd-laser beam radiation (pulse duration 25 ns). It is nearly ten times smaller than that of the pressed lead azide. At the same time complexes of mercury perchlorate with 5-hydrazinotetrazole (Ⅱ) and of silver perchlorylamide with 5-aminotetrazole (Ⅲ) as ligands have the threshold of initiation several times lower than that of complex (Ⅰ). Complex (Ⅲ) is the first representative of a new class of coordination salts. Consequently, the extremely light-sensitivity of metal azides is not unique, but is rather common due to fast reactions in primary explosives.

2.2 PBX sheets

Light-sensitive explosive sheets (0.1～1.5 mm thick) were also made and investigated. The sheets contained light-sensitive metal complexes bonded by optically transparent polymers. It was shown that thick sheets had lower thresholds of initiation as compared to pressed complexes (Fig. 1), whereas thin sheets had higher thresholds of

initiation. It was found that there exists some critical thickness of the sheet. The sheets thinner than the critical thickness could not be initiated even by laser beam radiation with the energy 15 times higher than the thresholds of initiation of thick sheets (Fig. 2). We did not observe any decomposition of the complexes in these thin sheets. Supposedly, the surface of the sheets influences not only the combustion process developing from ignition spots but also the spots formation.

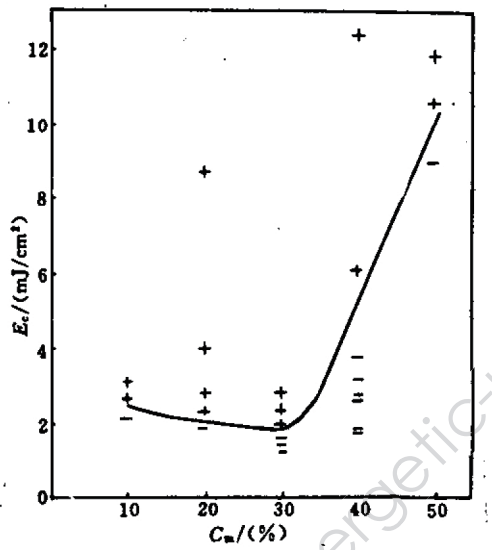

Fig. 1 Relationship between critical initiation energy (E_c) and mass fraction (C_m) of polymer in explosive (Ⅰ) sheets (laser beam diameter 4.7 mm)

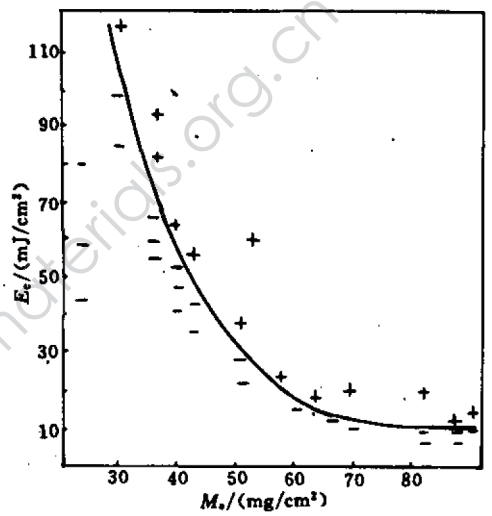

Fig. 2 Relationship between critical initiation energy (E_c) and the mass of explosive (M_e) (Ⅰ) sheets (laser beam diameter 4.7 mm, 10% of polymer)

3 CONCLUSIONS

It has been found some complex of transition metal salts is a new class of explosive extremely sensitive to laser beam radiation.

A clear dependence of sensitivity of explosive sheets towards laser initiation on their thickness has been established. Consequently, some mechanism for localization of the energy of a laser beam inside the explosive should exist.

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光敏炸药柱和药片的激光起爆

摘要　本文介绍了高光敏炸药需要解决的四个问题，并用 Nd 激光器(脉冲宽度 25ns)测定了三种过渡金属配位化合物压制药柱的临界起爆能，其中高氯酸·3(5)-氨基-4-肼基-1,2,4-三唑合铜(Ⅰ)药柱的起爆阈值约为 40mJ/cm²，比叠氮化铅药柱的小约 10 倍；还测定了高氯酸·5-肼-四唑合汞(Ⅱ)与透明的聚合物粘结制成的药片的临界起爆能 E_c，所得结果：聚合物含量在 10～30%范围内，E_c 值逐渐缓慢降低；当超过 30%时，E_c 值急剧升高。对配位化合物(Ⅰ)言，当聚合物含量为 10%时，E_c 值随药片中炸药含量(mg/cm²)的增加而明显下降。结论认为这类过渡金属的配位化合物是对激光敏感的新型炸药；还提到这样的现象：厚药片与单质药片比，其起爆阈值较低，而薄药片则起爆阈值较高，从而表明药片有临界厚度的问题，即当药片薄于临界厚度，即使用于厚药片所需起爆能的 15 倍，也不能被起爆，因此认为可能存在激光能在炸药内部产生定域(Localization)机理。

关键词　激光起爆　光敏炸药　起爆阈值　*d*-金属　临界厚度