Light Ignition of Carbon Nanotubes for the Initiation of Energetic Materials

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Summary

Carbon nanotubes have been shown to ignite when exposed to an intense flash of light such as from a camera flash or laser. This phenomenon has been proposed as a novel initiation method for fuels or explosives. Light initiation of materials provides many advantages over traditional initiation methods for fuels and explosives such as reduced degradation of the initiator over time, reduced interference from electrical fields, improved safety and faster ignition by initiating many points of a material at once. The purpose of this work was to investigate the use of light initiated carbon nanotubes in mining explosive initiators to replace the sensitive primary explosives currently used.

In order to investigate this, experimental methods and instruments needed to first be developed to control and reproducibly measure the ignition of carbon nanotubes by light. Subsequently, those experimental methods were used to comparably optimise the ignition output of carbon nanotubes by exploring the variables and investigating various additives and novel techniques.

Results were successfully recorded with the combination of a high speed camera and a high speed pyrometer. A comparison of the reactions when subjected to a camera flash and a laser was performed. It was found that a camera flash unit produced a slow, surface propagated deflagration while a laser produced a much faster explosion-like result which was determined to be preferable for controllable initiation of energetic materials.

The addition of ferrocene to carbon nanotube powder was found to increase the temperature and reaction of light initiated nanotubes and these mixtures were used to successfully ignite pentaerythritol tetranitrate (PETN). Incomplete combustion was found as a result of particle scattering and limited thermal transfer.

Growth of vertically aligned carbon nanotubes on a silicon substrate was performed and investigated as an alternative to randomly aligned nanotube powders. Light initiation of these samples demonstrated higher temperatures and greater reactivity due to the aligned nature of the nanotubes and the strong thermal conductivity of carbon nanotubes along their length. Vertically aligned carbon nanotubes coated in PETN produced explosive results when initiated by a laser and demonstrated great promise for the ignition of energetic materials.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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Steven Trewartha

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