Nanostructured Composites of Explosives and Single-Walled Carbon Nanotubes.

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In recent years, many methods for synthesizing explosives with characteristic particle sizes up to tens of nanometers were developed and described. It is expected that explosives made from nanosized material would have outstanding properties. Particularly, it was found that decreasing the grain size down to hundreds and tens of nanometers significantly reduces the sensitivity to mechanical influences (e.g. [1]). The decomposition temperature and especially the detonation characteristics also change. During the discussion after the report[2] at the 14th International Detonation Symposium, a significant reduction of the critical thickness of the detonating layer when the particle size was decreased down to hundreds of nanometers was reported. This indicates significant changes in the process of detonation transformation in nanostructured explosive materials. The present work is devoted to the study of the state of matter behind the detonation front in nanostructured explosives.

We prepare the nanostructured explosives by solvent/nonsolvent recrystallization with single-walled carbon nanotubes suspension in water (TUBALL™ COAT_E) as nonsolvent. Nanotubes dispersed in water are the centers of condensation when the explosive is precipitated from the solution. This leads to the formation of a condensed explosive material with a net fibrous structure with a cross section of tens and hundreds of nanometers. Scanning electron microscopy (SEM) photograph of the TNT-based nanocomposite are shown in Fig. 1. We also prepare explosive nanocomposites containing PETN, TNT, RDX, benzotrifuroxane (BTF) and 0.5% of single-walled carbon nanotubes.

The first expected result is a high electrical conductivity of the samples of about 0.1 S/cm. The high electrical conductivity of such explosive materials can significantly reduce their sensitivity to static electricity and increase the safety of their production and technical application.

Dynamic measurements of the electrical conductivity behind the detonation front allow one to trace the decomposition of the explosive material. The resulting profiles of electrical conductivity correlate with the width of the chemical reaction zone for various explosives and essentially depend on the initial particle sizes and the density of the charge[3]. The results obtained for the RDX-based nanocomposite demonstrate the effect of embedded nanotubes on the electrical conductivity profile (Fig. 2). With nanotubes, the profile is significantly wider that is surprising in view of their small concentration.

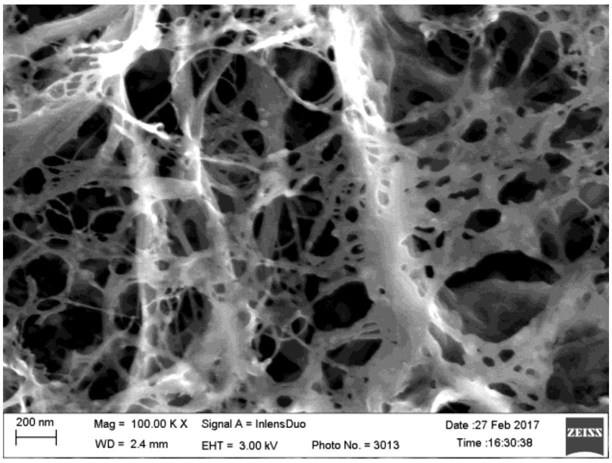

Figure 1. SEM photograph of TNT with 0.5% single-walled carbon nanotubes.

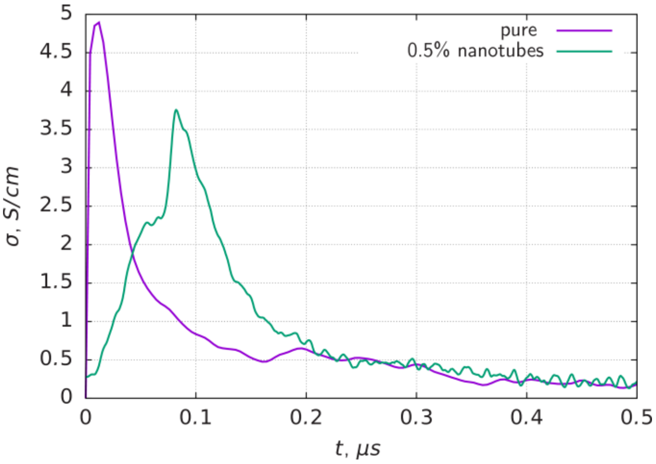

Figure 2. Average electrical conductivity behind the detonation front. RDX 1.8 g/cc.

For the analysis of detonation products we used high-resolution transmission electron microscopy. Regardless of the oxygen balance of the explosives, nanotubes in detonation products are not detected

We carry out measurements of small-angle X-ray scattering (SAXS) of synchrotron radiation at our experimental station[4]. Preliminary results show that embedded nanotubes lead to the appearance of an intense signal of SAXS. The measurement of the dynamics of SAXS during the explosion is a promising way of studying the state of matter behind the detonation front, including the process of decomposition of nanotubes.

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4. K.A. Ten, V.M. Titov, E.R. Pruuel et al., “Carbon condensation in detonation of high explosives”, Proc. 15th Int. Det. Symp., 2014, pp. 369-351.