SAXS measurement and dynamics of condensed carbon growth at detonation of condensed high explosives

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When using small-angle X-ray scattering (SAXS), a diffraction signal from a sample in the small-angle region is detected. This method is widely applied to static analysis of nano-dispersion structures. At SAXS measurements with the application of the highly-periodic synchrotron radiation from the VEPP-3 accelerator facility (with an exposure of 1 ns and periodicity of 250 ns), the evolution of the angular distribution of signal in the process of detonation of high explosives is recorded. A numerical simulation shows that the SAXS signal amplitude is equal to

$$E(q,R) = i_0 \cdot n \cdot \frac{1}{q^3}\left[Sin(qR) - (qR)\cdot Cos(qR)\right],$$

where

$$I_0(q,R) = i_0 \cdot \left[E(q,R)\right]^2 = i_0 \cdot ((R^3 n))^2 \cdot P(q)$$

is the amplitude of the scattered synchrotron radiation, i0 is the scattering by electrons in a 1-cm3 volume of the sample (carbon nanoparticles), n is the sample density, R is the radius of the sample, $\vec{q} = \vec{k} - \vec{k}_0$ - is the scattering vector, and P(q) is the form factor. The angular distribution of SAXS is determined by the form factor P(q), analyzing which one can determine the sizes of the arising particles of condensed carbon and changes in these sizes with time after the passage of the detonation wave.

In the experiments, we recorded the dynamics of the angular distribution of the small-angle scattering of synchrotron radiation, as well as the integrated SAXS signal. We investigated pressed charges of the following mixtures: 50/50 TNT/RDX, TATB (triaminotrinitrobenzene, $C_6H_6N_6O_6$), and BTF (benzo-tris(1,2,5-oxadiazolile oxide), $C_6N_6O_6$). The charges were 20 mm in diameter. Nanoparticles of d ~ 1.5-2 nm are recorded at the detonation front. Then the particle size increases and by the time t ~ 3 μs it reaches d ≈ 4 nm in TATB; in TG 50/50 the particle size d ≈ 6 nm; while in the BTF explosion products, particles with d ≈ 70 nm are detected.