Experimental study of spontaneous decay of some explosives

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Abstract

Explosives are so-called energetic substances, which are unstable and can decay even at room temperature. Decay probability is low enough, so half-life period varies from years to tenth of years. The interest to experimental study of the explosives decay is connected with the problem of noncontact detection of those substances. The aim of our study was to find rather simple decay particles - molecules, which can be detected via TDLS technique.

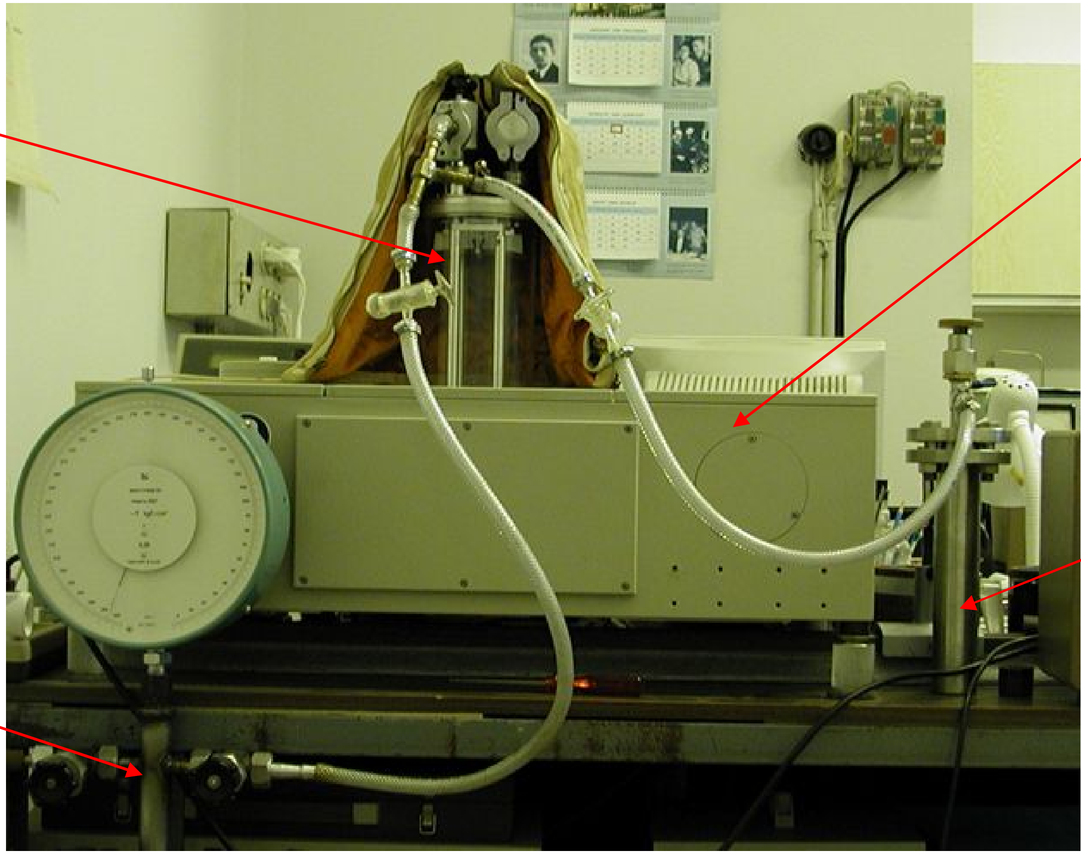
In this study samples of some explosives were placed in a stainless still vessel, which was evacuated and then filled with pure nitrogen. The vessel was exposed at room or higher temperature (in thermostatic apparatus). Intervals of the exposition were from some minutes up to some hours. After this exposition resulting gas mixture was introduced into a multiple-pass cell, which was a part of Fourier-spectrometer (Bruker IFS-66 v/S). Absorption spectra of the gas mixture were recorded in the range of 5000–800 cm^{-1} with resolution of 0.25 cm^{-1}.

For all the explosives containing NO_2 groups NO and N_2O (one or both) were detected. In some cases CO was observed. Rates of appearance of the gases were measured. Analysis of the temperature dependences of the rates gave estimates of activation energies. All of them were close to 1 eV. NH_3 was detected for the explosives containing ammonium nitrate.

Experimental setup

Multiple-pass cell

Spectrometer

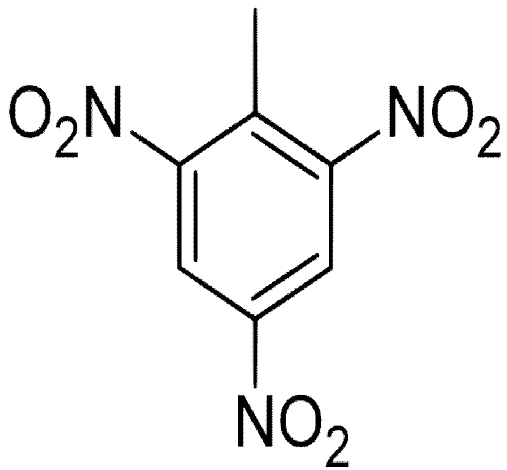


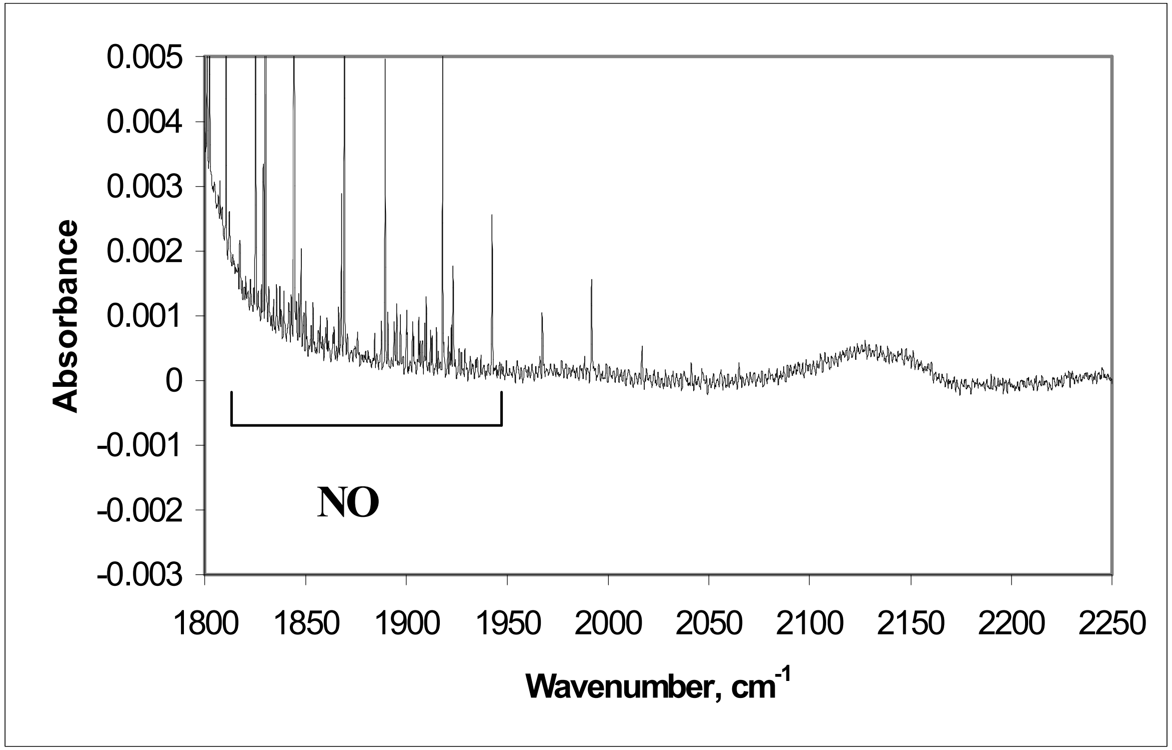
Stainless steel vessel

Pumping system

Trinitrotoluene (TNT)

2-Methyl-1,3,5-trinitrobenzene

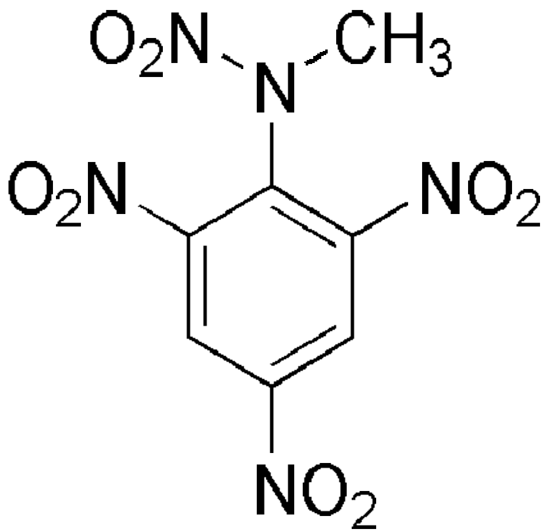


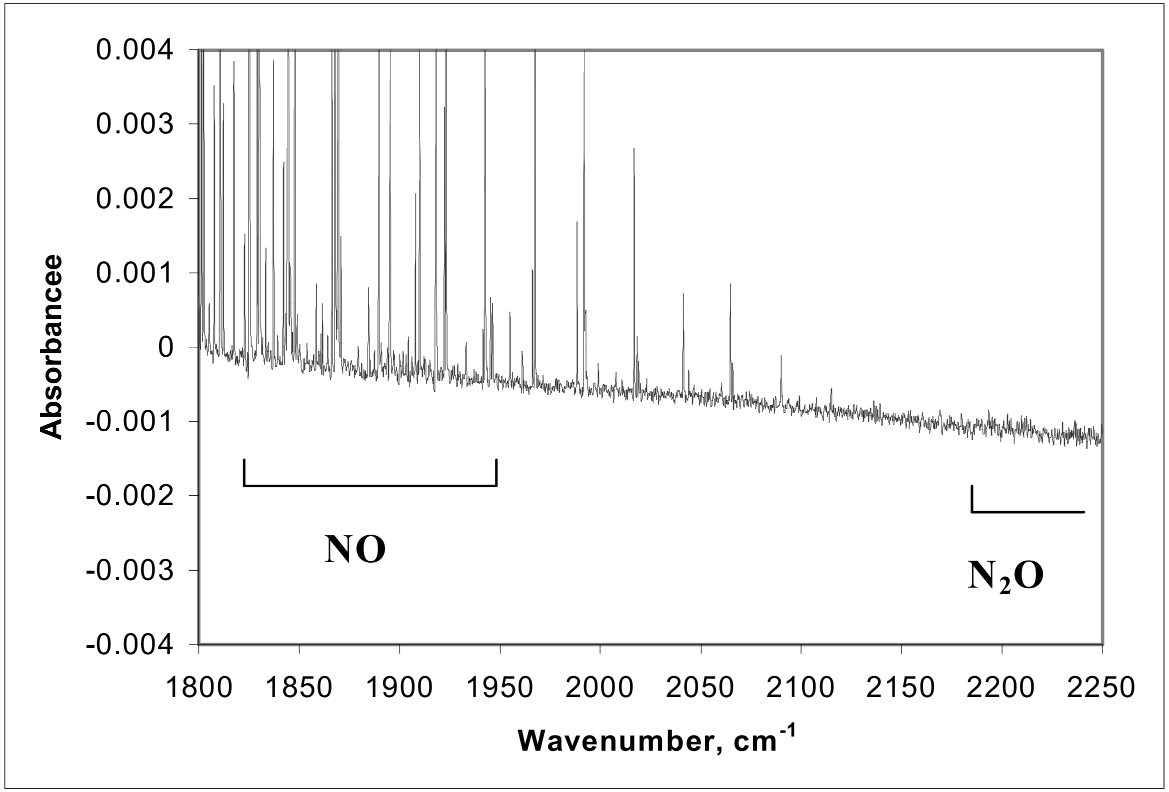


m=100 g, t=17 h, T=20 °C

Tetryl

2,4,6-trinitrophenyl-N-methylnitramine

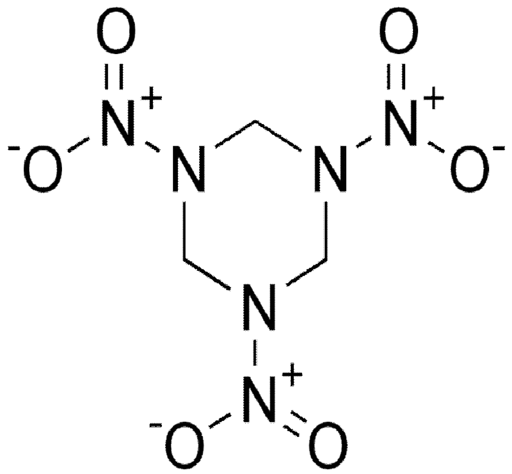


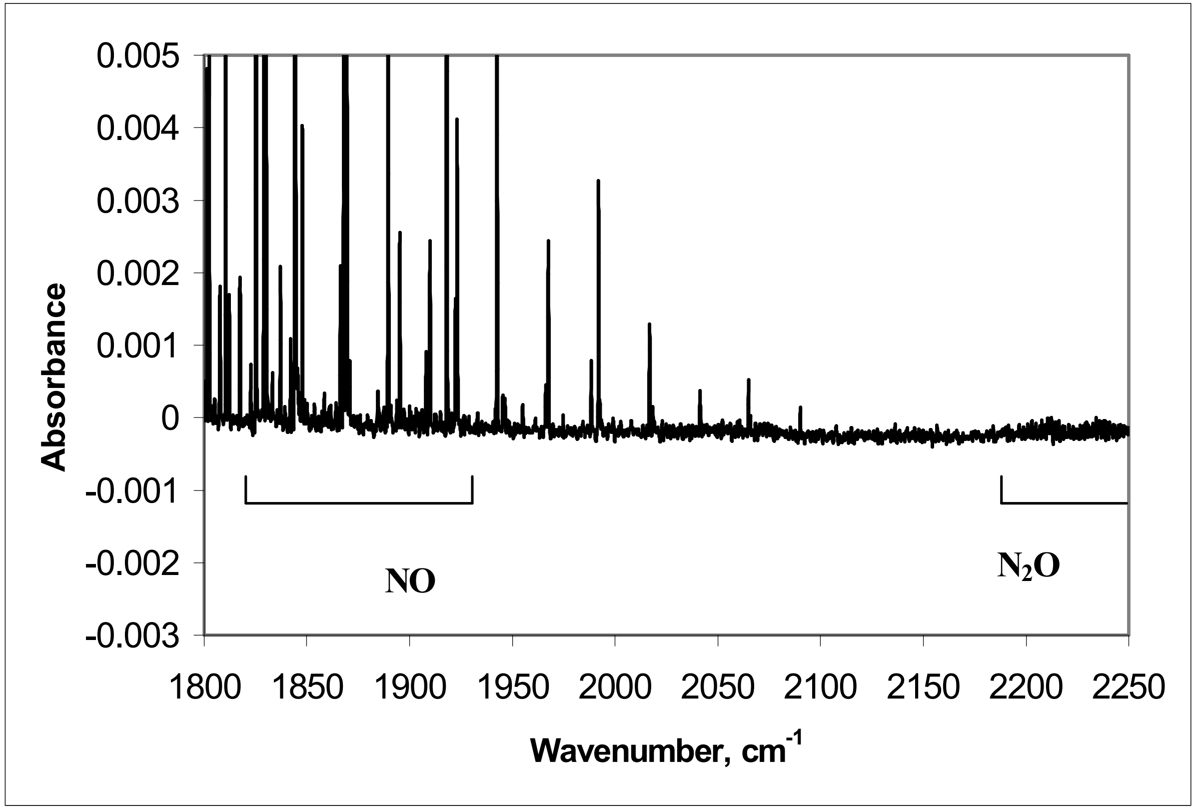


m=100 g, t=69 h, T=20 °C

RDX

1,3,5-trinitro-1,3,5-triazacyclohexane

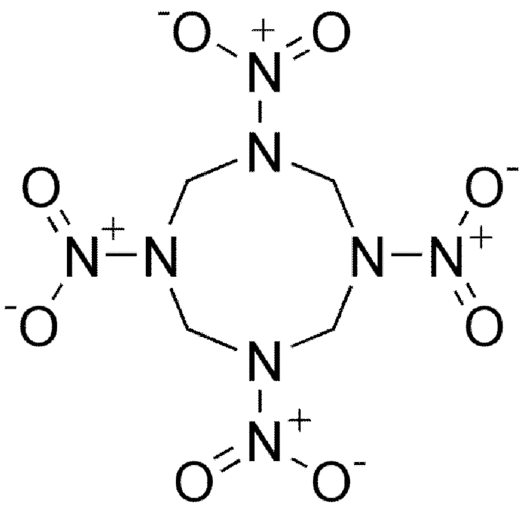


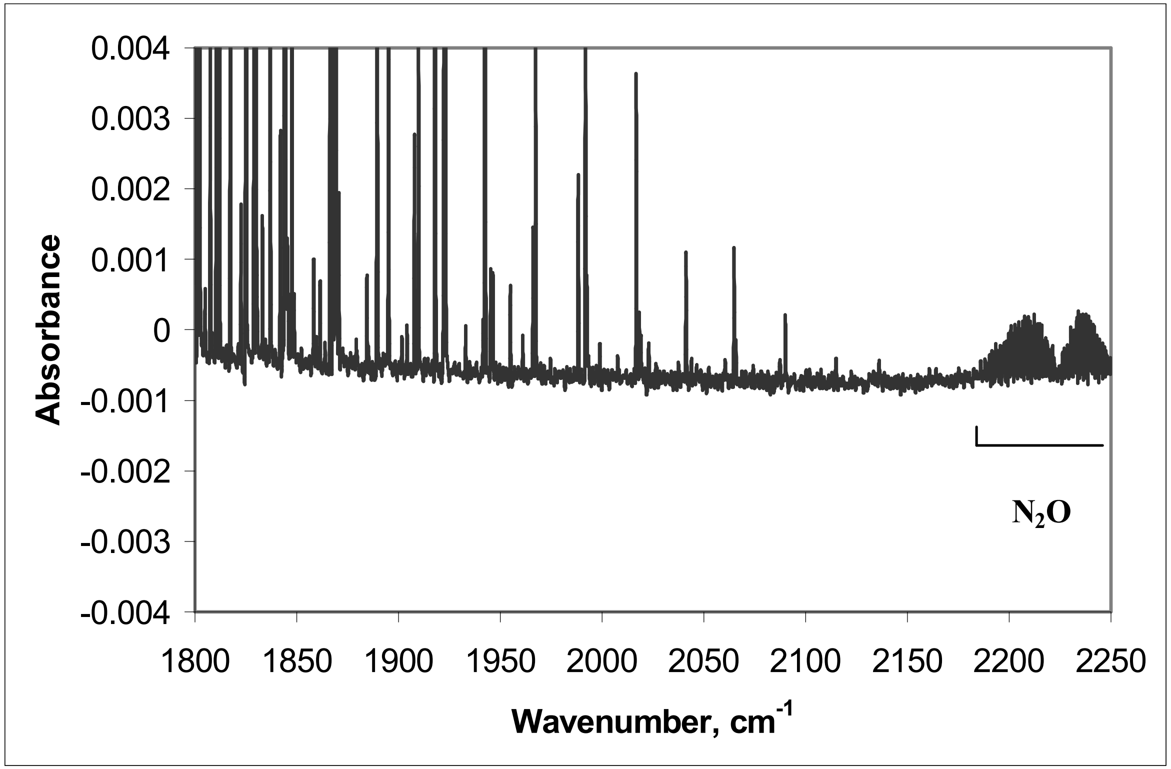


m=100 g, t=19 h, T=20 °C

HMX

1,3,5,7-tetranitro-1,3,5,7-tetrazocane

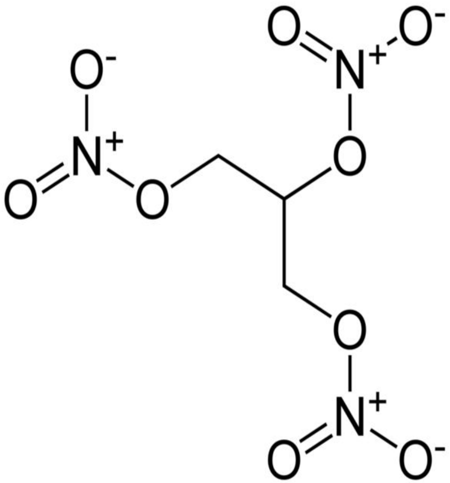


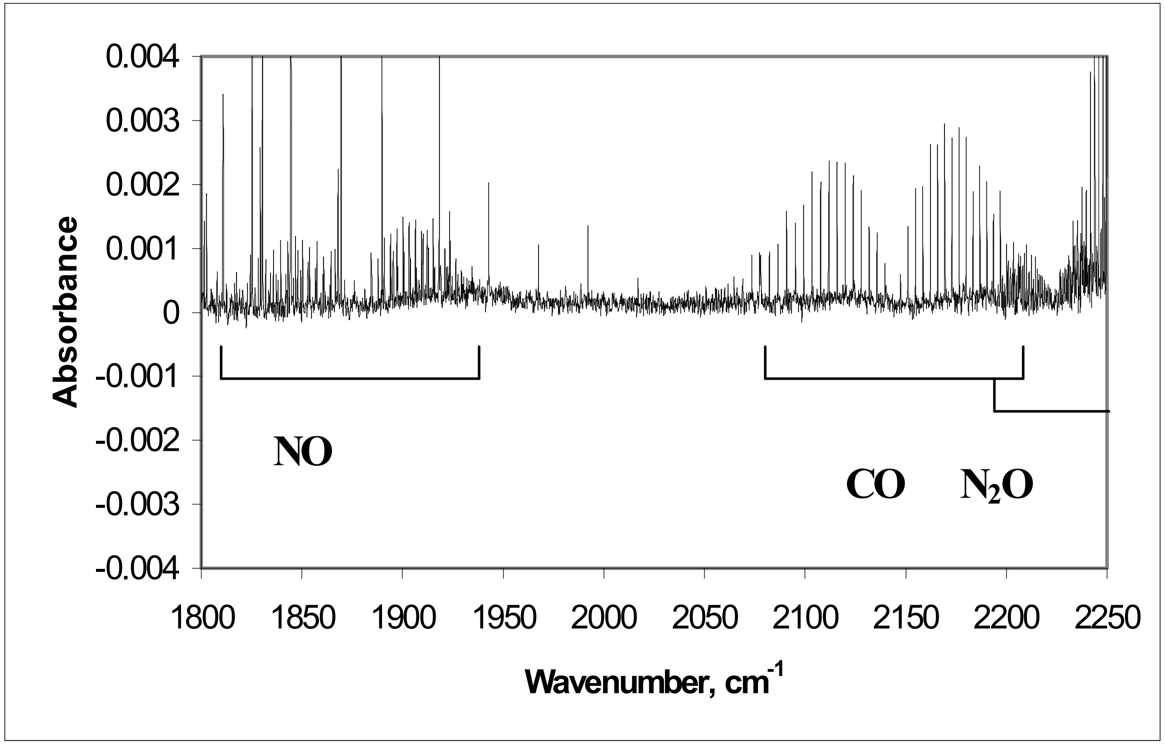


m=100 g, t=17 h, T=20 °C

Nitroglycerin (NG)

propane-1,2,3-triyl trinitrate



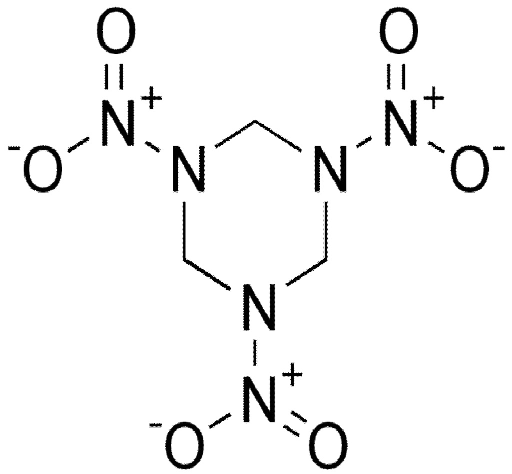


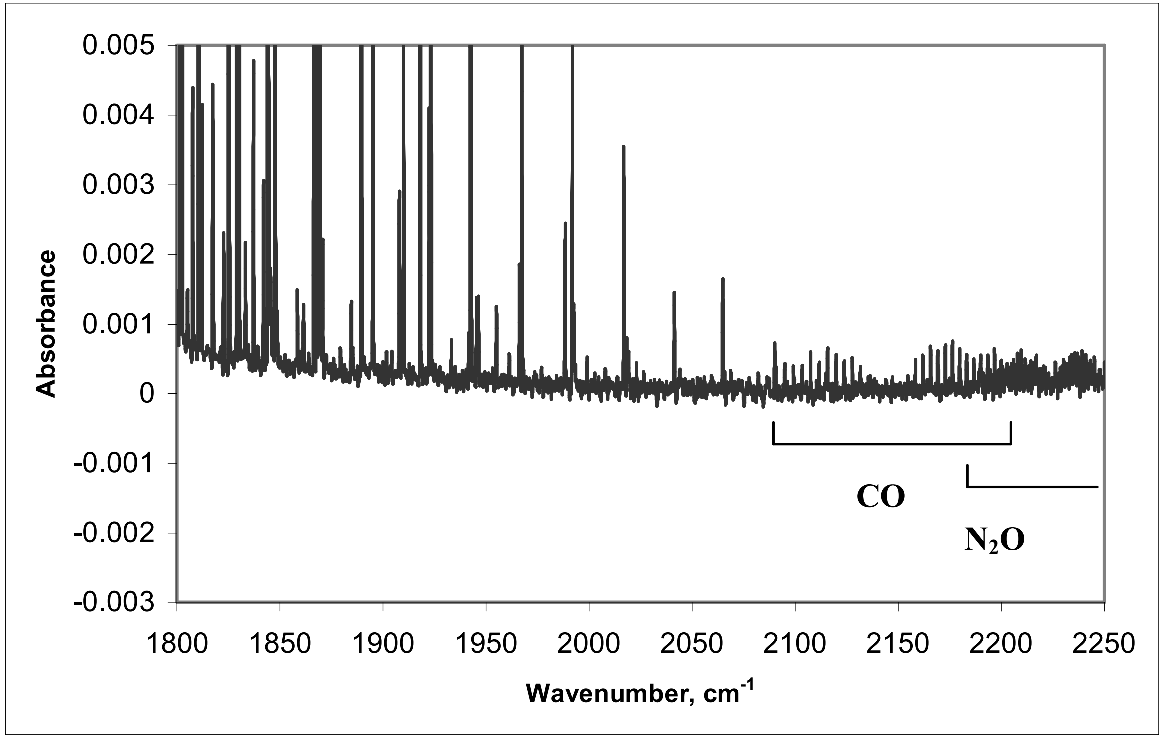
m=0.4 g, t=1 h, T=90 °C

(placed on paper filter)

Plastic explosive based on RDX

{85% 1,3,5-trinitro-1,3,5-triazacyclohexane}

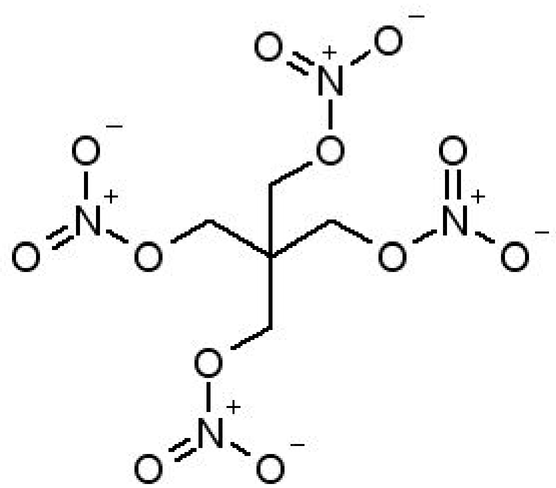


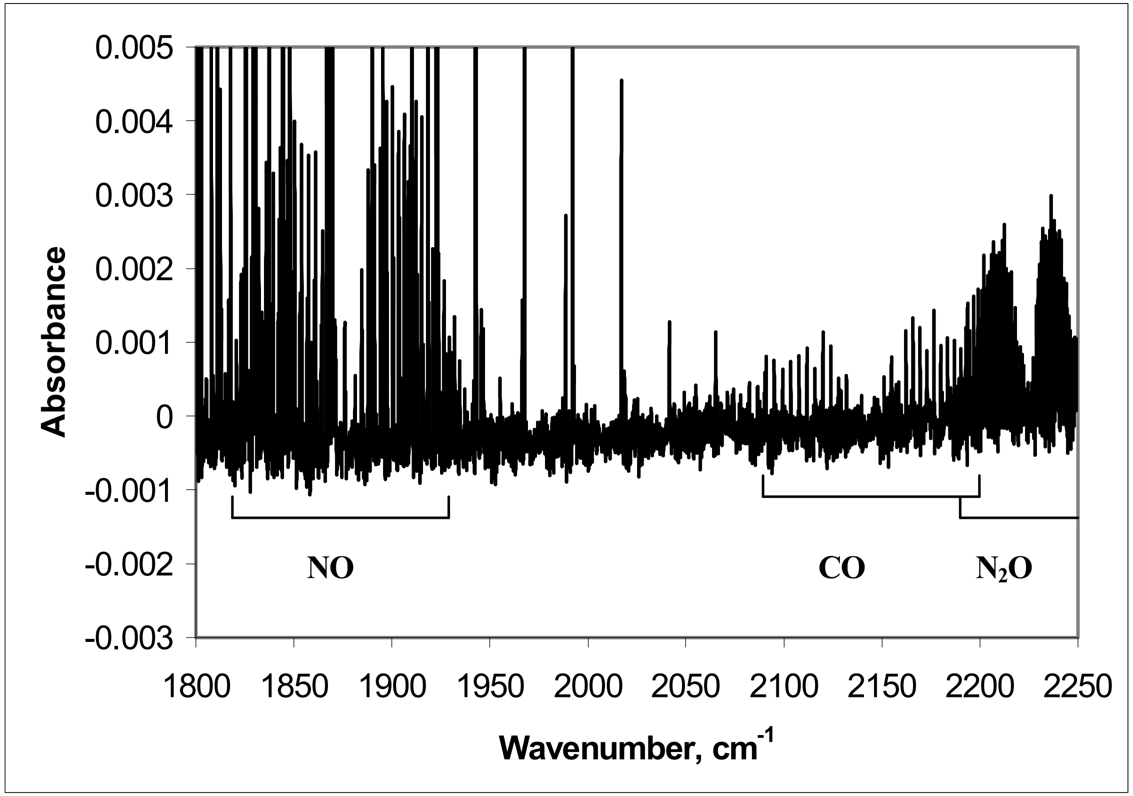


m=100 g, t=67 h, T=20 °C

Plastic explosive based on PETN

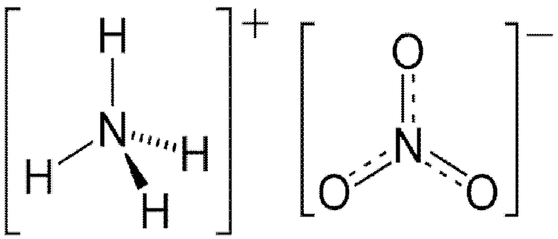
{85% 1,3-Dinitrato-2,2-bis (nitratomethyl)propane}

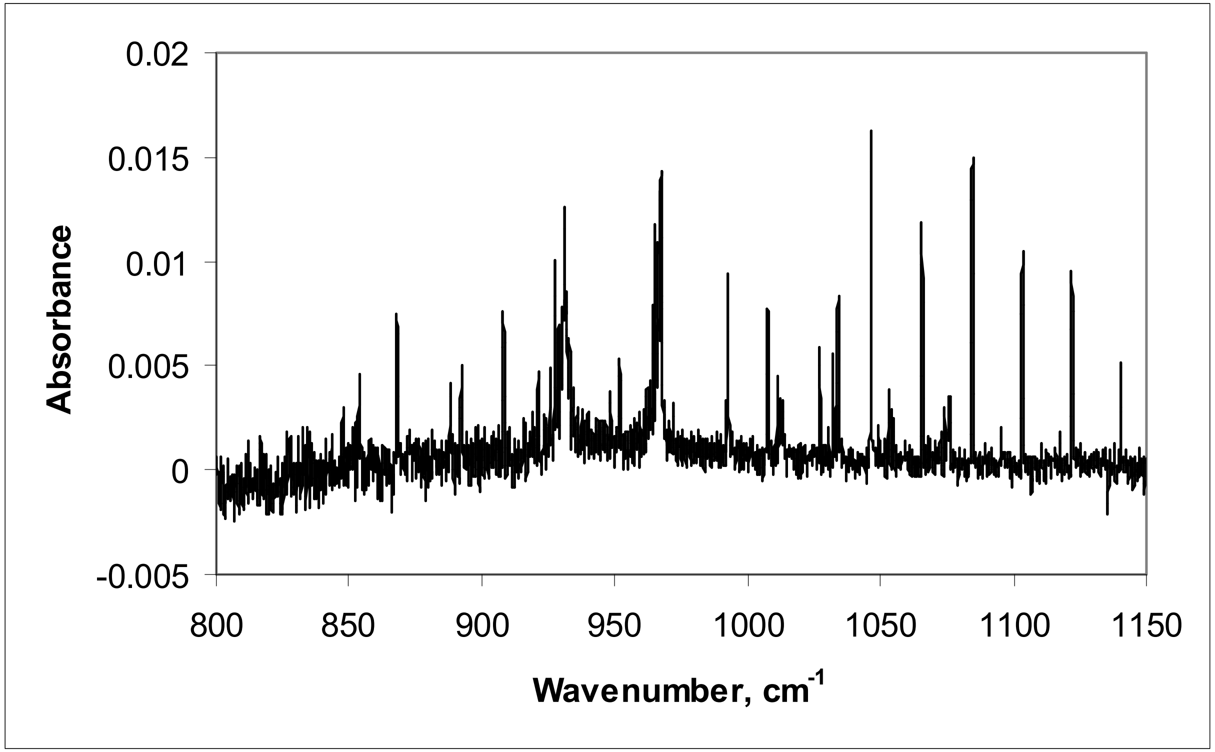




m=4 g, t=67 h, T=20 °C

Ammonium nitrate

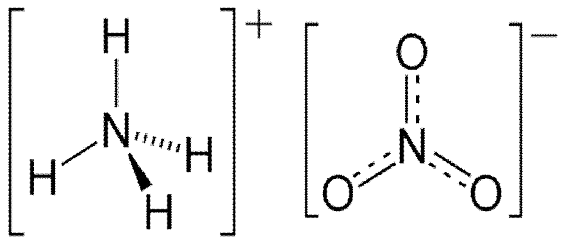


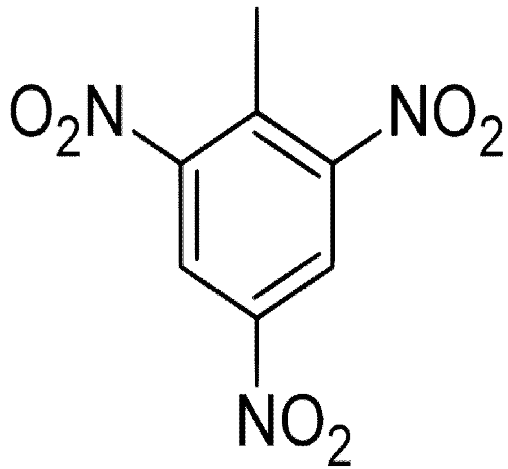


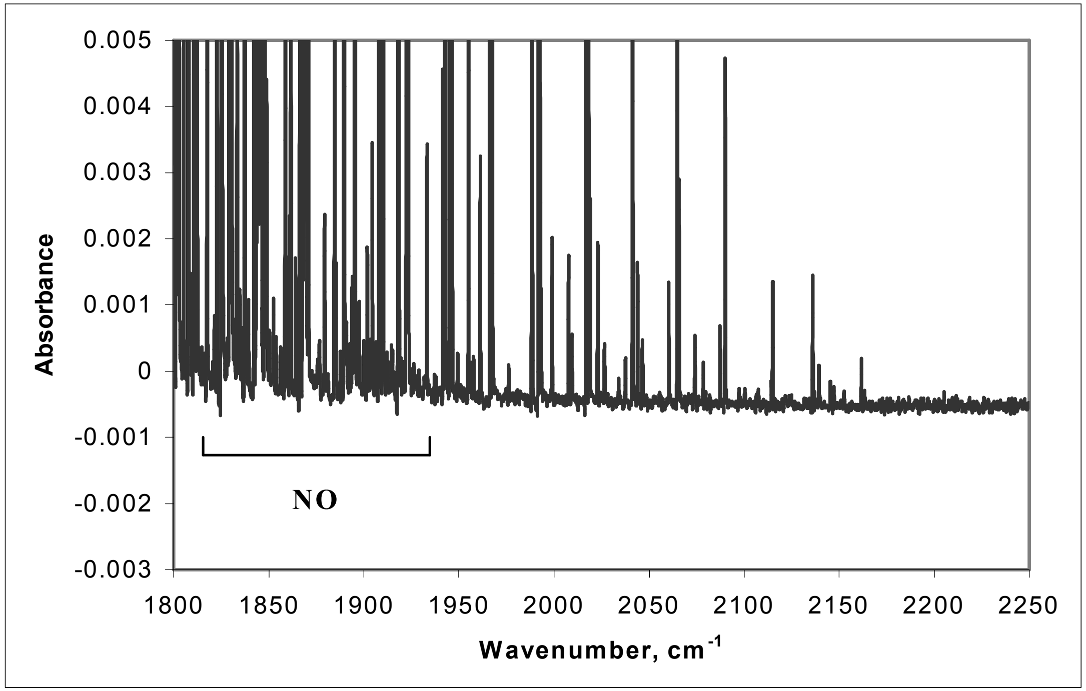
Ammonia in the air near of 1kg of ammonium nitrate

Ammonite

(70% of ammonium nitrate + 30% TNT)

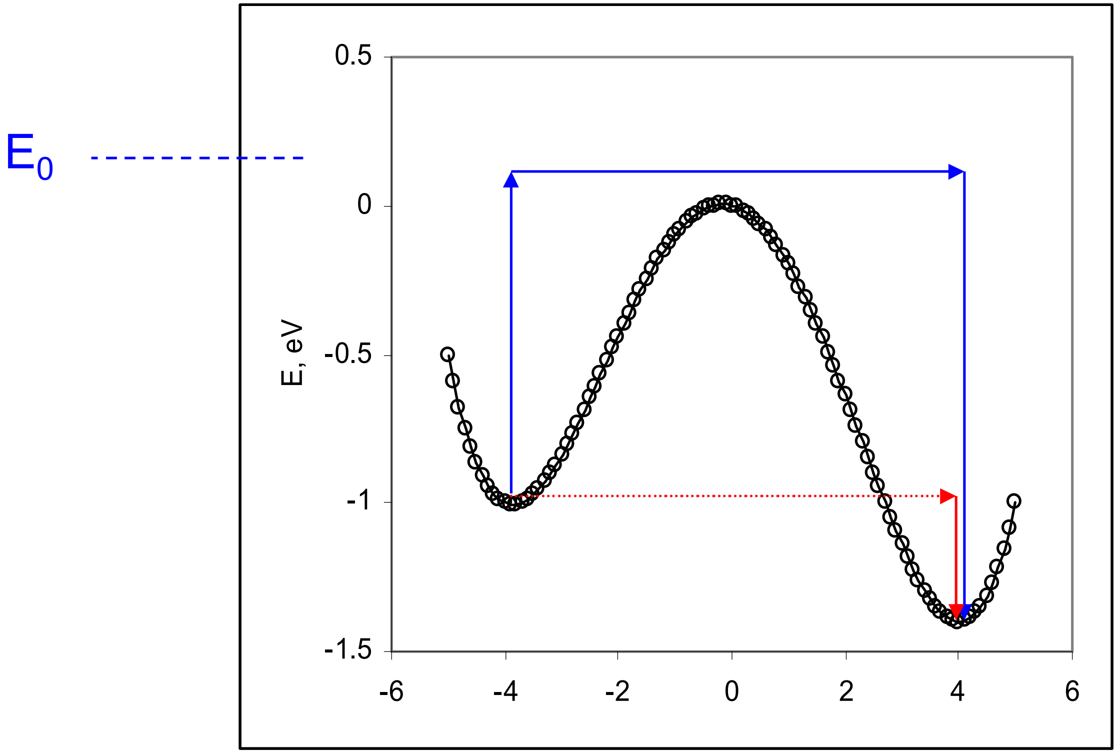






m=100 g, t=17 h, T= 20 °C

Back to Basic: explosives decay

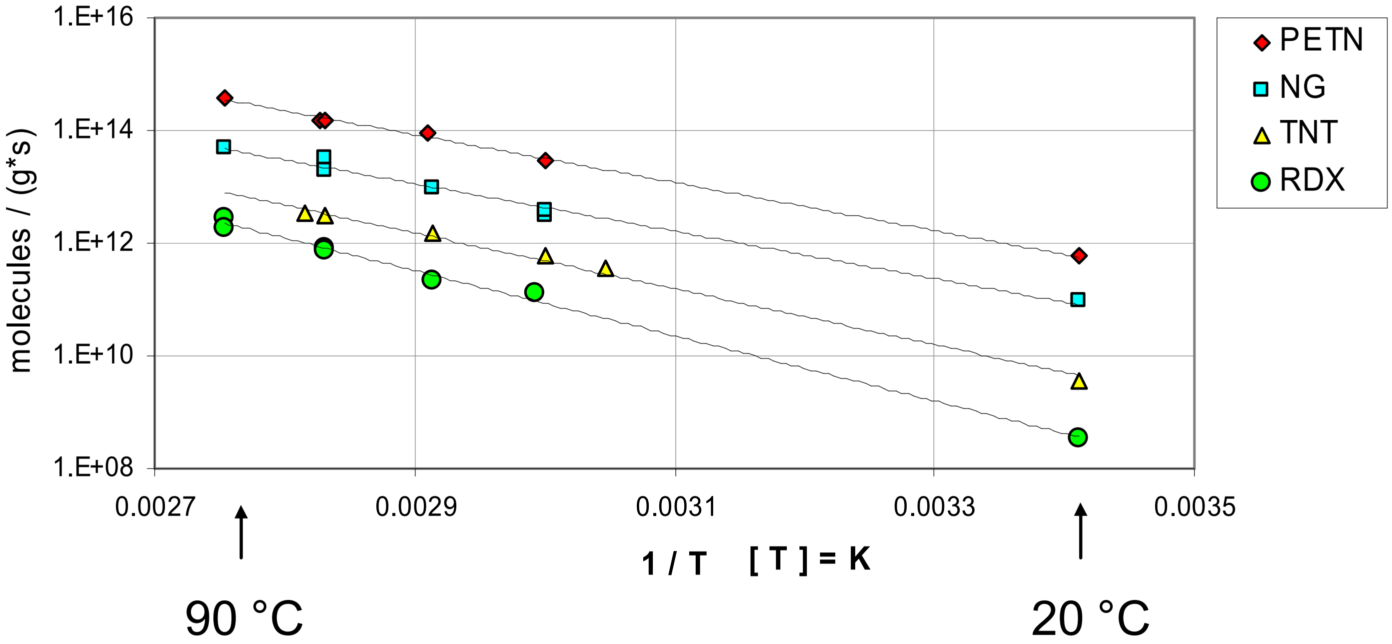


Explosives (metastable molecule) energy diagram in configuration space.

$$DR \approx \int_{E_0}^{\infty} \exp\left[-\frac{E}{kT}\right]\sigma(E)v(E)dE \approx \exp\left[-\frac{E_0}{kT}\right]\sigma(E_0)v_T$$

E_0 ~ 1 Ev = 12000 K
v_T ~ 300 m/sec
DR ~ $10^9 - 10^{14}$ mol/g sec

Temperature dependences of Decay Rate (DR) for different explosives



Trend lines

PETN: Y=2E+26exp(-9794.4x)

NG : Y=2E+25exp(-9700.3x)

TNT : Y=3E+26exp(-11401x)

RDX : Y=2E+28exp(-13318x)

Channels of explosives decay