DETECTION OF EXPLOSIVES, NERVE AGENTS, AND OTHER ILLICIT SUBSTANCES BY ZERO-ENERGY ELECTRON ATTACHMENT

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The Reversal Electron Attachment Detector (READ) used for generating low-energy electrons and extracting the product negative ions (Bernius and Chutjian, 1989; Boumsellek and Chutjian, 1992).
### PRESENT READ SENSITIVITIES

<table>
<thead>
<tr>
<th>molecule</th>
<th>molecular weight (g/mole)</th>
<th>headspace vapor density (g/cm³)</th>
<th>mole fraction at 760 torr (VP/760)</th>
<th>moles nₐ/10 sec</th>
<th>grams Mₐ/10 sec</th>
<th>signal rate (counts/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNT</td>
<td>182</td>
<td>$1.4 \times 10^{-9}$</td>
<td>184 ppb</td>
<td>$1 \times 10^{-12}$</td>
<td>182 picogram</td>
<td>65,000</td>
</tr>
<tr>
<td>2,4,6-TNT</td>
<td>227</td>
<td>$1.2 \times 10^{-10}$</td>
<td>13 ppb</td>
<td>$8 \times 10^{-14}$</td>
<td>1.8 picogram&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9,000</td>
</tr>
<tr>
<td>PETN</td>
<td>316</td>
<td>$1.2 \times 10^{-13}$</td>
<td>26 ppbr</td>
<td>$2 \times 10^{-16}$</td>
<td>63 femtogram</td>
<td>300</td>
</tr>
<tr>
<td>RDX</td>
<td>222</td>
<td>$7.6 \times 10^{-14}$</td>
<td>8.4 ppbr</td>
<td>$6 \times 10^{-17}$</td>
<td>13 femtogram</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>a</sup> to be compared to 300 picogram for the Barringer ionscan, at an unspecified SNR [see F. Garofolo, et al., Rapid Commun. Mass Spectrom. 10, 1321 (1996)]

<sup>b</sup> $4 \times 10^6$ c/s effective count rate with new ionizer
NEGATIVE-ION MASS SPECTRAL "SIGNATURES" OF THE EXPLOSIVES

![Graphs of RDX, PETN, and TNT mass spectra]
The Miniature Quadrupole Mass Spectrometer Array (QMSA) for the Trace Gas Analyzer (TGA)

Battery Voltage: 28 to 45 Vdc
Power Consumption: Total input power, including display, heaters etc. NTE 60W at 150 amu.
TGA envelope dimens: 6.5" X 7.1" X 17.5"
Weight: TGA without battery NTE 12 lb

**Spectrometer Type** Quadrupole Mass Spectrometer Array. Consisting of 9 parallel analyzers
**Mass Range** 1-600 amu (a 1-150 amu @ rf=10Mhz version is being deliverer to ISS)
**Mass resolution** 0.5 amu (FWHM)
**Sensitivity** $2 \times 10^{12}$ counts/torr-sec ( neutrals), $\sim 10^{14}$ counts/torr-sec (ions)
**Dynamic range** 10^7
**Mass crosstalk** better than 1:10^4
**Detector type** Channel multiplier OR Microchnnel plate
**Power Consumption** 15W at 150amu (including electronics and pumps)
**Weight** 1400 gr. (including electronics and pumps)
**Front ends** Straight-thru OR gas chromatographic input
**Envelope dimensions** 4" (height) x 6" (width) x 12" (length)

The Miniature Quadrupole Mass Spectrometer Array (QMSA) has been developed at JPL to reduce sensor size while maintaining the same performance as the large commercial units. The system maintains a mass range, resolution, precision, and stability comparable to larger units, with a sensitivity corresponding to $\sim$ 500 ppb.

Currently slated for International Space Station (ISS) application for detection of leaks and contamination.

Other applications are: Planetary geology, isotopic analysis, surface-evolved gases (Europa), comets and asteroids; and ion composition in the Io torus and other planetary magnetospheres and ionospheres.