

EM synthesis at FOI, Sweden

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Maryland, 2011

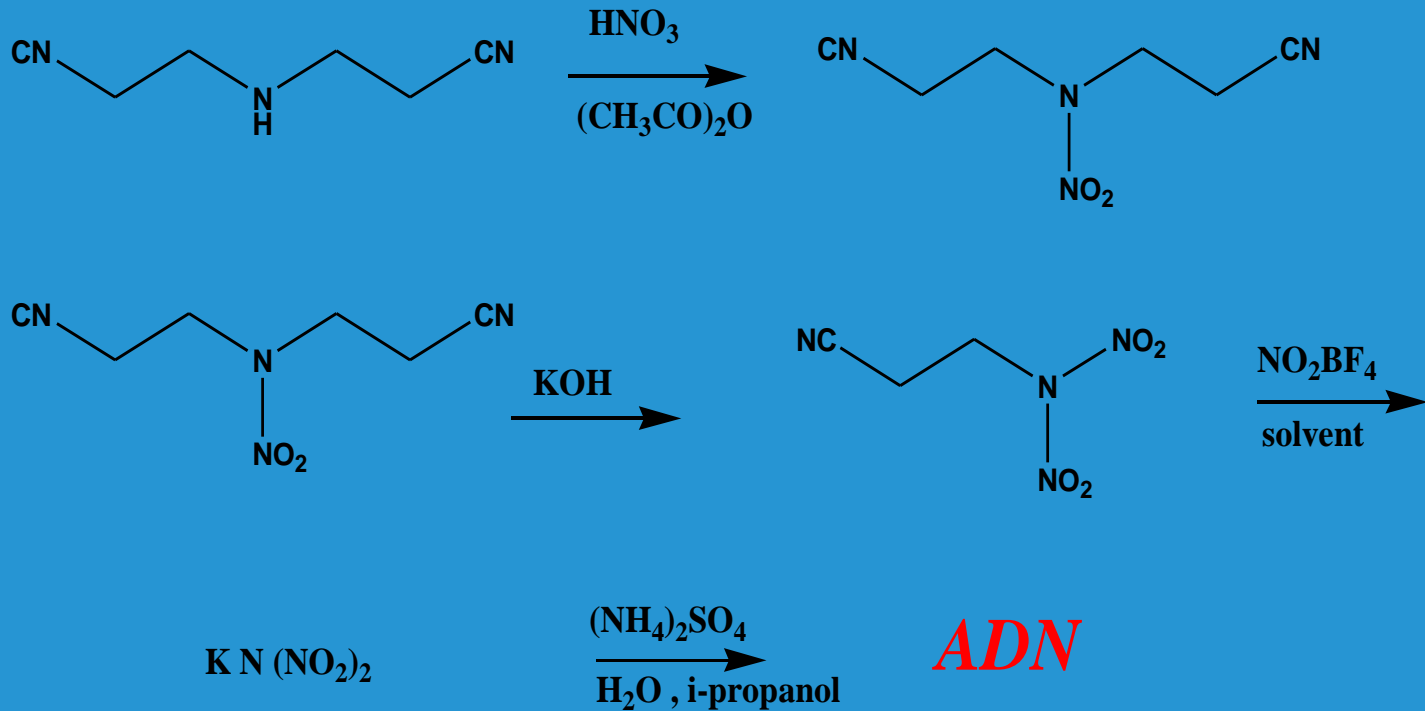
New approaches and synthons in designing known and new EM

- Energetic nitramine oxidizers
- *Gem*-dinitro derivatives
- Nitroheterocycles

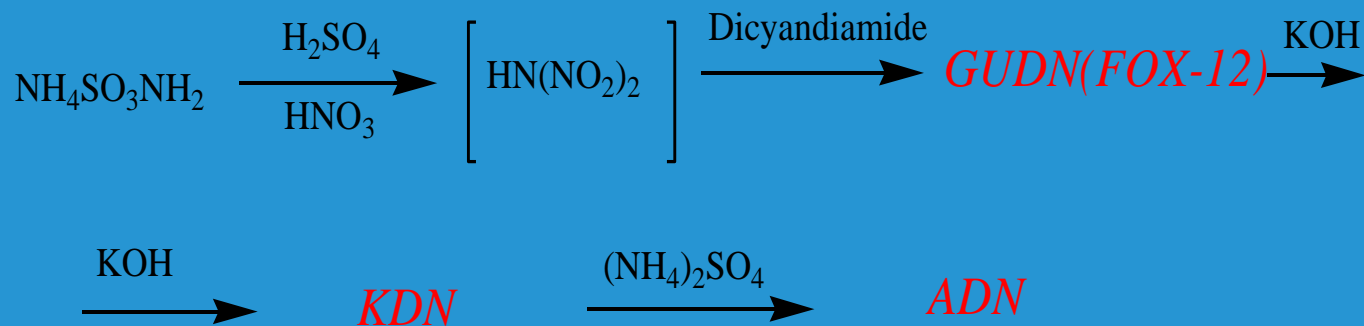
Our contribution to the area; products and methods developed

- Dinitramide and its salts
- N,N'-dinitro-urea and nitramide
- N,N'-dinitro-guanidine
- Nitroheterocycles
- Di- and tri- nitro methane and salts thereof
- 1,1-diamino-2,2-dinitro-ethene (FOX-7)

ADN, original synthesis



Advanced method for making dinitramides

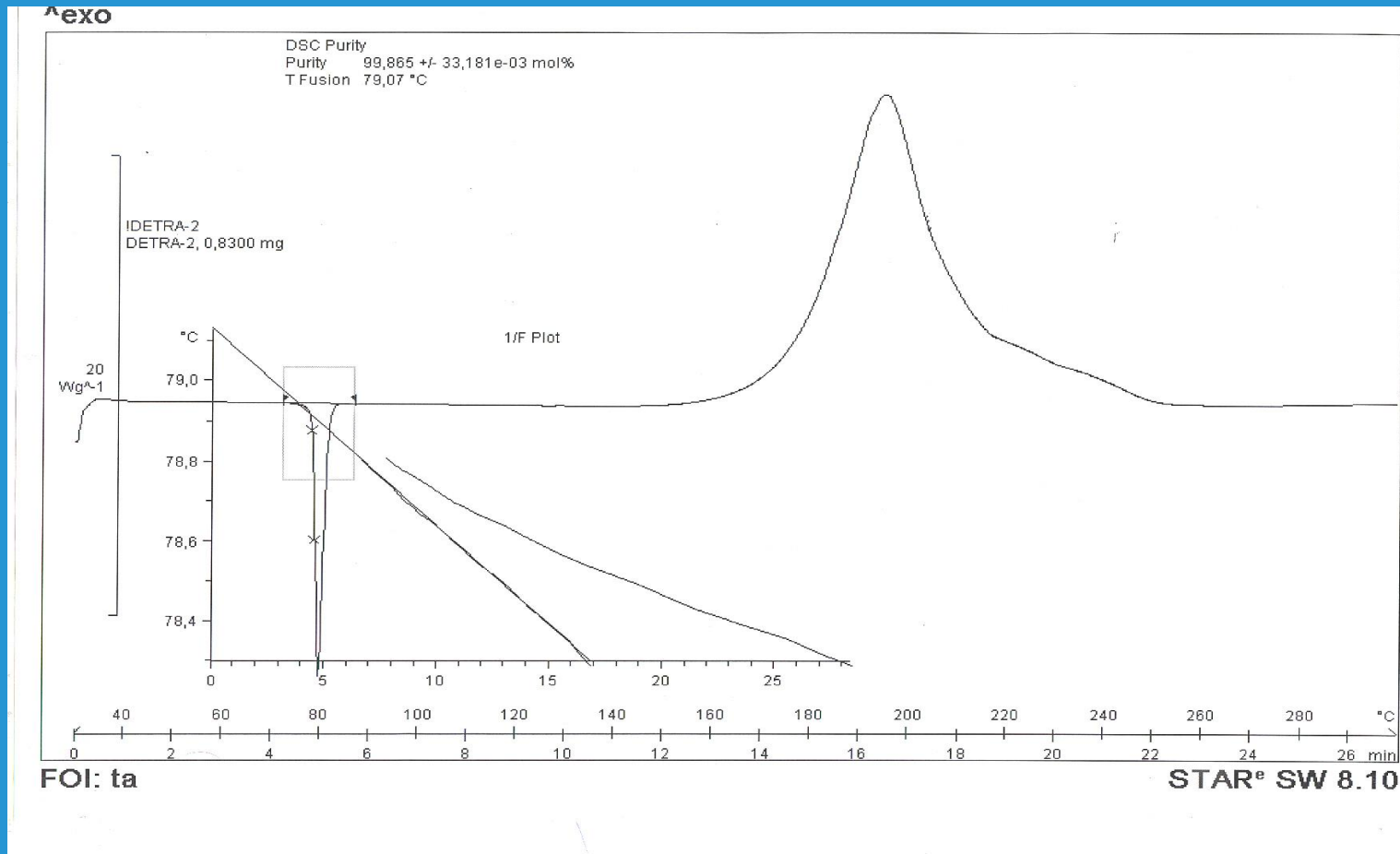


No organic chemicals

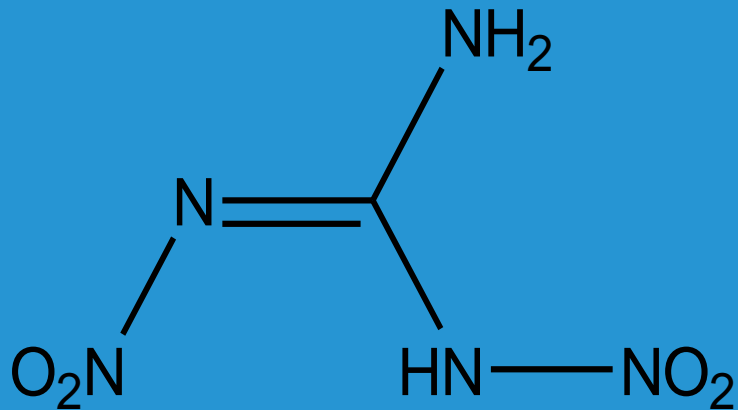
No waste waters

Three products from the same process

A new dinitramide salt, "DED", thermal properties

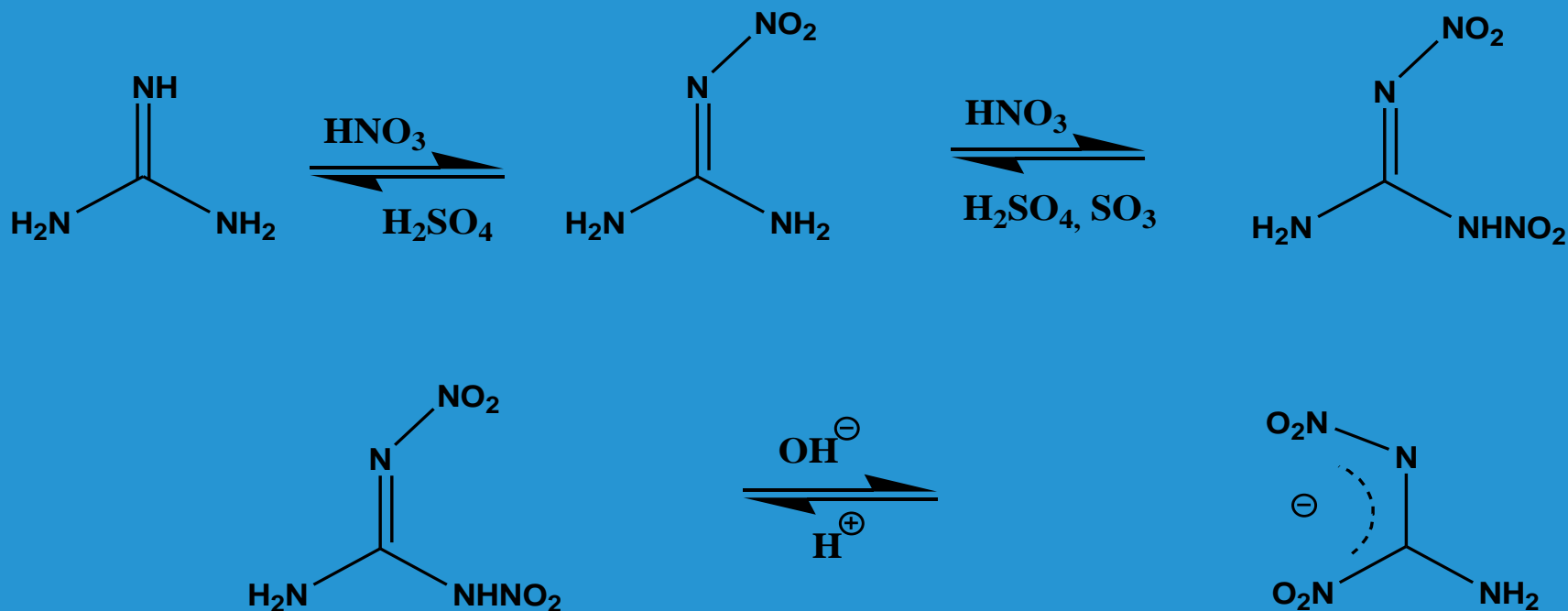


New Oxidizer, 1,2 -dinitroguanidine



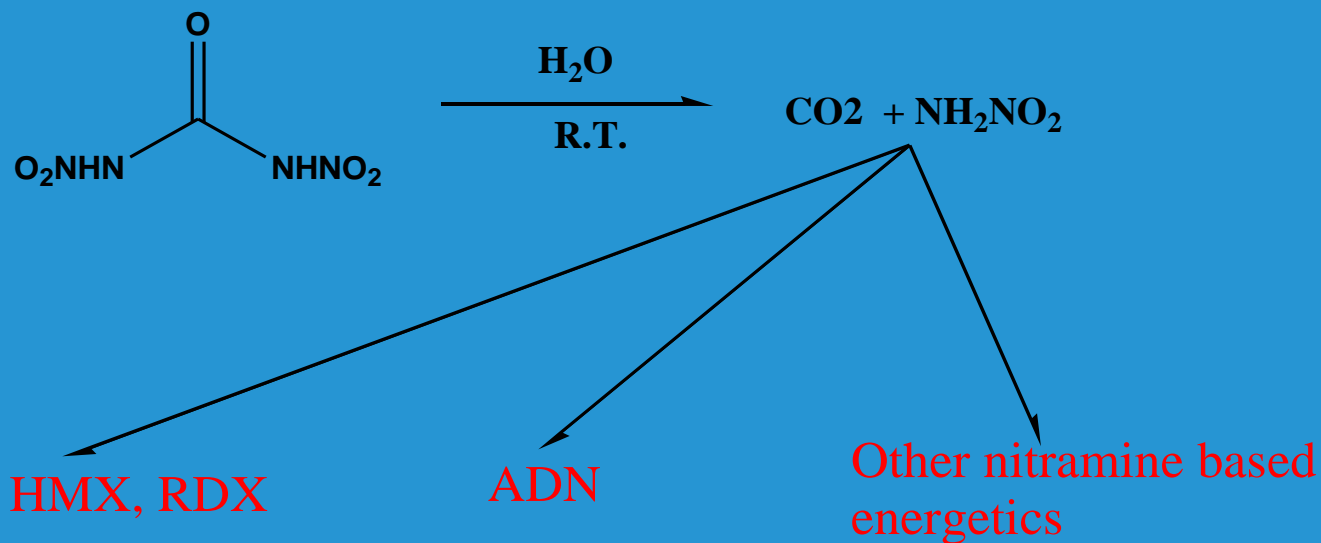
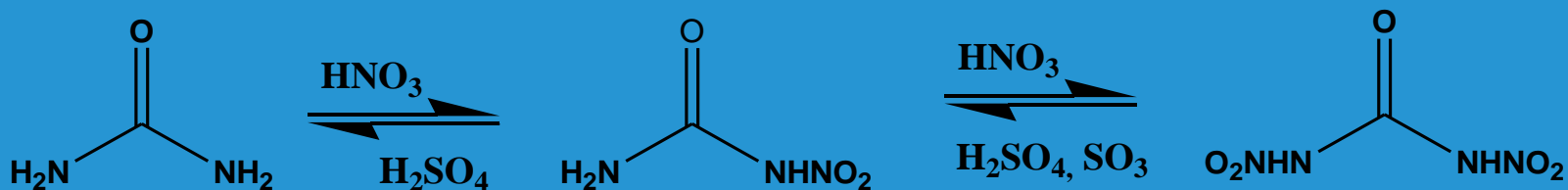
- Oxidizer (+5,4%)
- Attractive in explosive and propellant formulation
- Synthesis developed in Russia
- Synthesis and characterisation performed at FOI

1,2-dinitroguanidine; synthesis and properties

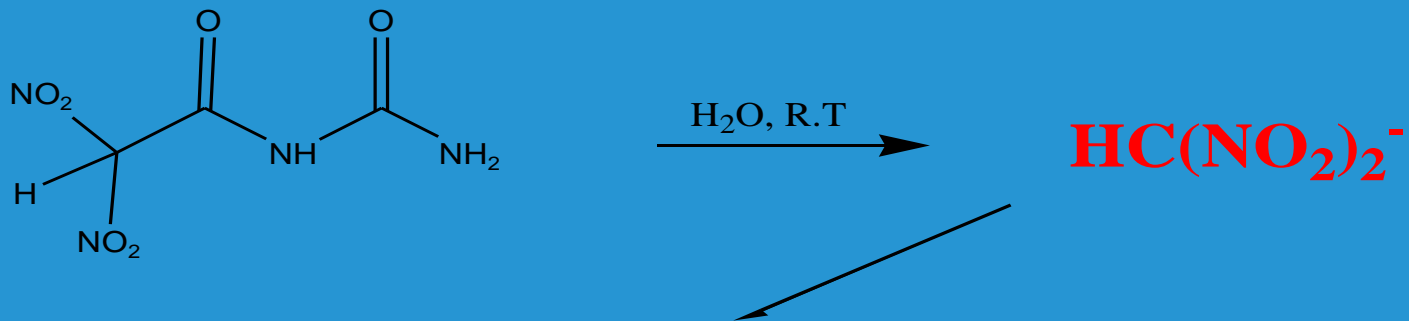
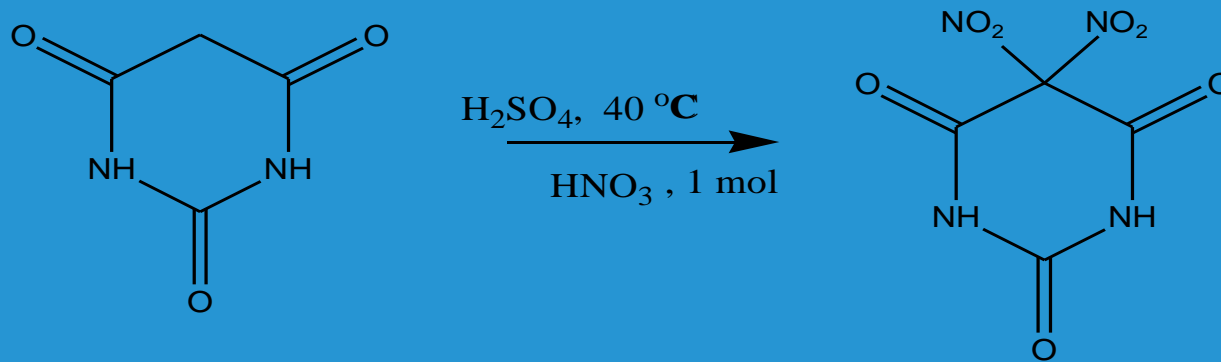


pKa = 1,2 !!!

N,N'-dinitrourea and dinitramide



Dinitromethane and derivatives



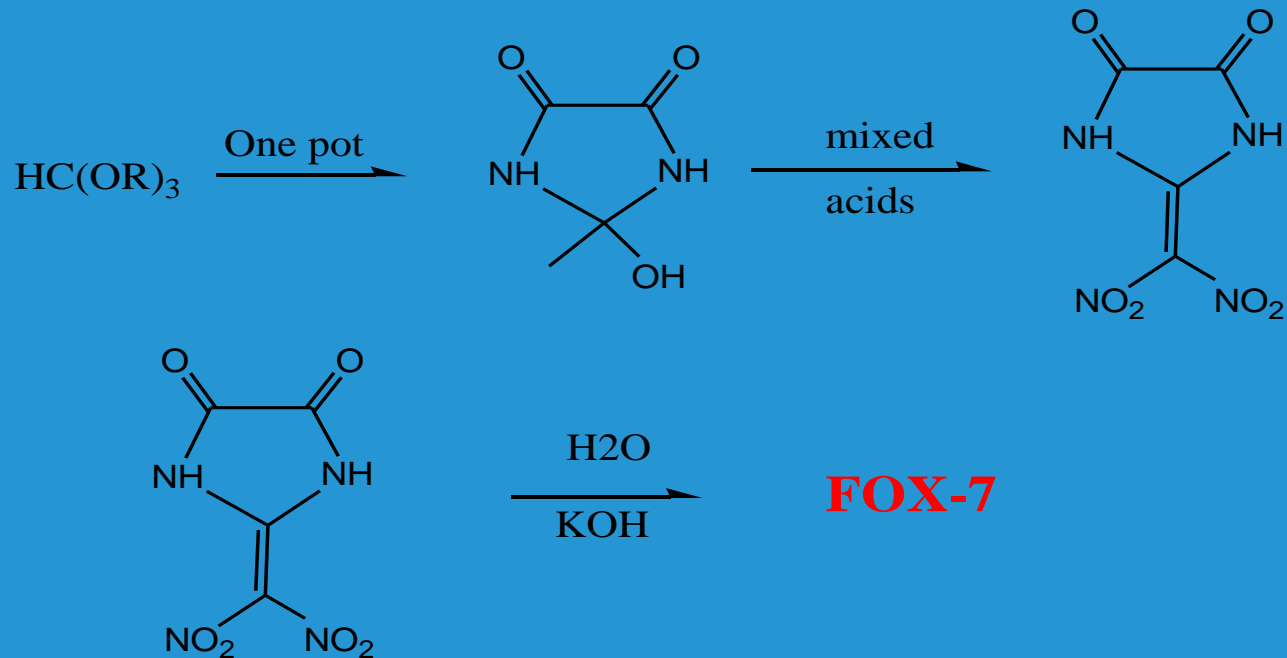
**Energetic plasticizers,
example- $\text{C}(\text{NO}_2)_2(\text{CH}_2)_3(\text{N}_3)_2$**

Nitroheterocycles

- Syntheses of 3,4 dinitro and 3,4,5,trinitropyrazoles have been developed and optimized
- Several approaches to 4-amino-3,5-dinitro-pyrazoles have been developed and optimized
- New product-N-allyl- 3,4-dinitropyrazole has been synthesized, looks promising as conceivable plasticizer

FOX-7

- A new synthetic procedure developed lately



FOX-7 explosive properties in comparison with known substances;
 Russian data(34th Annual Conference of ICT,poster 119)

Explosive	ρ , g/cm ³	Q,expl., Kcal/kg	ΔH_f , Kcal/mol	d_{cr} ,mm	D, km/s	M.P.A., %
TATB	1,938	920	-39,4		8,00	81,8
TNT	1,654	1030	-15,0		6,95	75,6
FOX-7	1,885	1090	-31,0	5-6mm	8,73	89,2
RDX	1,802	1320	16,0		8,86	95,6
HMX	1,904	1340	20,9		9,26	100,0

FOX-7 explosive properties in comparison with known substances;
 Russian data (Annual all-Russian Conference on EM, 2006, Moscow)

Composition	D, m/ sec	Pcr, kbar
HMX-98, TNT-0,5; Vinilit(binder)	8900	23
FOX-7-98; TNT-1,5; Vinilit-0,5	8740	32
HMX-97,5; PMA-1,2; Wax-0,8; grafite-0,5	8800	30
RDX-98; PMA-1,0 Wax-1,0	8700	32
FOX-7-97,5; PMA-1,2; Wax-0,8; grafite-0,5	8730	47

Summary

- **Do we really need new Energetic Materials?!?**
- **If so, the customers should realize that:**

New energetic fillers

- New energetic fillers with performance not more than 20-25% over that of HMX may be synthesized at the expense of inferior IM properties,
- Examples CL-20, Hexanitrobenzene

New energetic fillers

New energetic fillers with good compromise between performance (RDX level) and sensitivity (TNT level) may be synthesized at the expense of higher production cost.

Examples- FOX-7 and LLM-105

New energetic binders/plasticizers

New energetic plasticizers and binders with good performance and improved thermal stability may be synthesized at the expense of increased production cost

Examples- BDNPA/F ; GAP

Conclusions and acknowledgements

- FOI's activity in the synthesis of new energetic materials has facilitated development of several new EM
The participation and technical assistance of Stefan Ek, Larisa Judina, Martin Johansson, Frederic Alvarez, Marita Wanhatalo and Patrick Goede as well as many others is also highly appreciated

Thank you for your attention (and patience)