Uptake and Fate of Explosives : TNT, RDX, AND HMX in Poplar Tissues (*Populus deltoides* X *nigra,* DN34)

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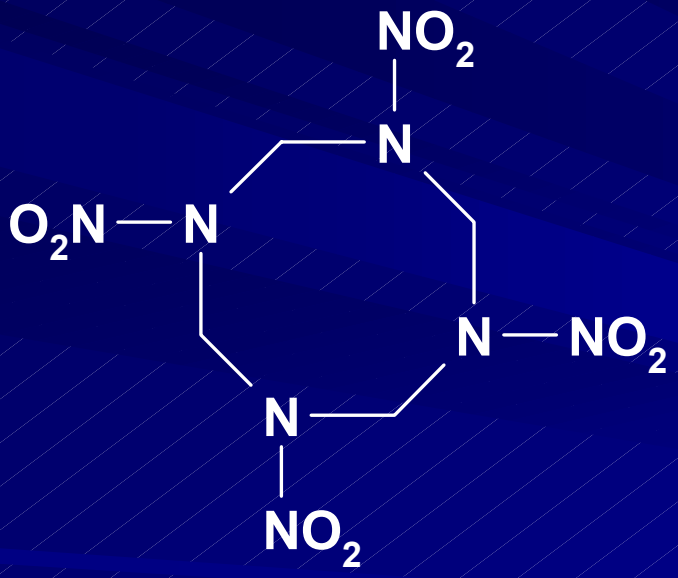
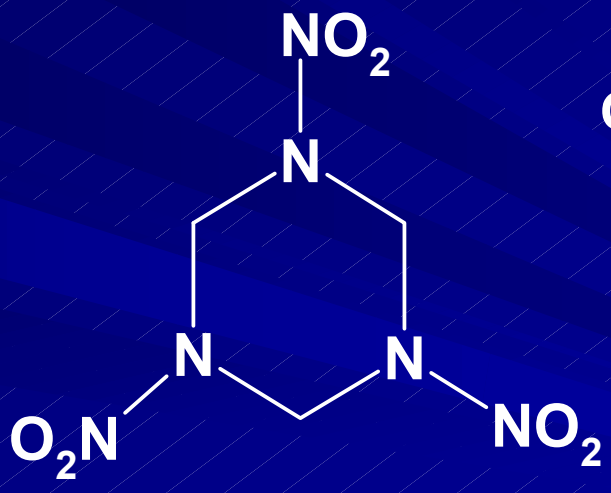
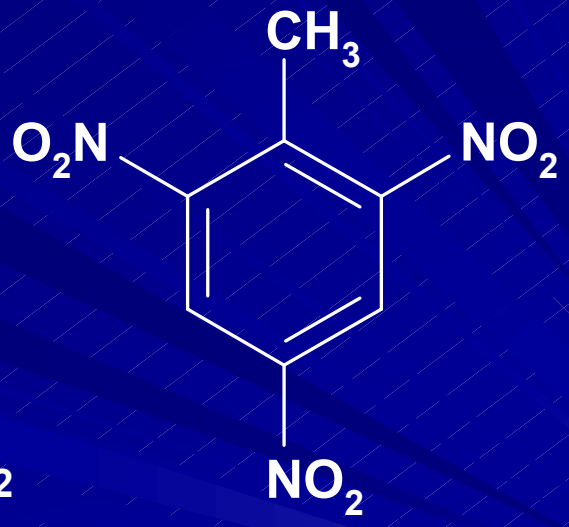
Molecular Structures of HMX, RDX, and TNT



HMX



RDX



TNT

Long plumes of RDX are present in groundwater at Iowa Army Ammunition Plant

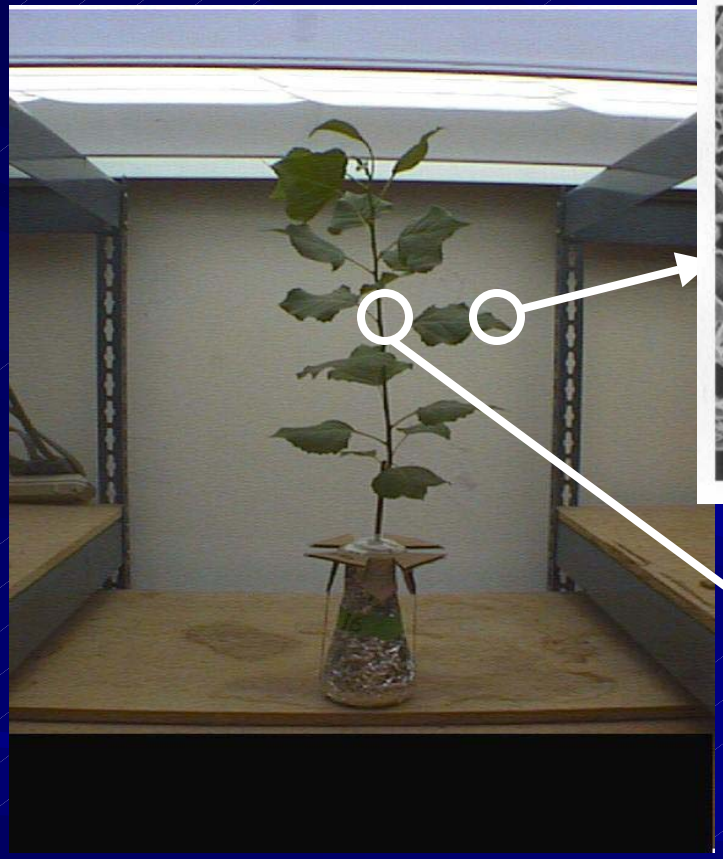
- From leaking wastewater ponds and lagoons
- Spills in manufacturing, open detonation, and decommissioning
- Improper treatment of wastewater produced in manufacturing processes

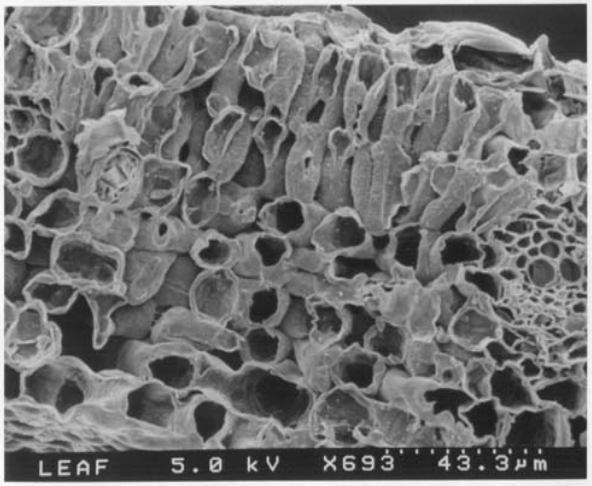
Physical and Chemical Property of HMX,RDX, and TNT

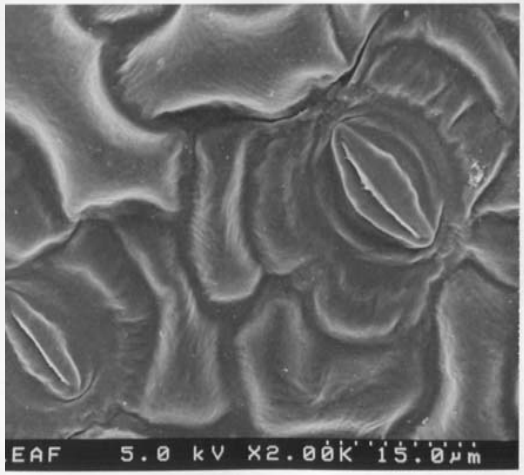
	HMX	RDX	TNT
Log K_{ow}	0.06-0.26	0.81-0.87	1.6-1.84
Solubility in water (mg/L)	6	42	100
Vapor Pressure (mmHg)	$3.3x10^{-14}$	$1.0-4.0x10^{-9}$	$1.99x10^{-4}$
Henry's Constant (atm-m^3/mole)	$2.6x10^{-15}$	$1.2x10^{-5}$	$4.57x10^{-7}$

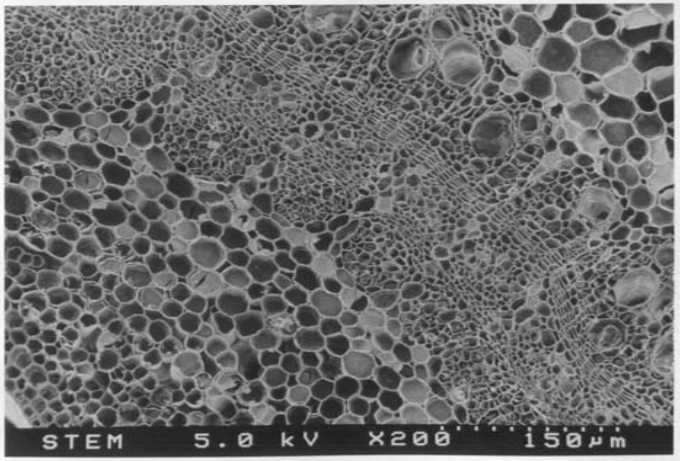
Data taken from Talmage et al., (1999)

Morphology of Hybrid Poplar Tissues







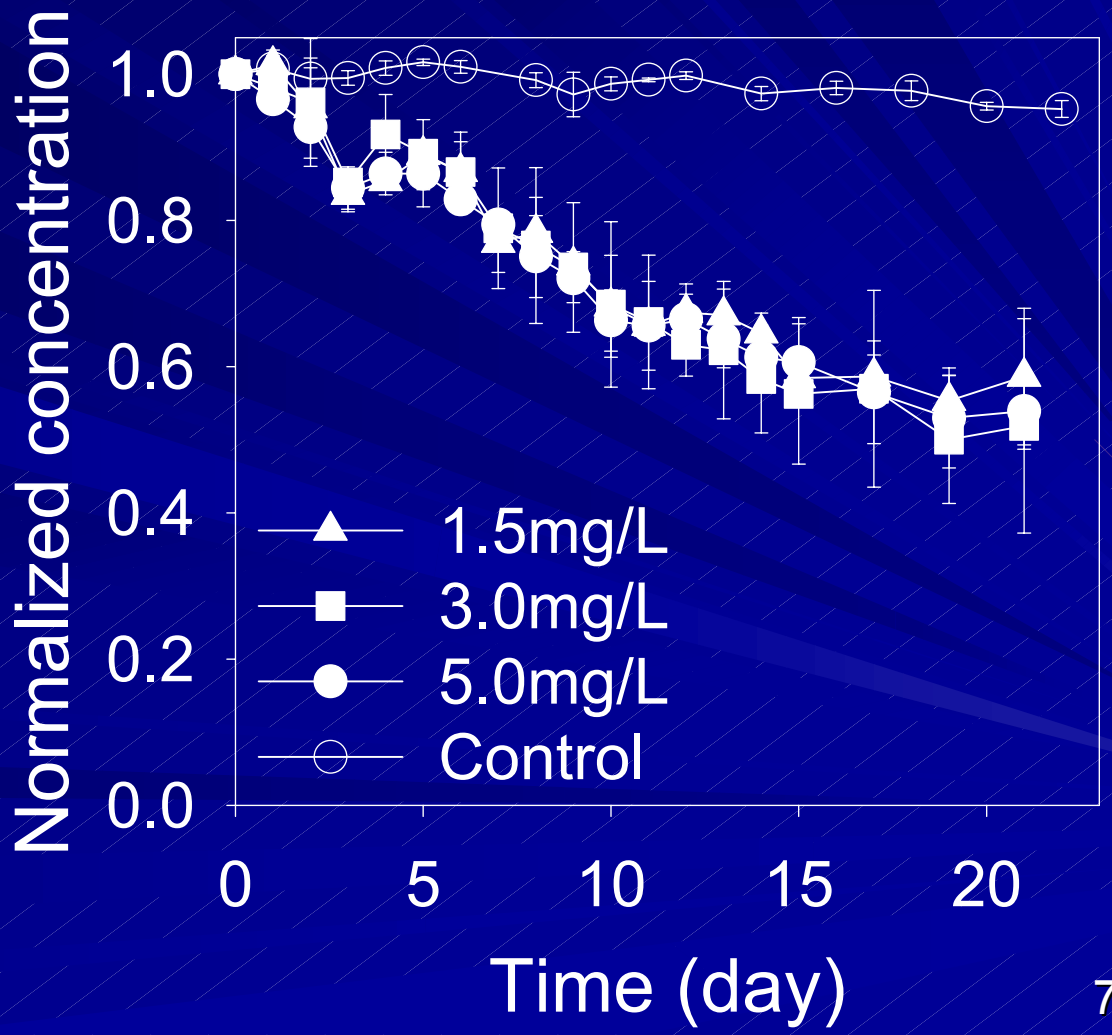


***Populus deltoides* x *nigra* DN-34**

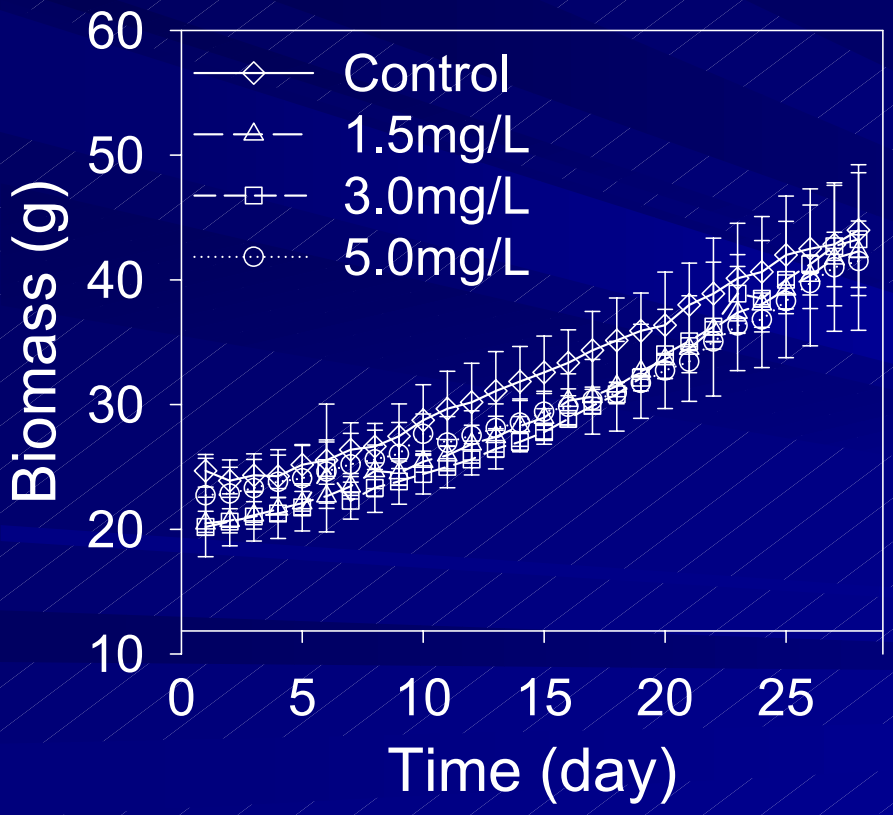
Objectives

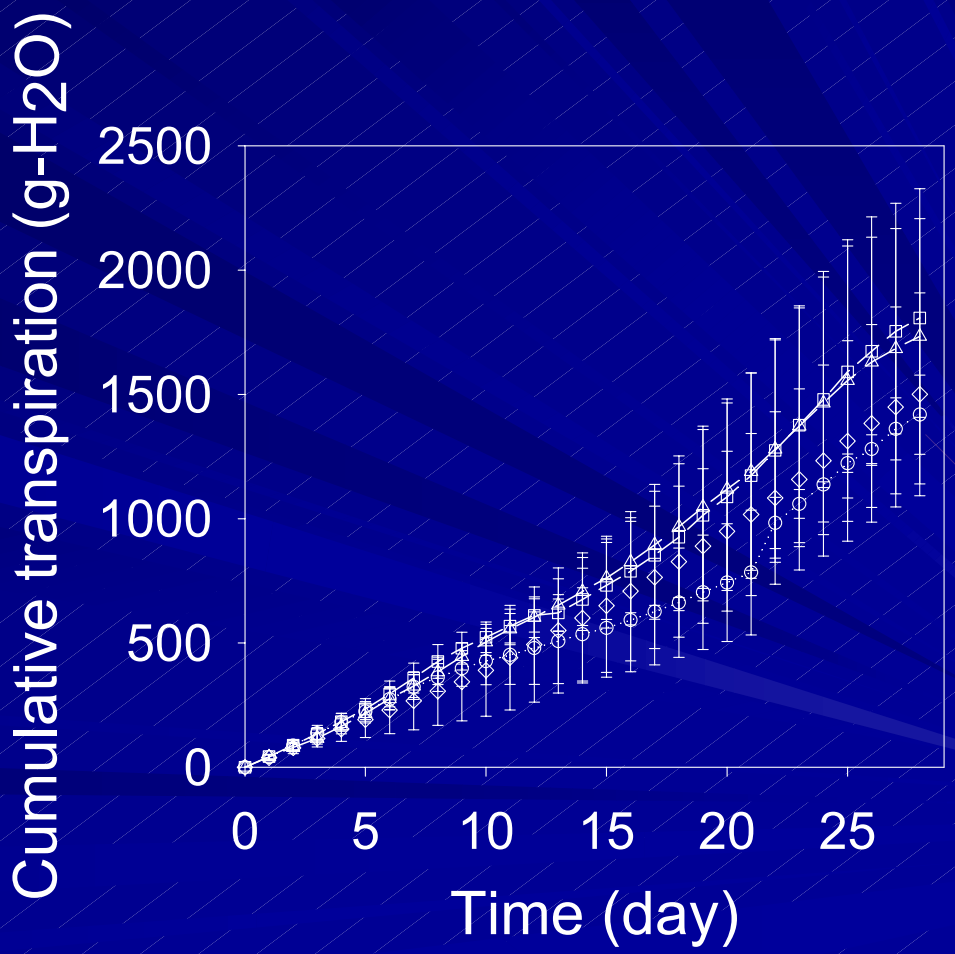
- Investigate uptake and transformation of HMX
- Compare fates of TNT, RDX, HMX in plants
- Investigate transformation of explosives using a different plant material
- Study leaching of contaminants from leaf tissues exposed to explosives

Uptake of HMX from batch reactor under hydroponic solution

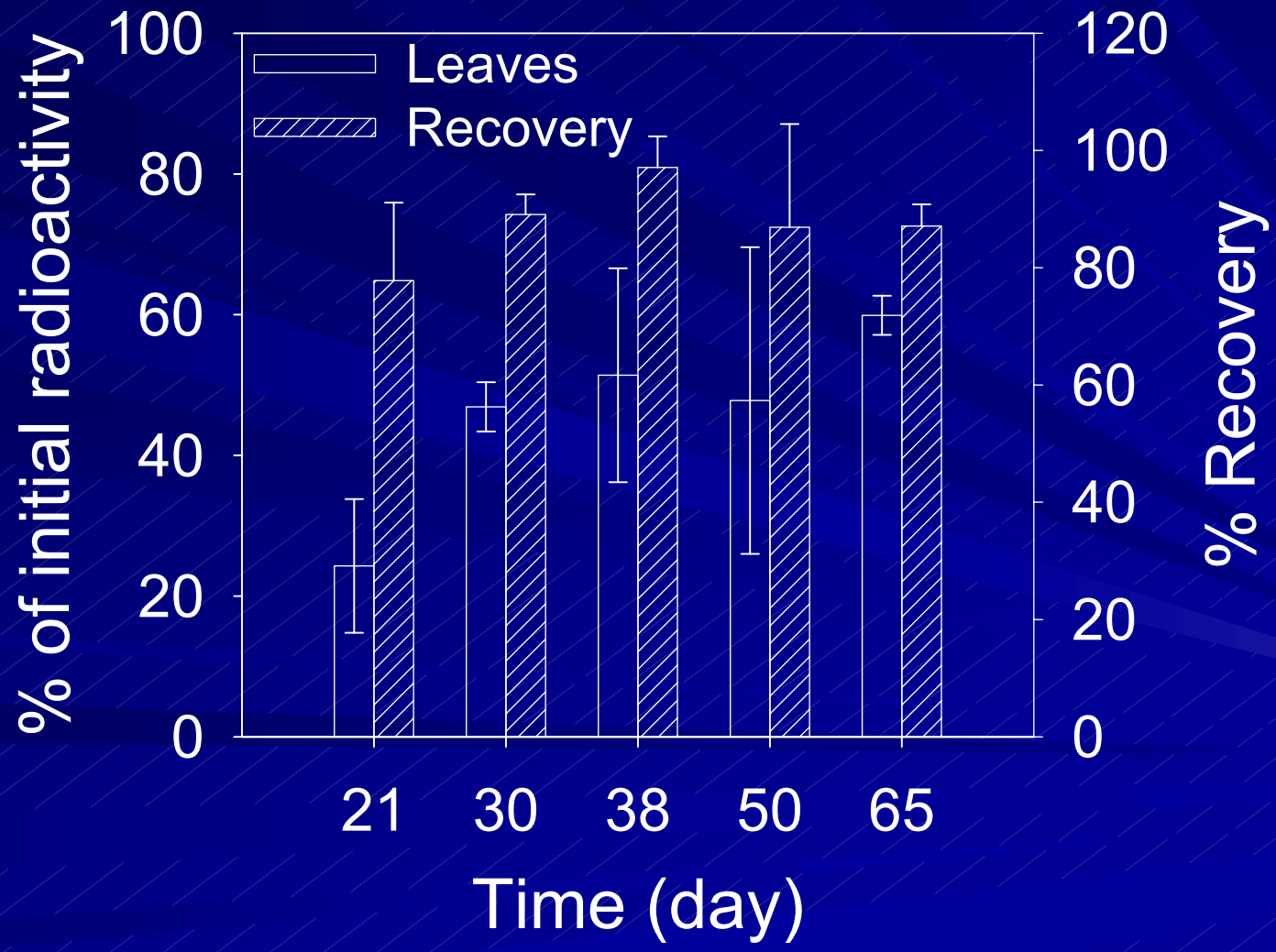


No phytotoxicity of HMX:poplar cuttings in chemostats demonstrate continuous growth and transpiration even at the solubility limit

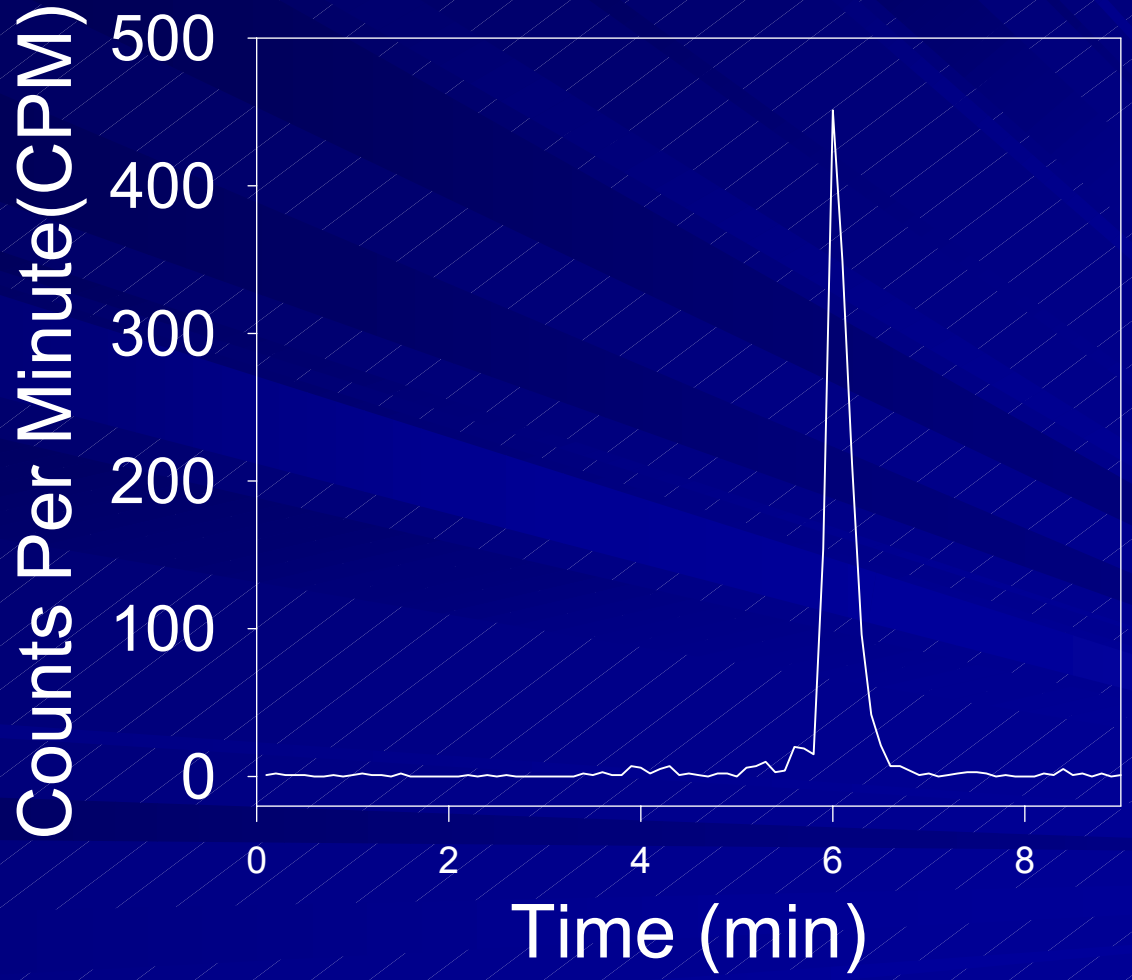




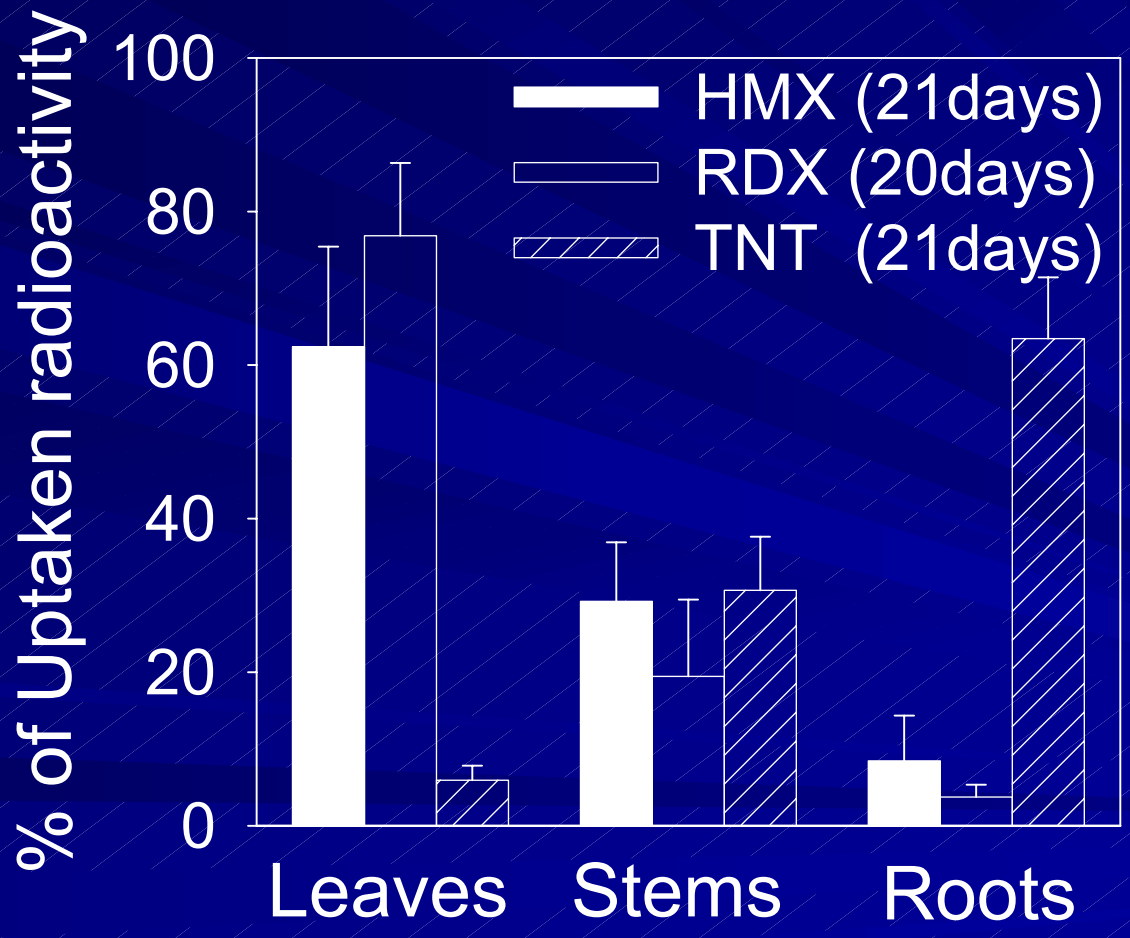
Percent radioactivity in leaves exposed to ^{14}C HMX and total recovery



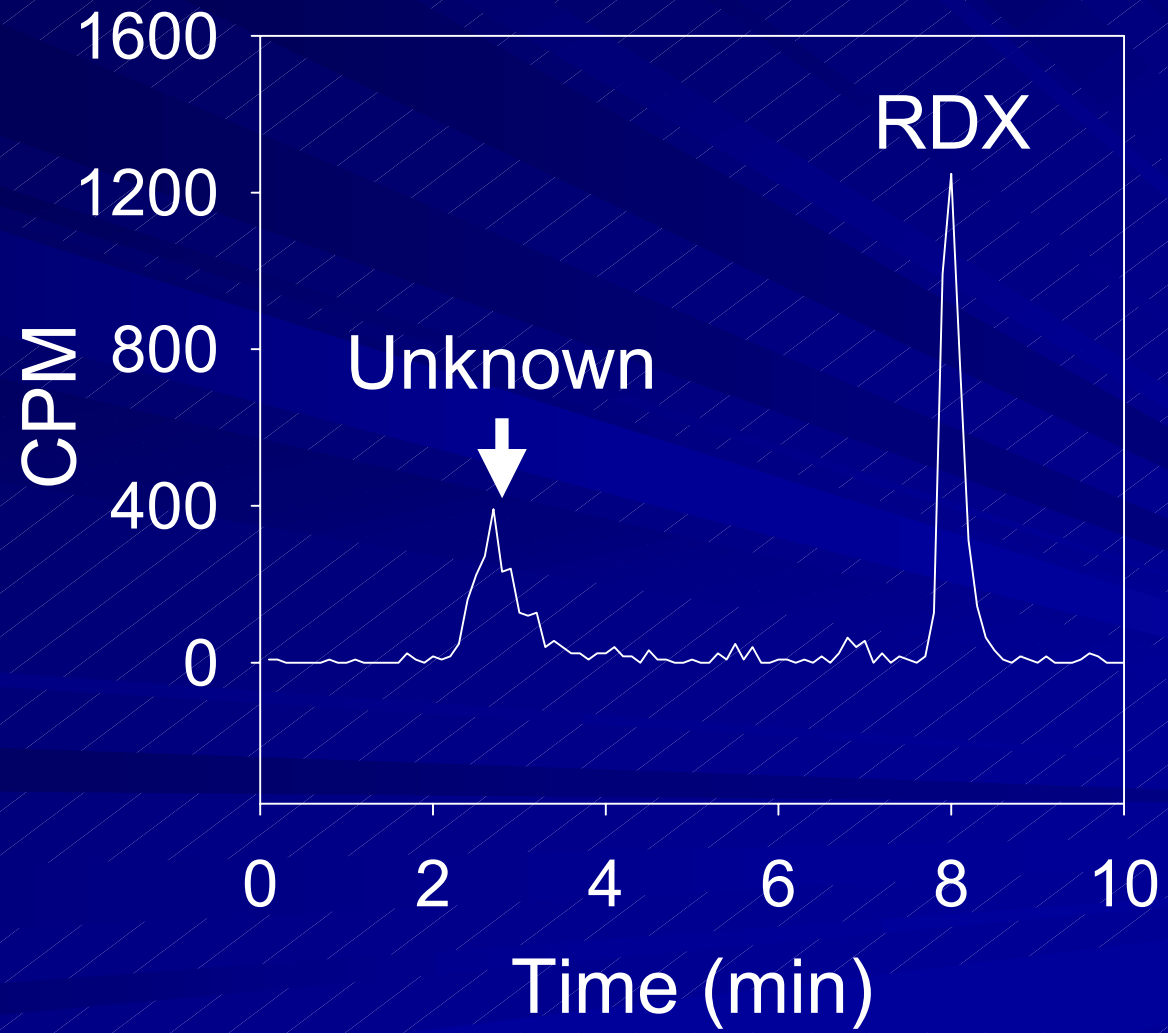
Radiochromatogram from extracts of leaves exposed to HMX after 50 days



Distribution of ^{14}C in plants



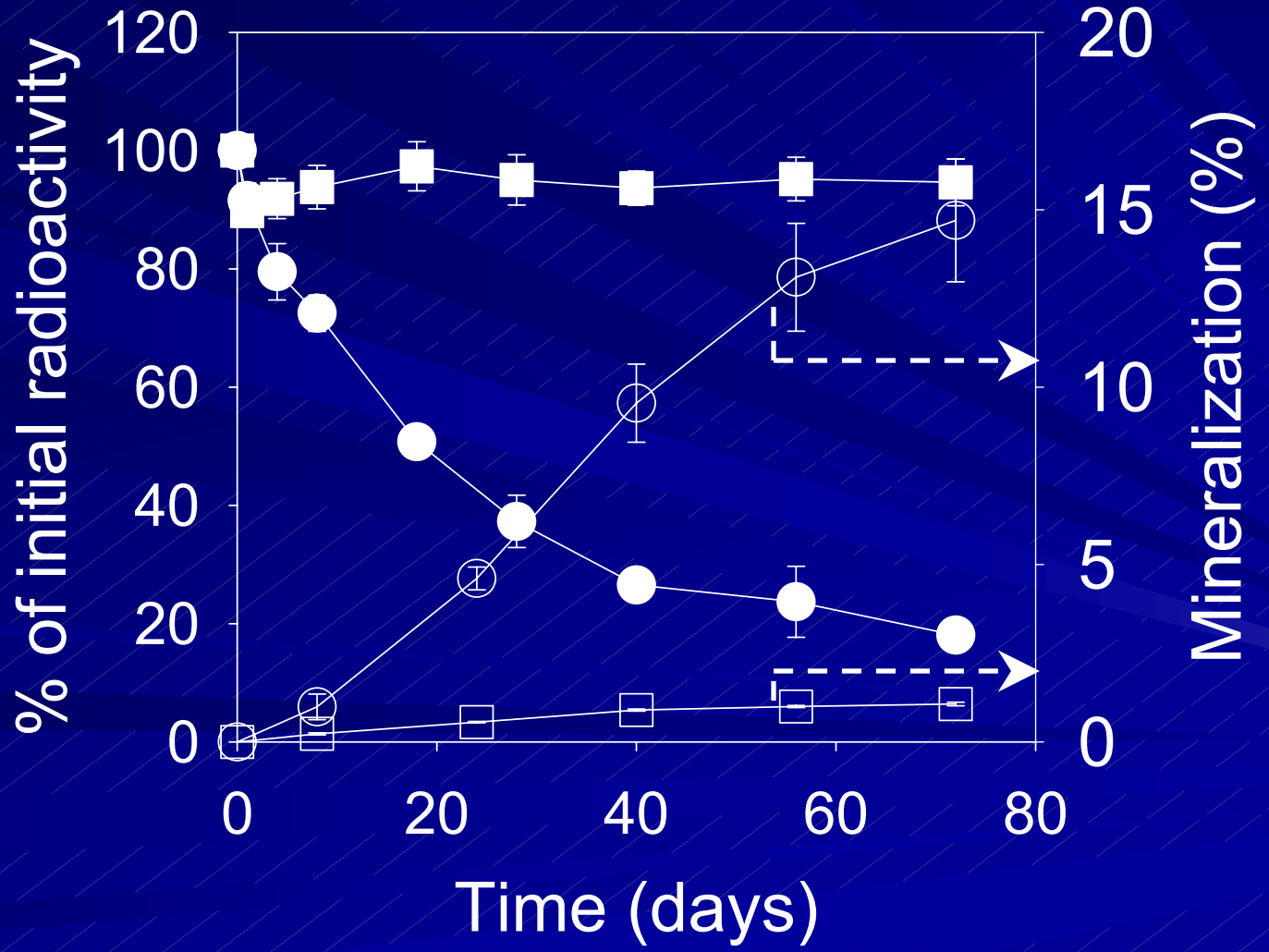
Radiochromatogram from extracts of leaves exposed to RDX for 30 days



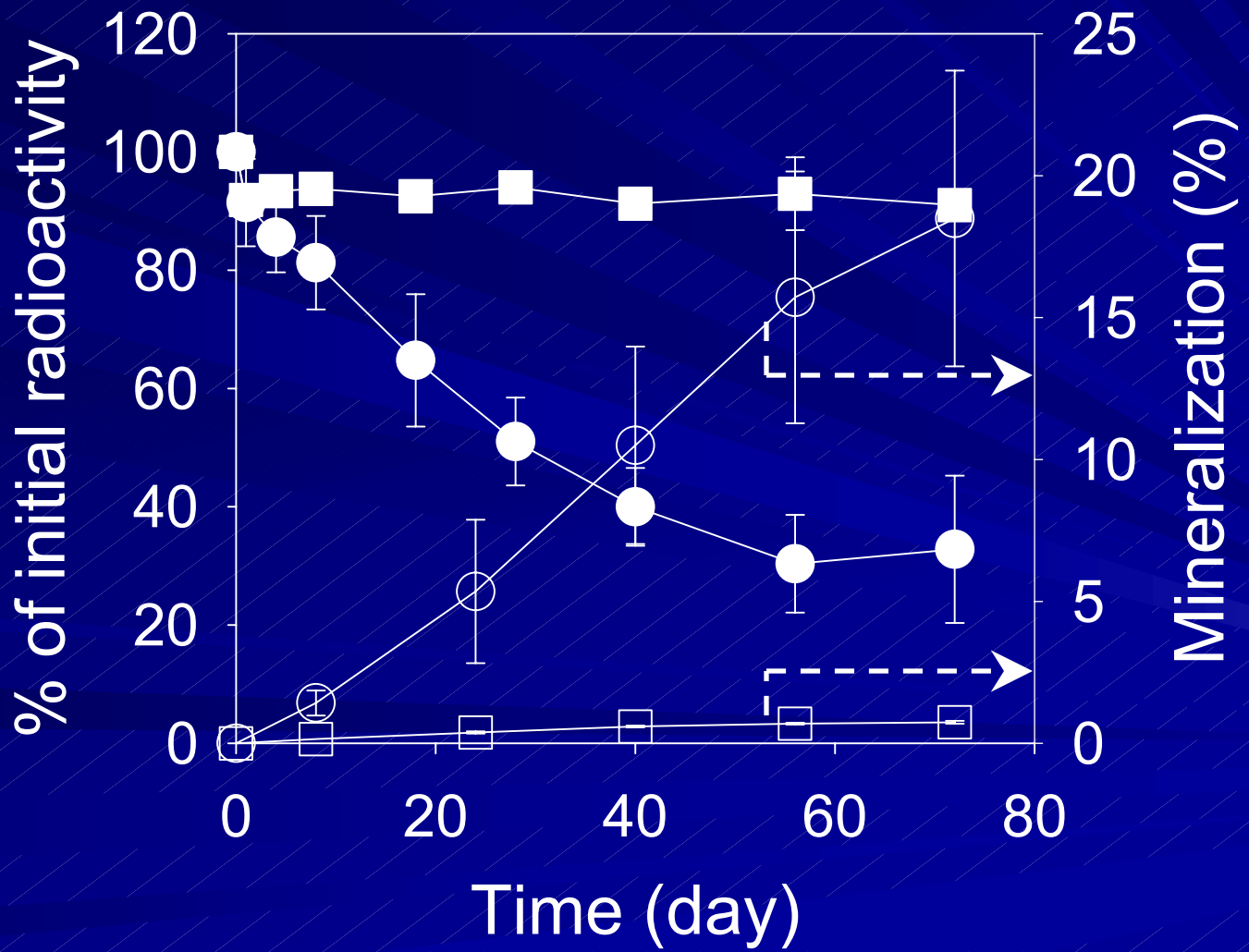
Nodules

- Nodules
  - Meristemic
  - Well differentiated
  - Round shape of cell clusters
- Advantages of cell cultures
  - Axenic
  - Space saving
  - Small amount of chemicals
  - All seasons

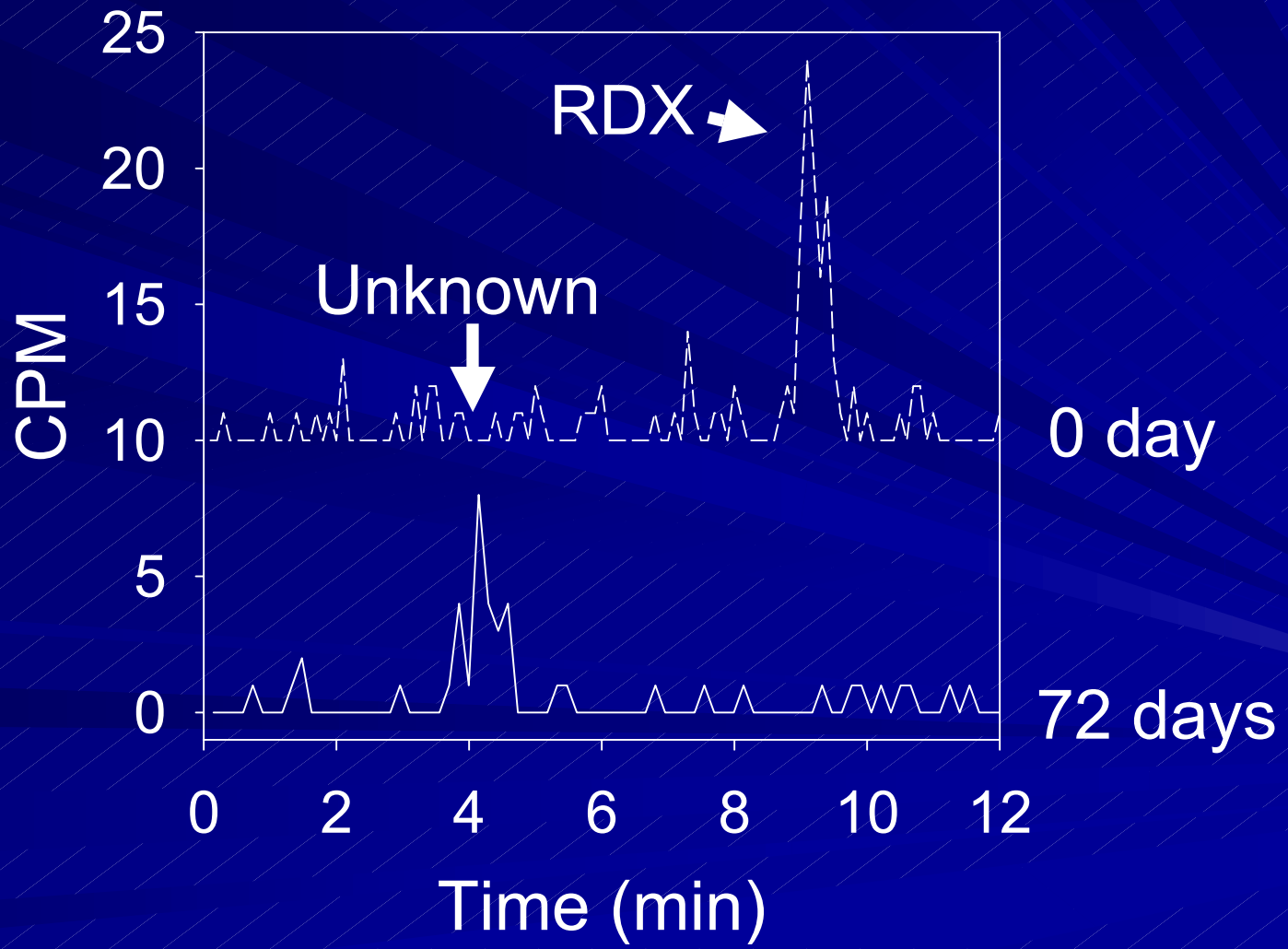
Mineralization of **RDX** by nodule cultures



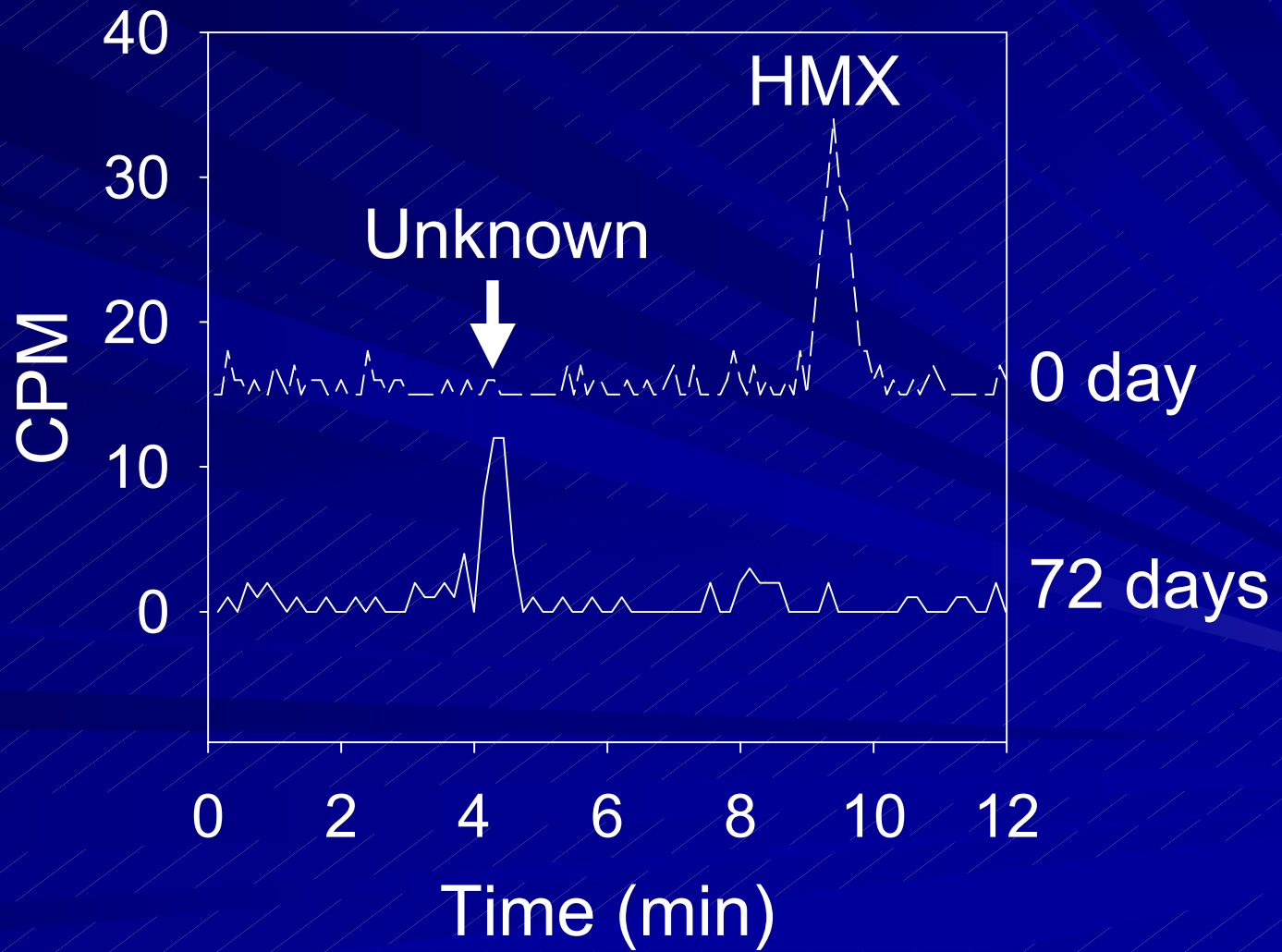
Mineralization of **HMX** by nodule cultures



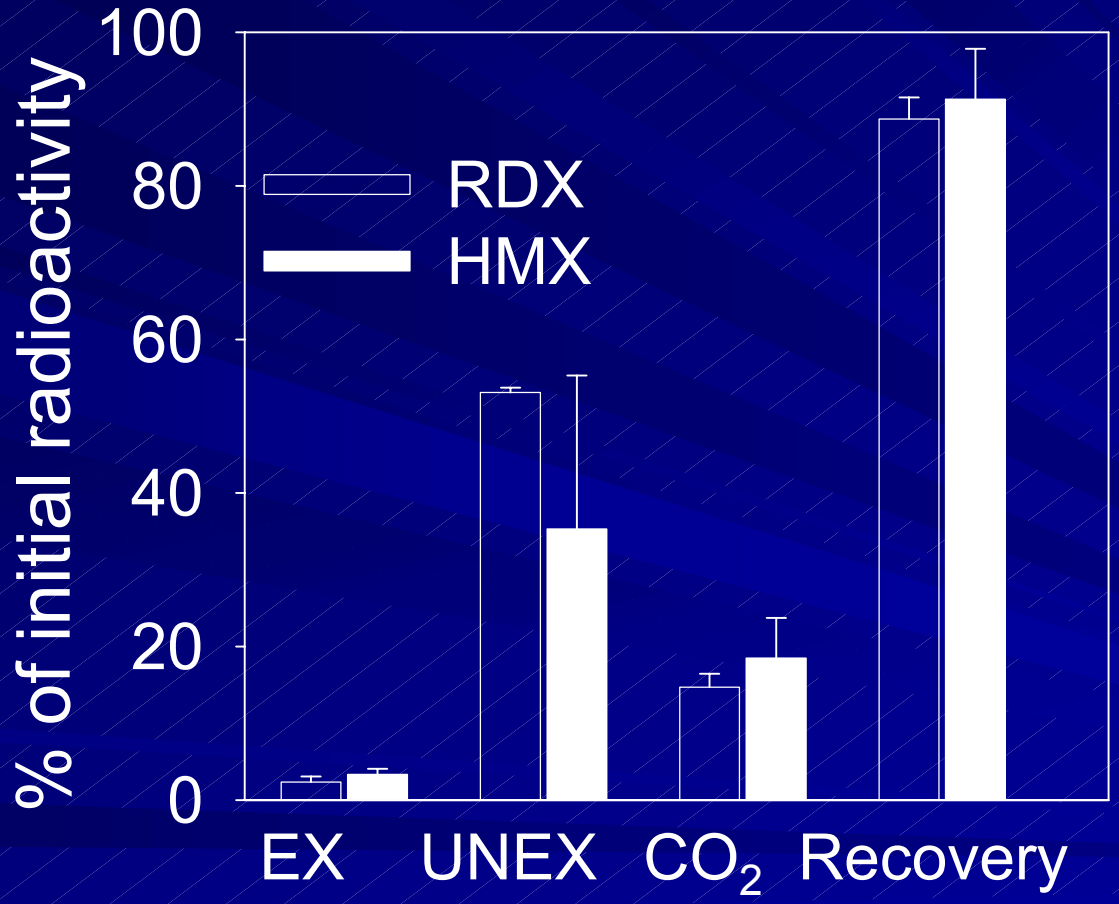
Radiochromatograms of liquid media at 0 day and after 72 days (RDX exposure)



Radiochromatograms of liquid media at 0 day and after 72 days (HMX exposure)

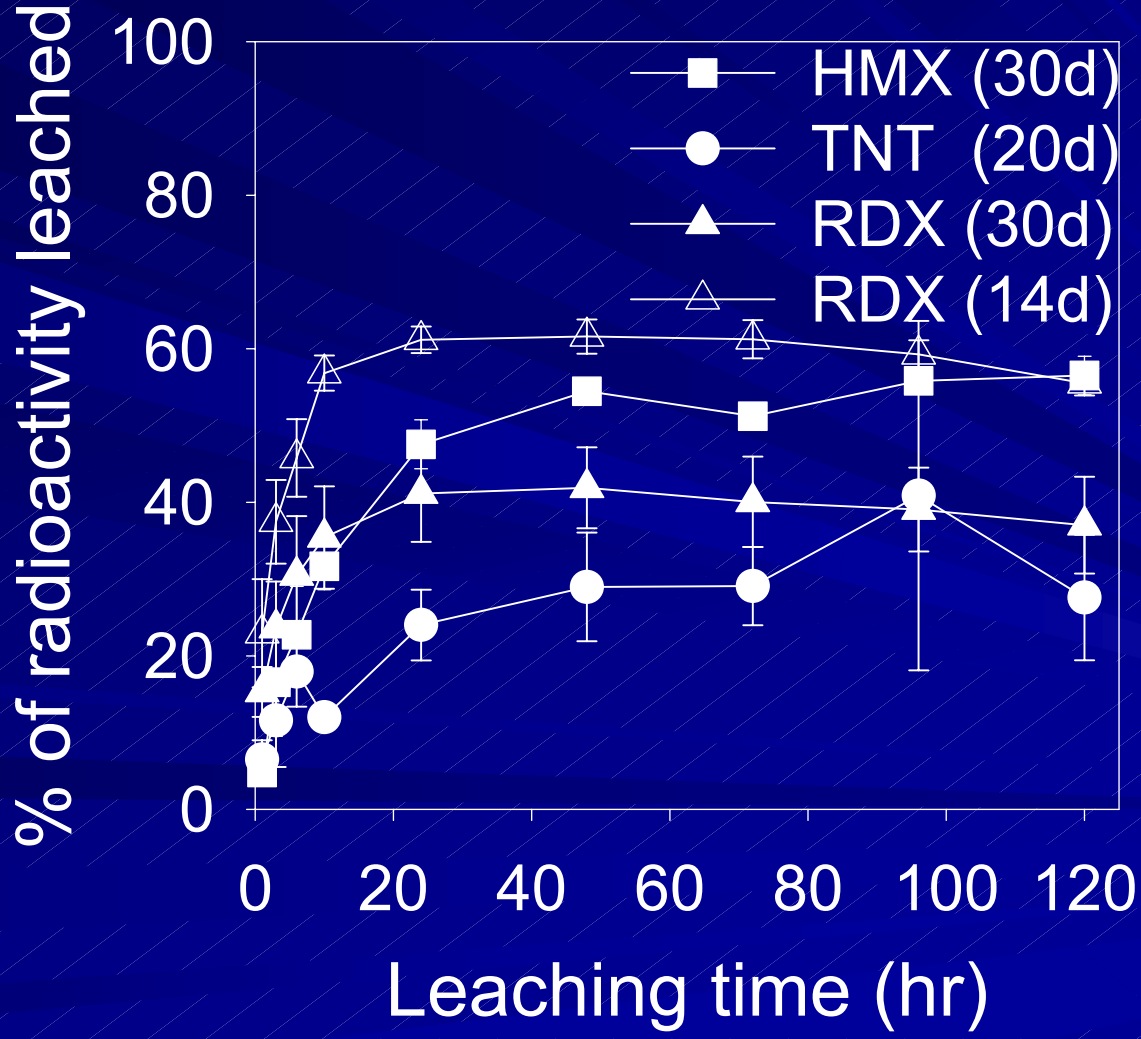


Distribution of ^{14}C-label in nodule cultures exposed to RDX and HMX

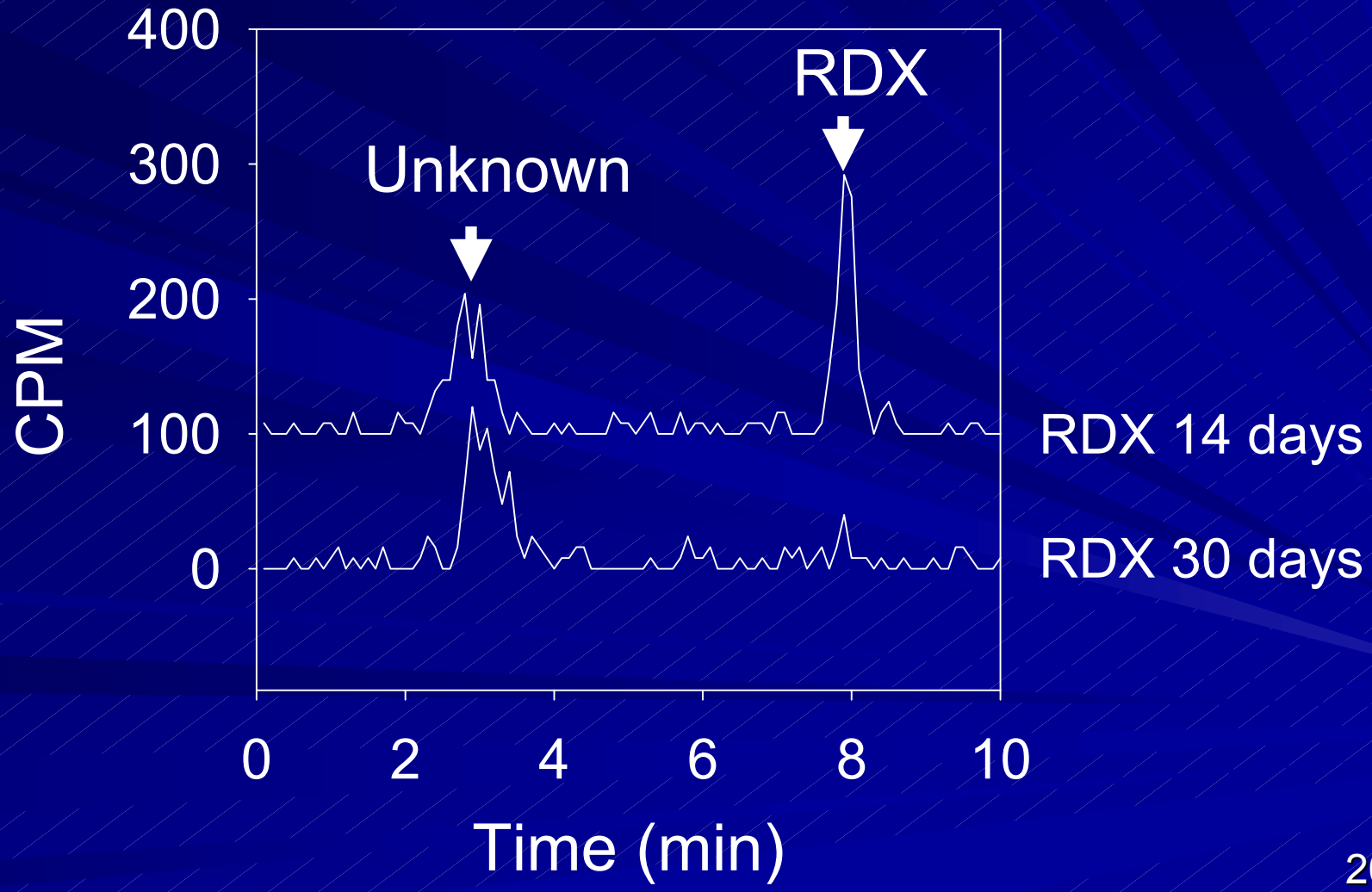


EX:Extractable UNEX:Unextractable

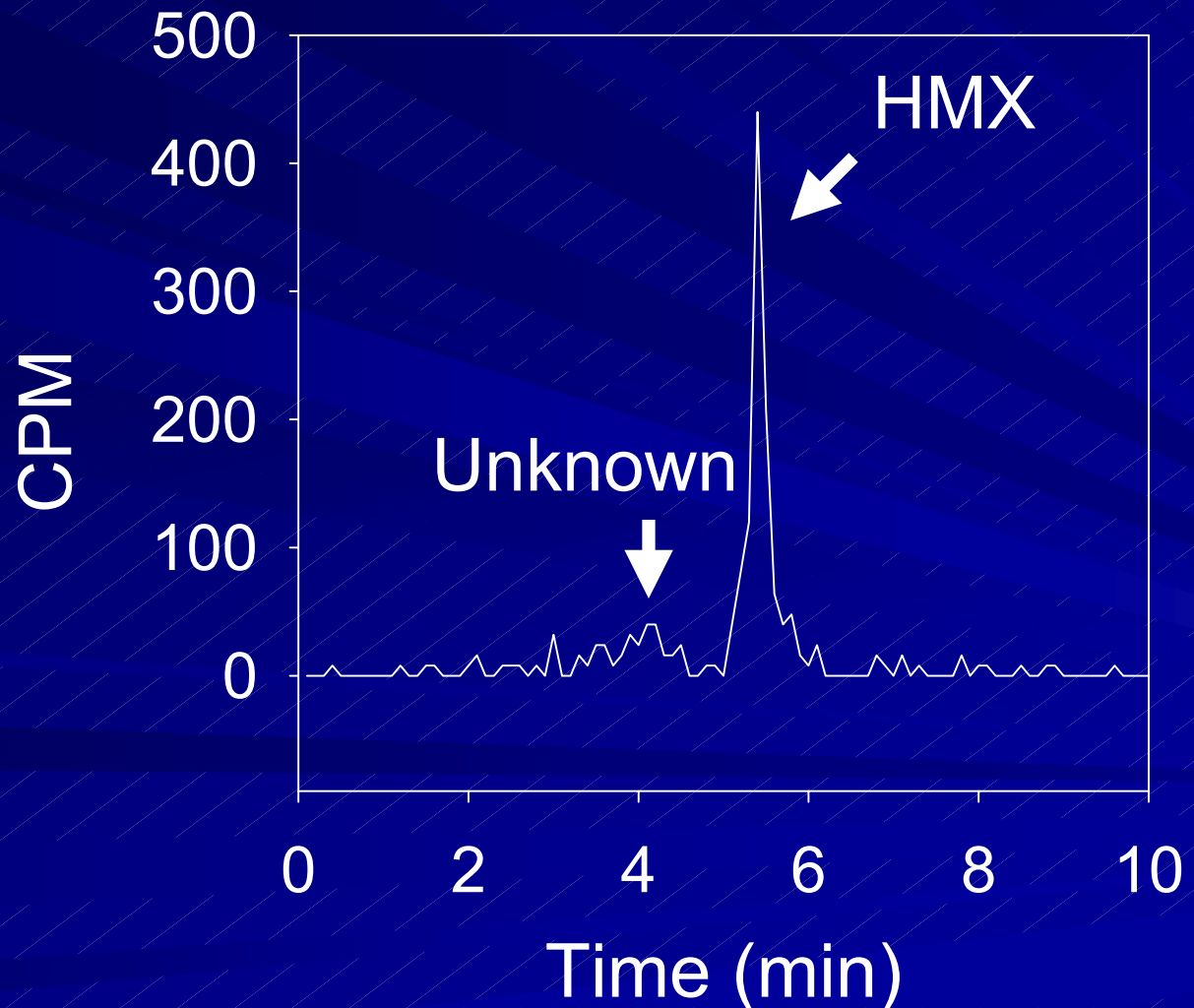
Leaching of radiolabel by water from dried leaf tissues after exposure to HMX, RDX, and TNT



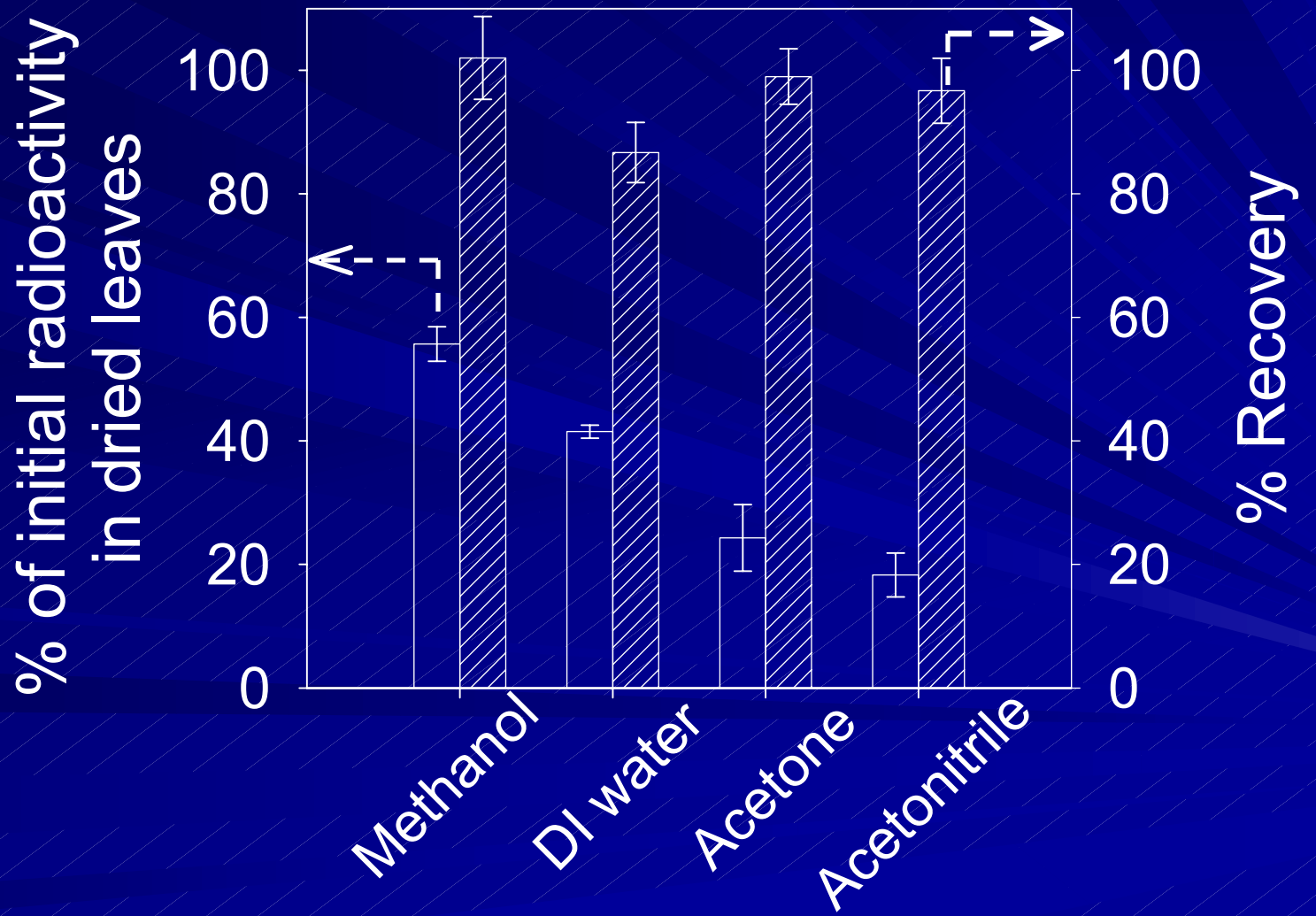
Radiochromatograms of aqueous phase after 5 days leaching from dried leaves, poplars exposed to RDX for 14 and 30 days



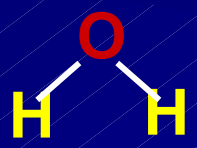
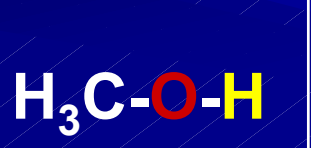
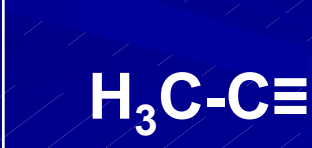
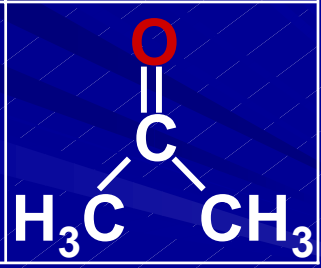
Radiochromatogram of aqueous phase after 5 days leaching from dried leaves, poplars exposed to HMX for 30 days



Radioactivity in different solvents after 5 days and total recovery



Solvent Effects:protic solvents cause more leaching of RDX, HMX, TNT and their products

	Protic		Aprotic	
	Water	Methanol	Acetonitrile	Acetone
Dielectric constant* (at 20 °C)	80.1	33.0	36.64	21.01
Molecular Structures				

*Data taken from CRC Handbook of Chemistry and Physics (CRC Press)

Summary

- HMX was not toxic to hybrid poplars.
- HMX and RDX were translocated into leaves, but TNT was not translocated readily to shoots/or leaves.
- Nodules transformed HMX and RDX, and mineralized them into CO_2 , approximately 15-18%.
- RDX, HMX and their metabolites were leached from dried leaves more easily than TNT and its metabolites.

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