

“We are like tenant farmers chopping down the fence around our house for fuel when we should be using Nature's inexhaustible sources of energy — sun, wind and tide. ... I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that.”

--Thomas Edison, in conversation with Henry Ford and Harvey Firestone (1931);

*Uncommon Friends : Life with Thomas Edison, Henry Ford, Harvey Firestone, Alexis Carrel & Charles Lindbergh* (1987) by James Newton, p.

# Enhanced Sensing Utilizing Raman Spectroscopy

Carl C. Wamser Symposium

Portland State University

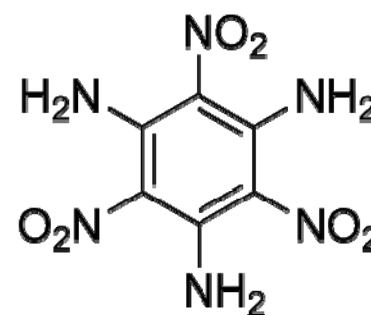
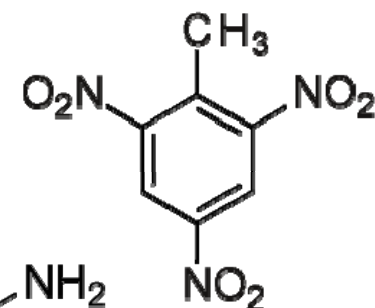
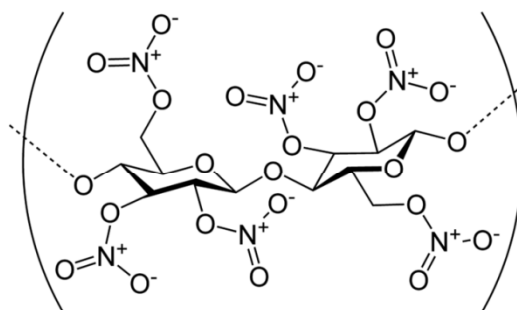
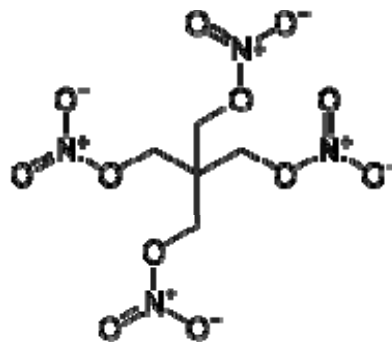
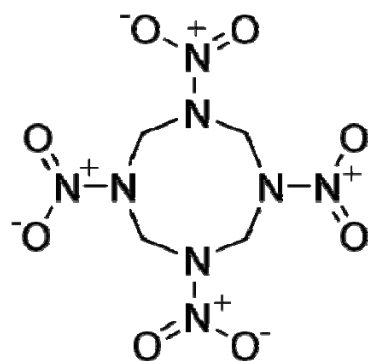
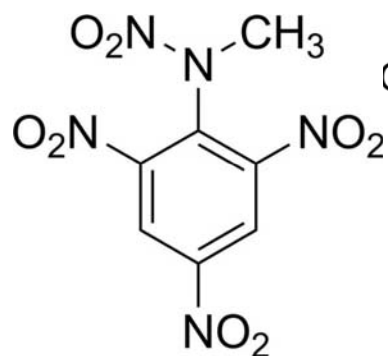
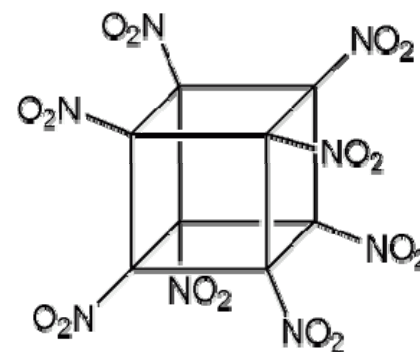
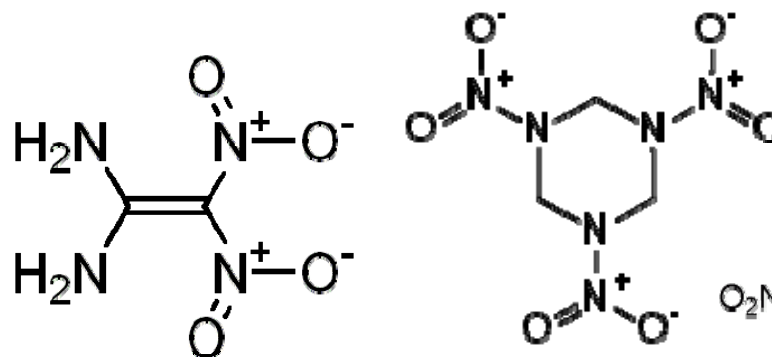
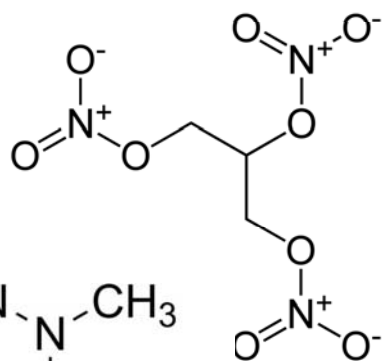
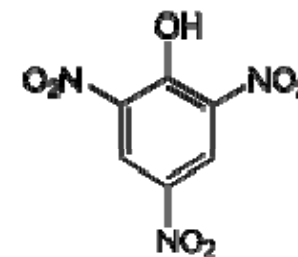
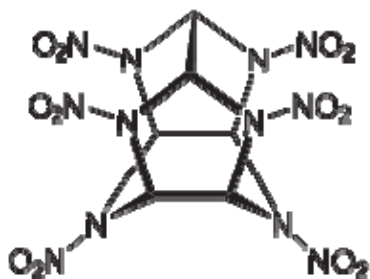
21 Sept 2012

# Invisible Explosives

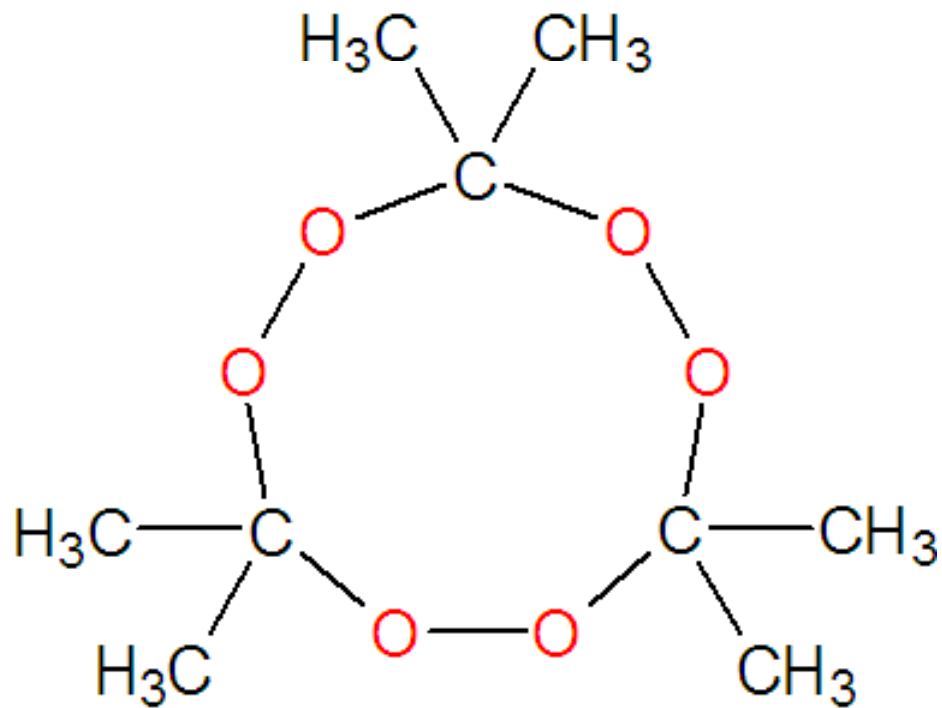


*"Yeah, but it doesn't smell like a bomb!"*

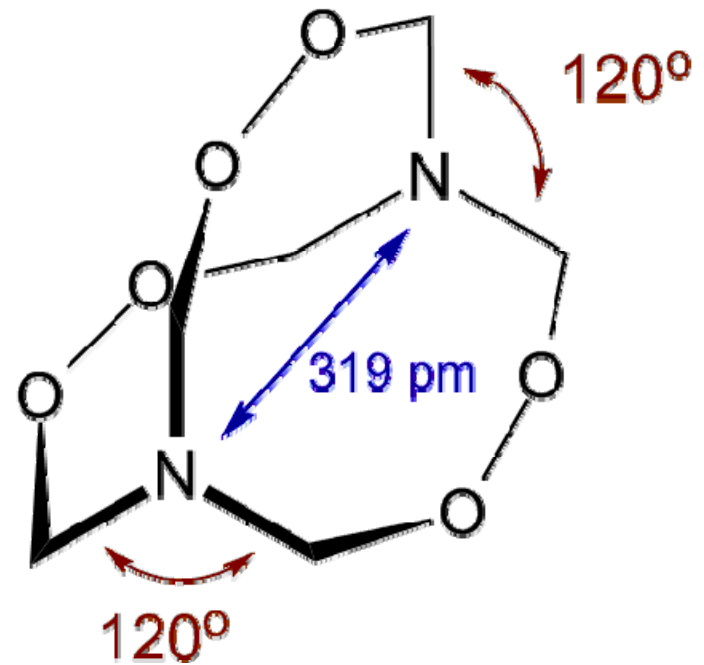
# Invisible Explosives



# Invisible Explosives



Triacetone Triperoxide (TATP)



Hexamethylene triperoxide diamine (HMTD)

# 7 July 2005

London



4 Bombs - TATP

3 on the underground

1 on a double-decker bus

52 victims killed + 4 suicide bombers

--underwear bomber



# 20 Nov 2010

Escondido, CA



9 pounds HMTD

Also found PETN

--Millennium bomber, 2006 trans-Atlantic

Home / Text Search / Acetone

## Search Results

Results In:

CONTENT TYPE

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DEPARTMENT

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Bath (96)

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Paint (14)

Refine by:

PRICE

☐ \$0 - \$10 (2)

☐ \$10 - \$20 (2)

☐ \$20 - \$30 (1)

☐ \$50 - \$100 (10)



### Klean-Strip 1-Gallon Acetone

★★★★★ 0 Reviews  
**\$16.96**

**Description:**  
The Klean-Strip 1-Gallon Acetone can be used indoors and outdoors. It's designed to help thin and remove polyester, epoxy resins, ink, adhesives, contact cement coatings and fiberglass. Also, it can be used as a cleanup solvent and remover for fiberglass projects and resin.

QTY:

STORE EXCLUSIVE

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+ ADD TO CART

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SEARCHED THIS  
TERM VIEWED...



**\$142.80**

GE Silicone  
II Window & Door 9.8  
oz. Clear (24 count)

★★★★★ (5)

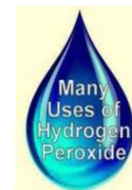
+ ADD TO CART



**\$34.97**

Rubbermaid  
23 gal. Gray Slim Jim  
Waste Container

★★★★★ (3)



### Quarts of 35% Food Grade Hydrogen Peroxide



1 Quart 35% Food Grade  
Hydrogen Peroxide  
Regular Price: ~~\$63.00~~  
Special Price: **\$48.72**  
**You Save: \$14.28**

**PLUS you also receive 1 Free Bonus:**  
• 1 ounce amber glass (not plastic) dropper bottle

### Gallons of 35% Food Grade Hydrogen Peroxide



1 Gallon 35% Food Grade  
Hydrogen Peroxide  
Regular Price: ~~\$78.50~~  
Special Price: **\$58.20**  
**You Save: \$20.30**

**PLUS you also receive 1 Bonus:**  
Free 1 ounce amber glass (not plastic) dropper bottle  
**1 Gallon Special Price: \$58.20**

### Gallons of Bath, Pool & Spa 35% Food Grade Hydrogen Peroxide



1 Gallon Bath, Pool and  
Spa  
35% Food Grade  
Hydrogen Peroxide  
Regular Price: ~~\$69.42~~  
Special Price: **\$53.78**  
**You Save: \$15.64**

**PLUS you also receive 1 Free Bonus:**  
• 4 ounce Sea Soak Sampler



# Invisible Explosives

Explosive	Density (g/cm <sup>3</sup> )		Detonation velocity		% TNT Trauzl <sup>†</sup>	Nitrogen (%)	Oxygen (%)
	TMD	Bulk	mm/μs <sup>1</sup>	g/cm <sup>3</sup>			
Nitromethane	1.1	(liquid)	6.3	1.1	138	22.9	52.3
PETN	1.76		8.4	1.8	174	17.7	60.7
Tetryl	1.73		7.7	1.6	144	24.4	44.6
Picric acid	1.77		7.5	1.7	105	18.3	48.9
TNT	1.65		6.9	1.6	100	18.5	42.3
RDX	1.82		8.6	1.8	160	37.8	43.2
HMX	1.96		9.1	1.9	160	37.8	43.2
NG	1.6	(liquid)	7.7	1.6	185	18.5	63.4
AN	1.72	0.8	3.7	1.5	60	35.0	60.0
TATP	1.2		5.3	1.2	88	0	43.2
HMTD	1.6		5.1	1.1	60	13.5	46.1
UN	1.59		4.7	1.2	95	34.1	52.0

AN, ammonium nitrate; HMTD, hexamethylene triperoxide diamine; HMX, C<sub>4</sub>H<sub>8</sub>N<sub>8</sub>O<sub>8</sub>; NG, nitroglycerin; PETN, pentaerythritol tetranitrate; RDX, C<sub>3</sub>H<sub>6</sub>N<sub>6</sub>O<sub>6</sub>; TATP, triacetone triperoxide; TNT, trinitrotoluene; UN, urea nitrate; TMD, theoretical maximum density.

<sup>†</sup> TNT equivalence measured by the Trauzl (lead block expansion) test. Data compiled and adapted from Refs [1, 2].

# Standoff Detection

Technique applicable at distance

Technique able to perform unambiguous identification

Instrument field deployable

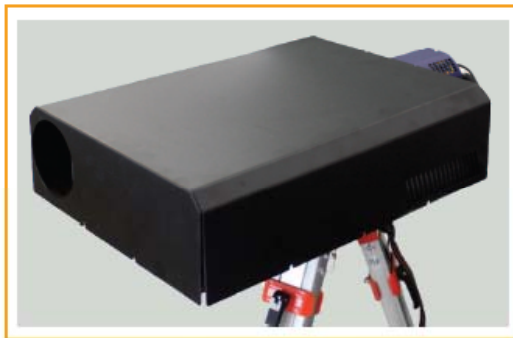
# Standoff Detection

**Intevac Photonics**

*INNOVATION AT THE SPEED OF LIGHT®*

**ObserveR™ LR**

**Long Range Stand-Off Raman Spectrometer**



ObserveR LR

The ObserveR LR is a long range stand-off detection system. It keeps war fighters at safer distances during identification of unknown objects. The stand-off capabilities range from 10 to 25 m to minimize exposure. Video imaging is used to position the detection laser on the target. This long range system identifies materials through unique spectroscopic signatures. The identification algorithms are designed to eliminate false positives and maintain a high specificity for materials. It is precalibrated for hazardous materials including chemical weapons, bio-warfare agents, and explosive ordnance. It is user programmable for new material library entries.

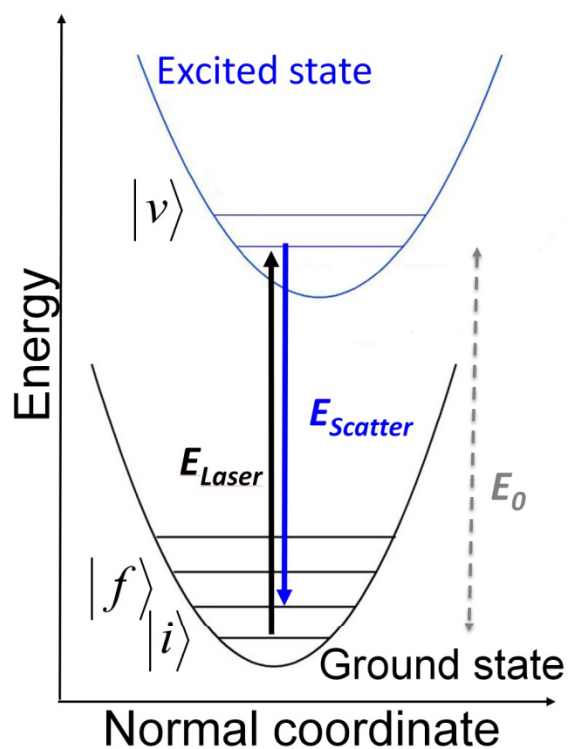
# Improving the Current System

Shift to resonance Raman

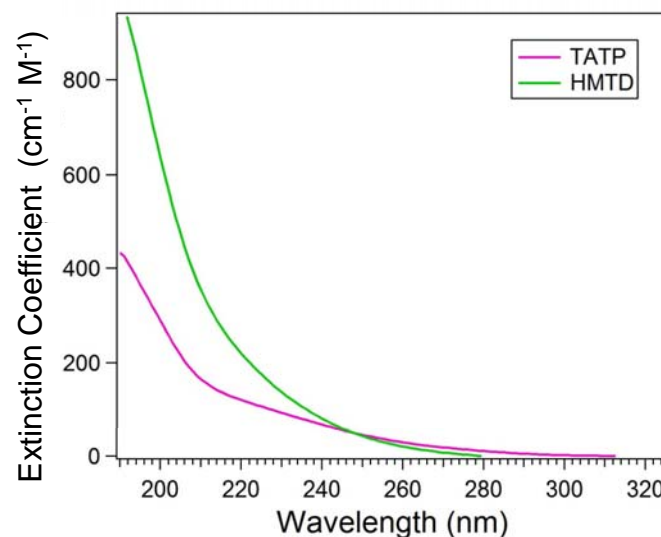
Utilize SERS

# Improving the Current System

## UV Resonance Raman



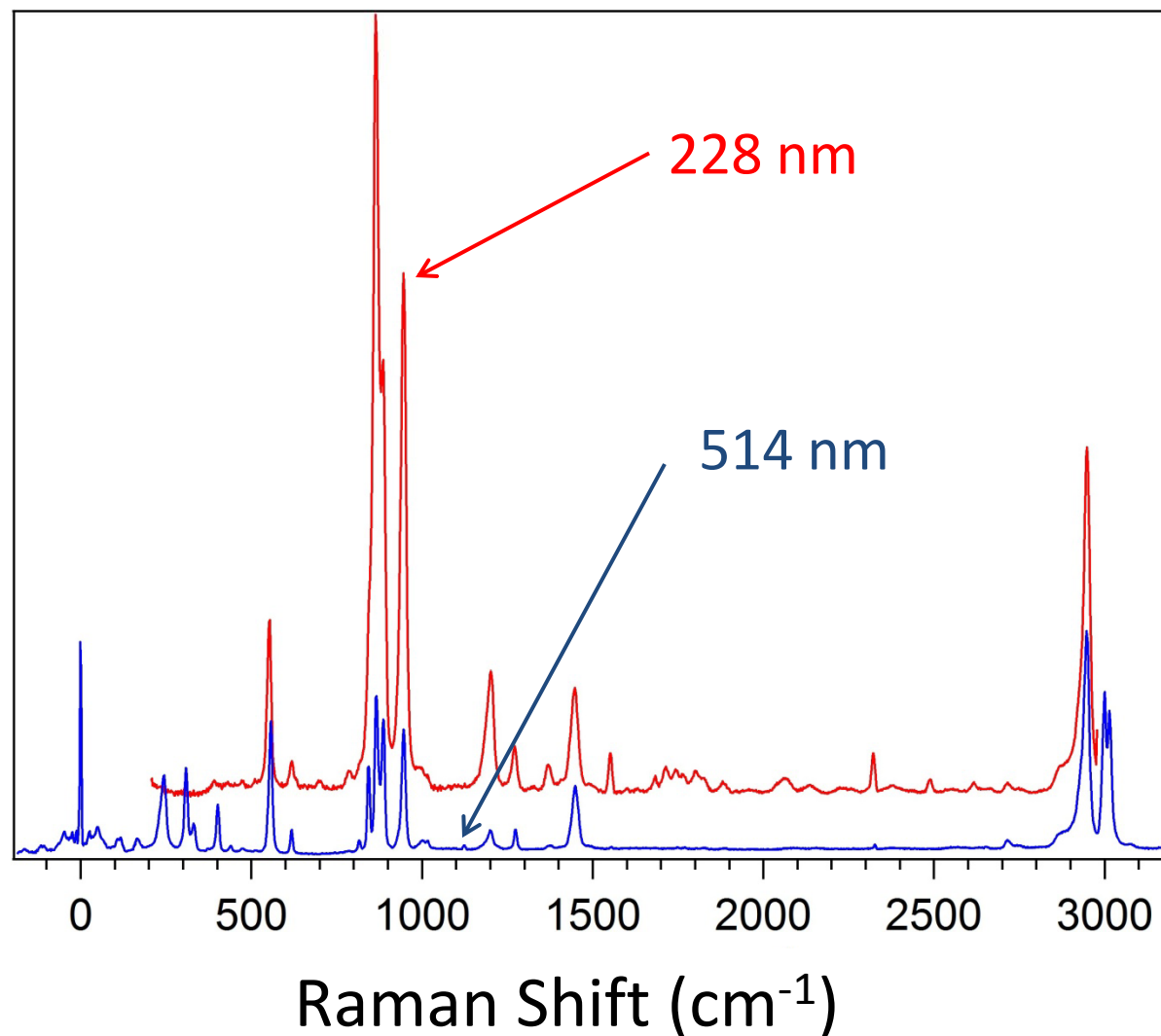
$$\sigma_{RR} \propto E_S^3 E_L \left| \sum_v \frac{\langle f|v\rangle \langle v|i\rangle}{\epsilon_v - \epsilon_i + E_0 - E_L - i\Gamma} \right|^2$$



# Improving the Current System

## UV Resonance Raman

TATP

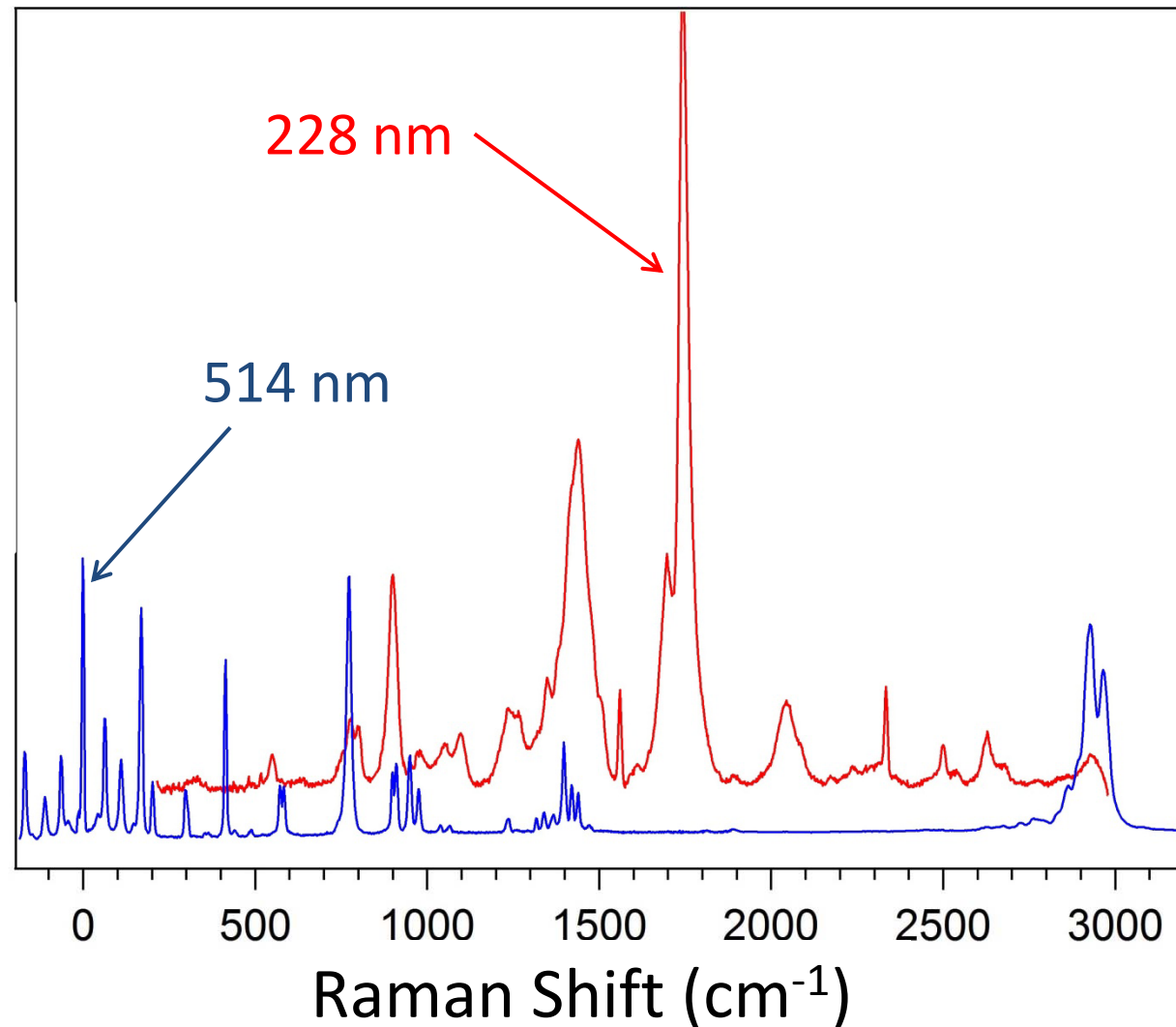




# Improving the Current System

## UV Resonance Raman

HMTD

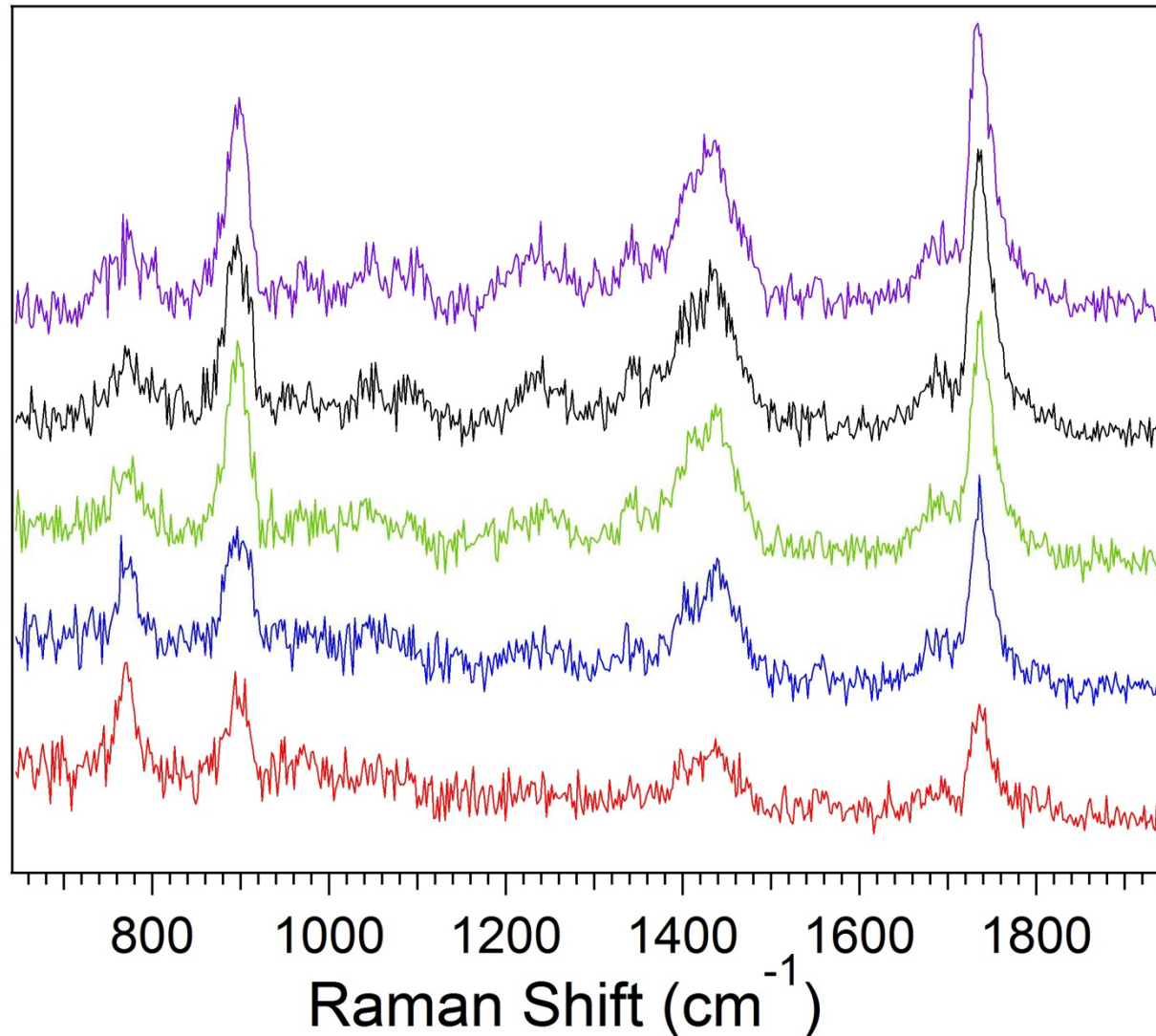


# Improving the Current System

## UV Resonance Raman

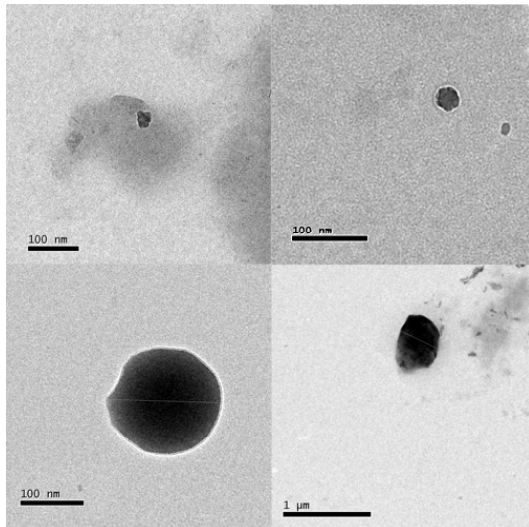
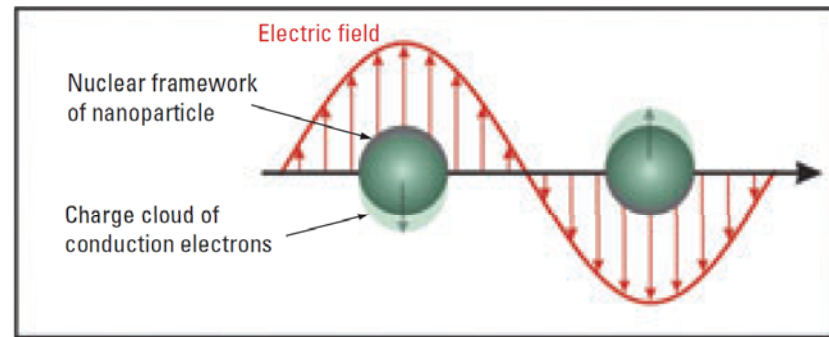
HMTD

Time – 1 Minute Intervals

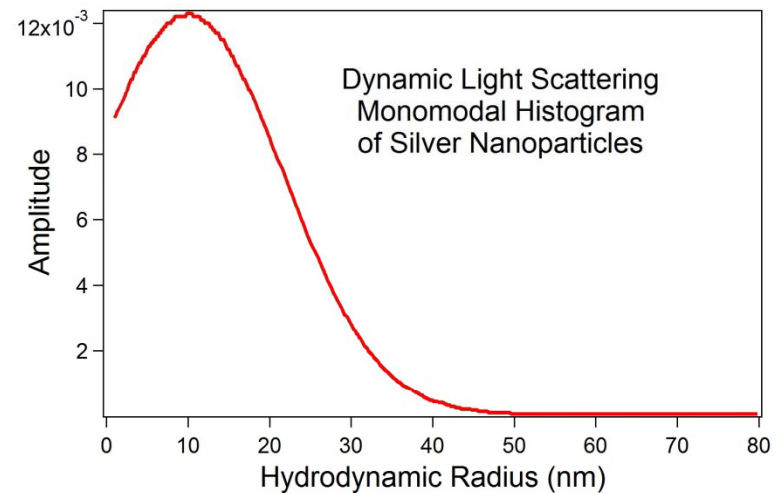


40  $\mu$ W  
@ 228 nm

# Improving the Current System Surface Enhanced Raman

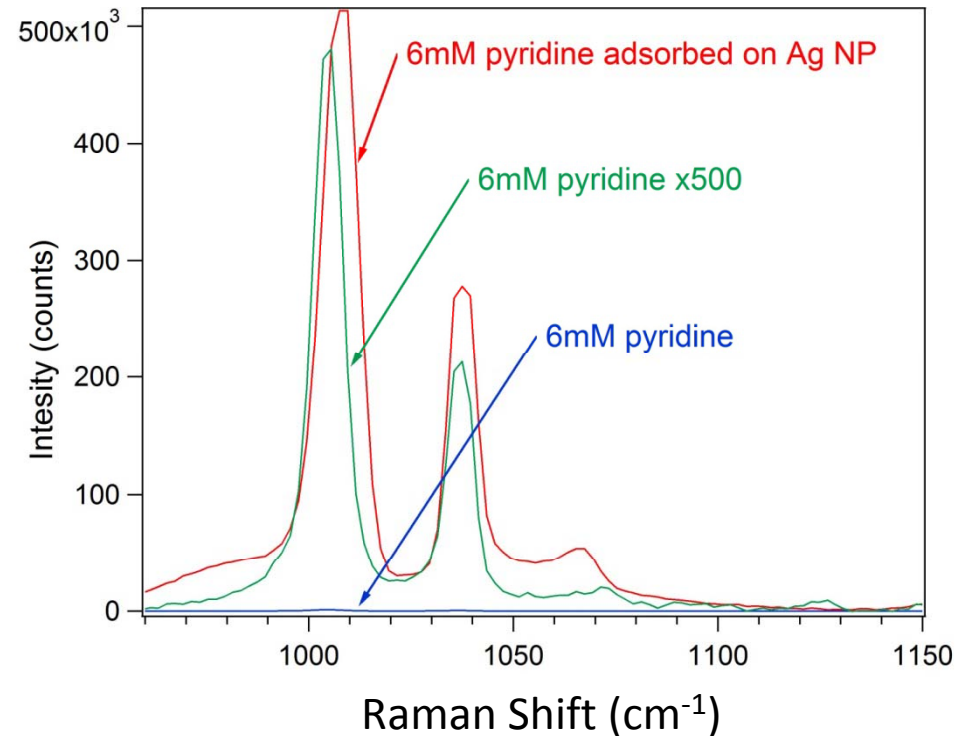
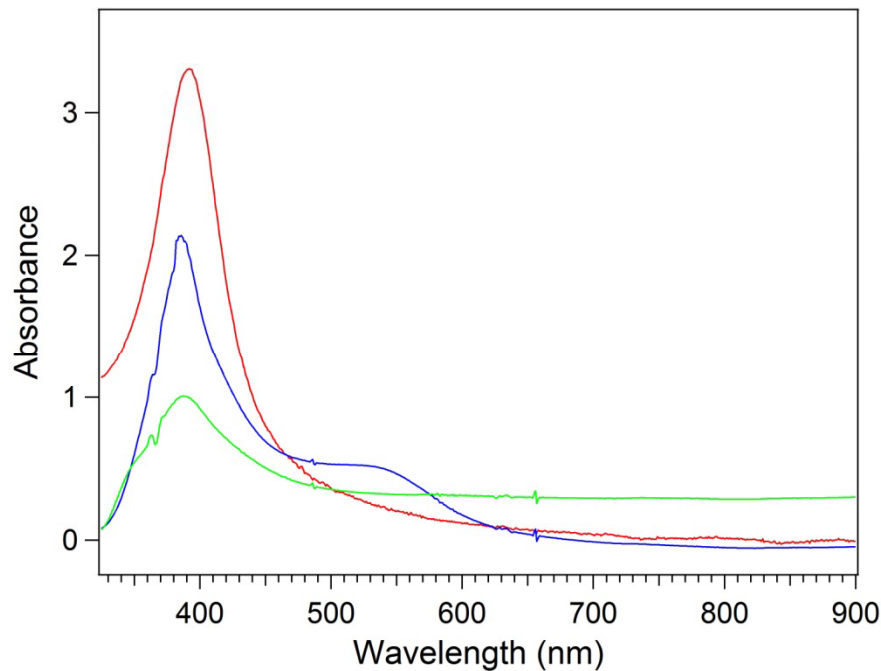


TEM



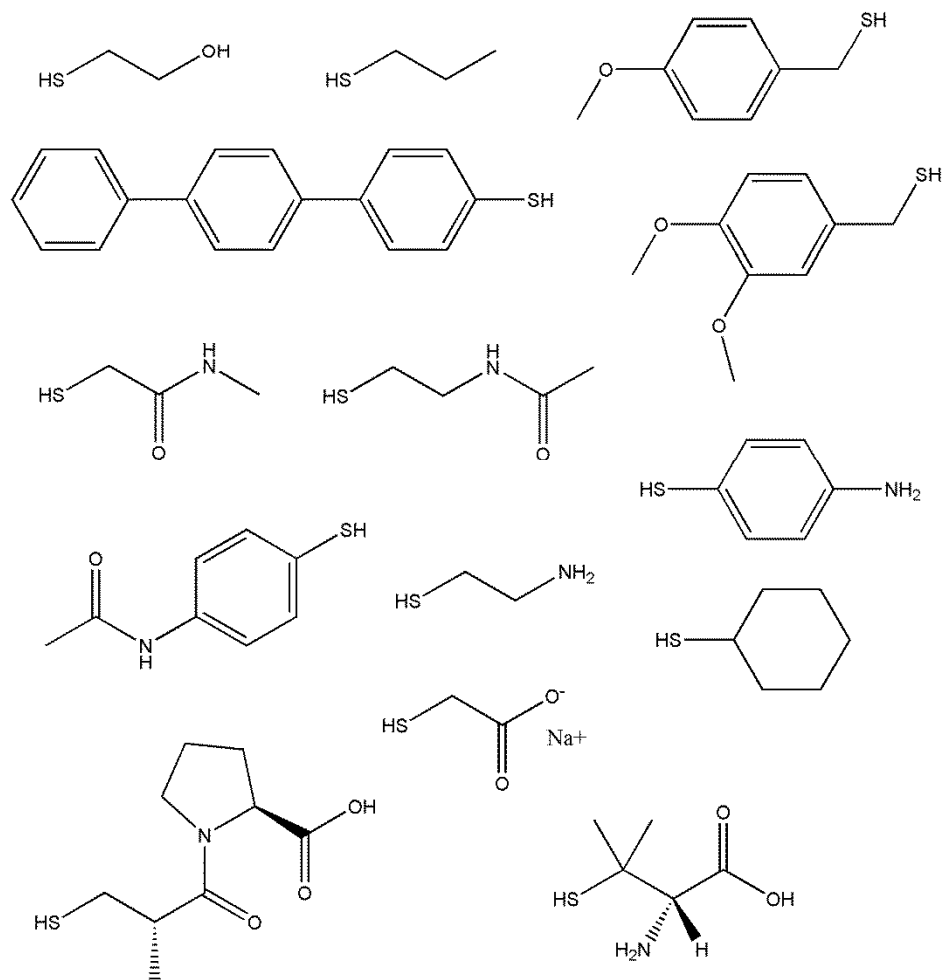
DLS

# Improving the Current System Surface Enhanced Raman

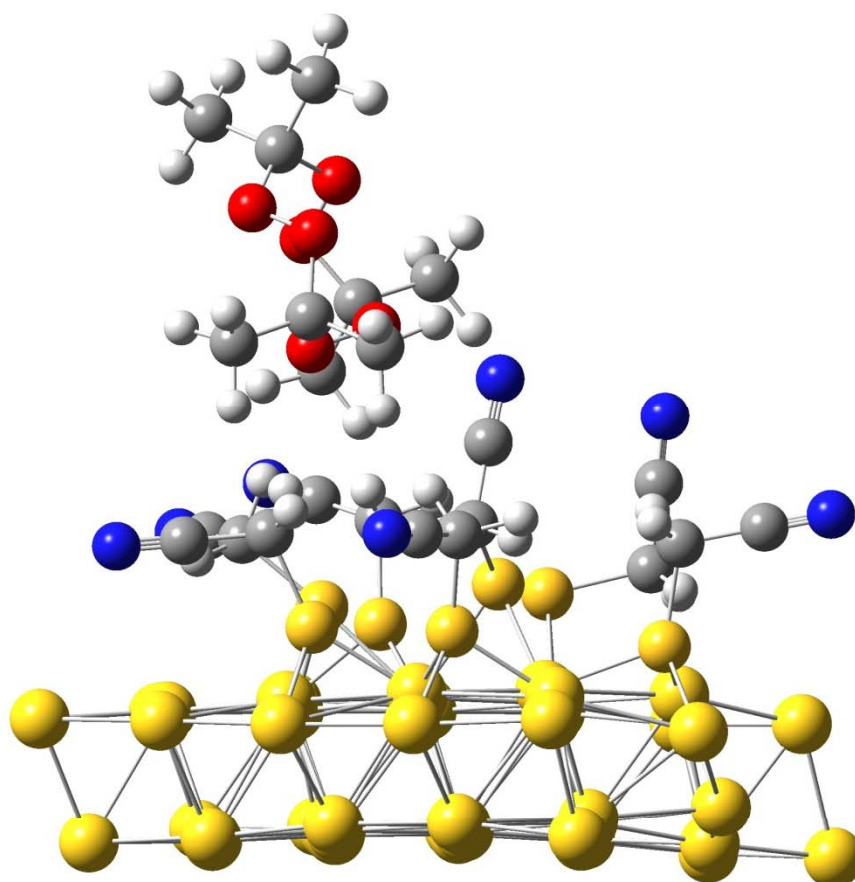


How do we increase the binding?

# Improving the Current System Surface Enhanced Raman



# Improving the Current System Surface Enhanced Raman



Gaussian 09 – B3LYP



# Improving the Current System

## Added Bonuses

UVRr able to work in daylight

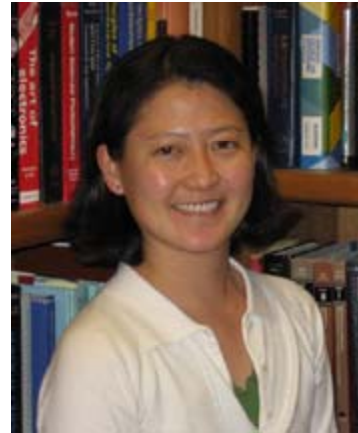
- no need for gating
- no need for background subtraction

Limited only by library

- chemical
- biological
- narcotics

# Acknowledgments

- Professor Judy Kim
- Professor Michael Tauber
- Dr. Keith Monson
- Kim Group



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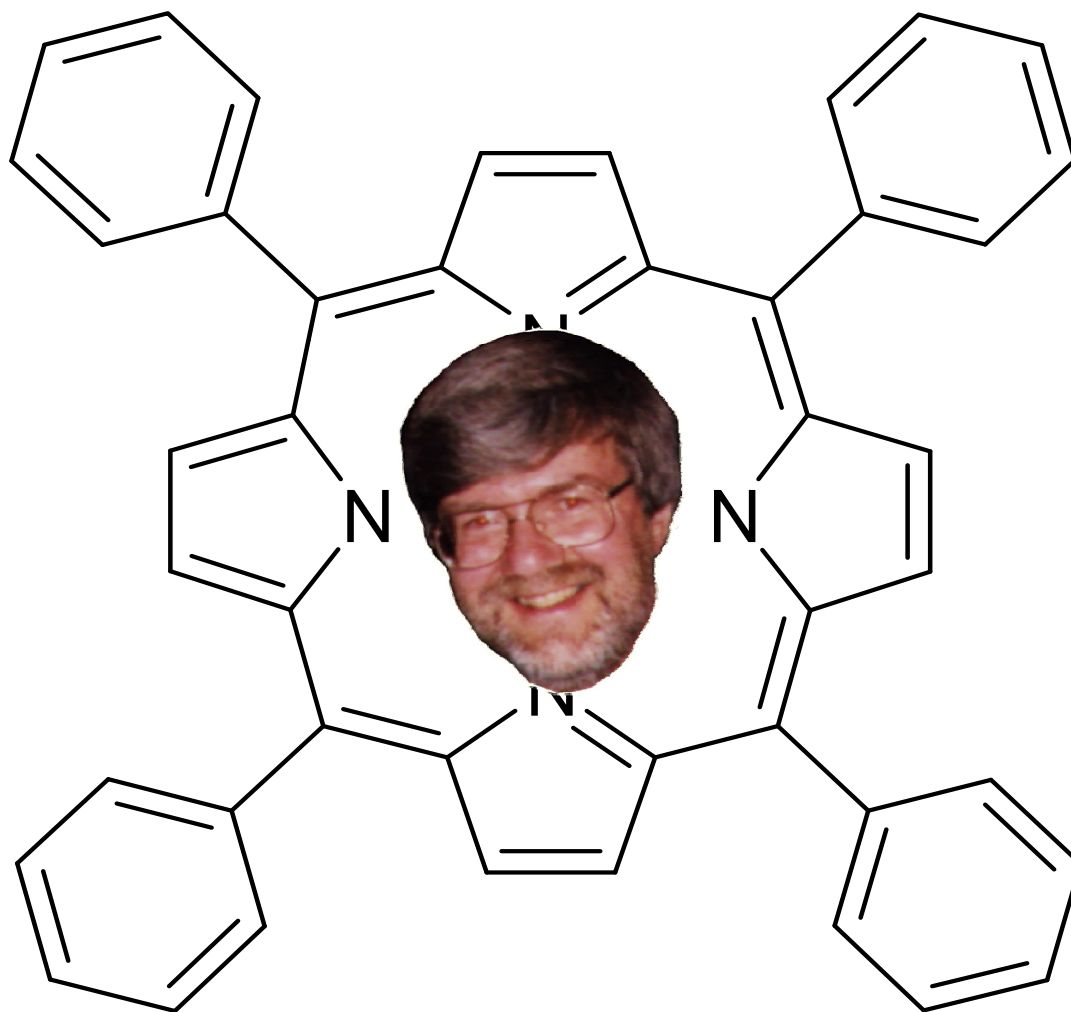
# Facts about Carl C. Wamser

- Patient
- Compassionate & Kind
- Passionate
- Dedicated
- Diligent
- Humble
- Sometimes, he would beat us....





# Thank you Carl



tetraphenyl-CARL-pyrin