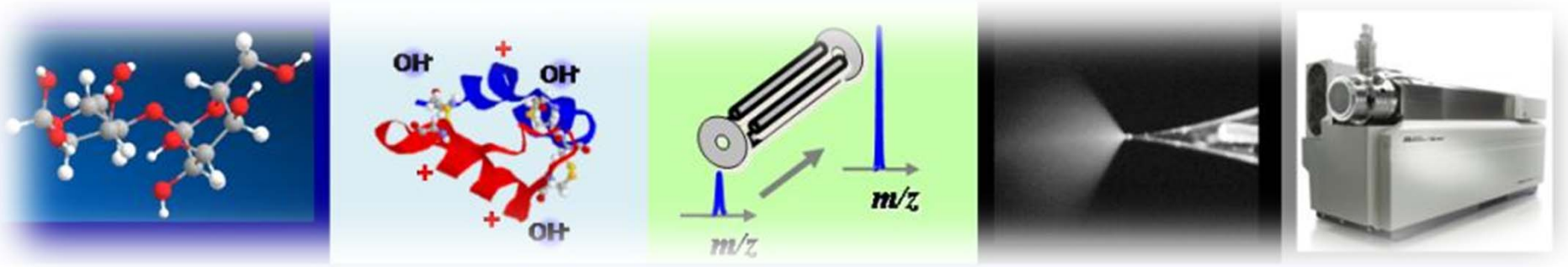


Peptide Sulfinyl Radical Ions: Gas-Phase Formation, Unimolecular Dissociation, and Ion/Molecule Reactions

Lei Tan, Yu Xia

Department of Chemistry

Purdue University

Introduction

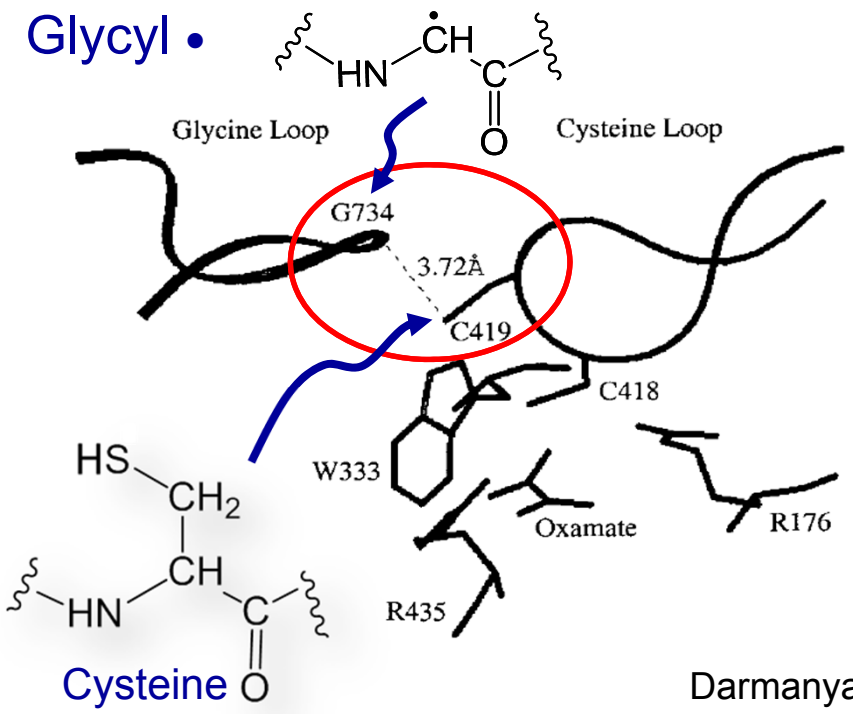
- Sulfinyl radical (-SO•)
  - Photolysis of sulfoxide (sulfur cycle)

$$(CH_3)_2SO + h\nu \rightarrow CH_3SO\bullet + \bullet CH_3$$

HSO• CH_3SO• ArSO•

  - Observed in protein system

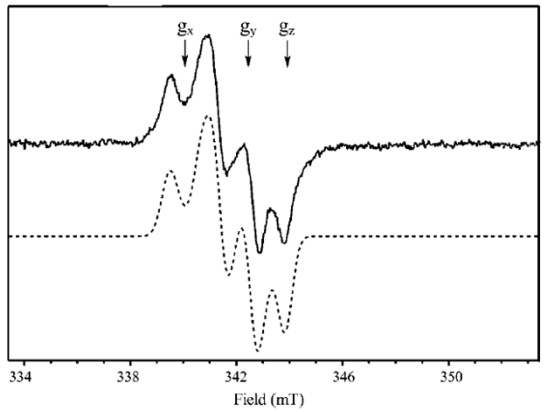
Inactivation of Pyruvate Formate-Lyase (PFL)



Enzyme with Radical
- Storage site: Glycyl radical
- Active site: Thiyl radical

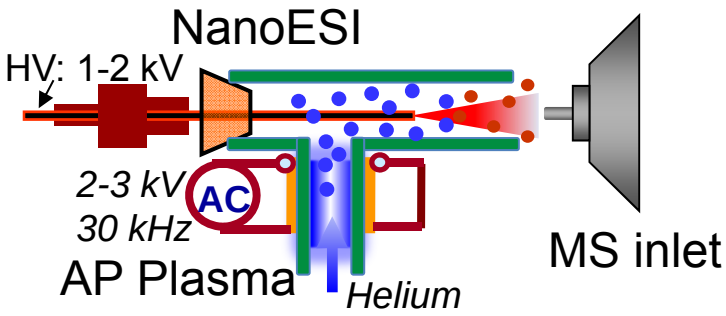
Oxygen

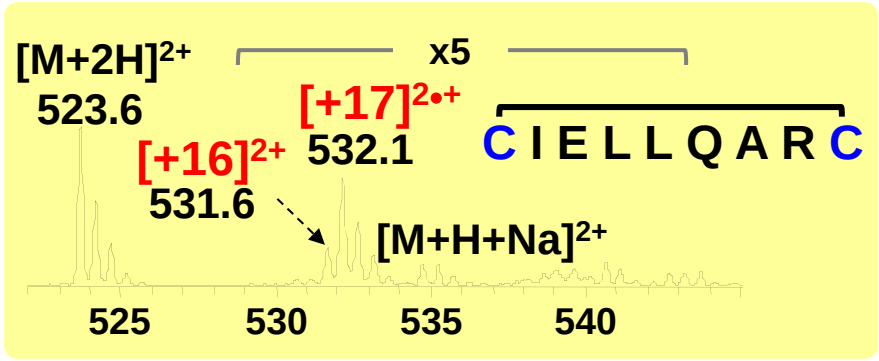
ESR of protein sulfinyl radical



Darmanyan A.P. et al, *J. Phys. Chem. A.* **1997**, *101(37),* 6855-6863
Gauld J.W.; *J. Am. Chem. Soc.* **2000**, *122,* 2035-2040

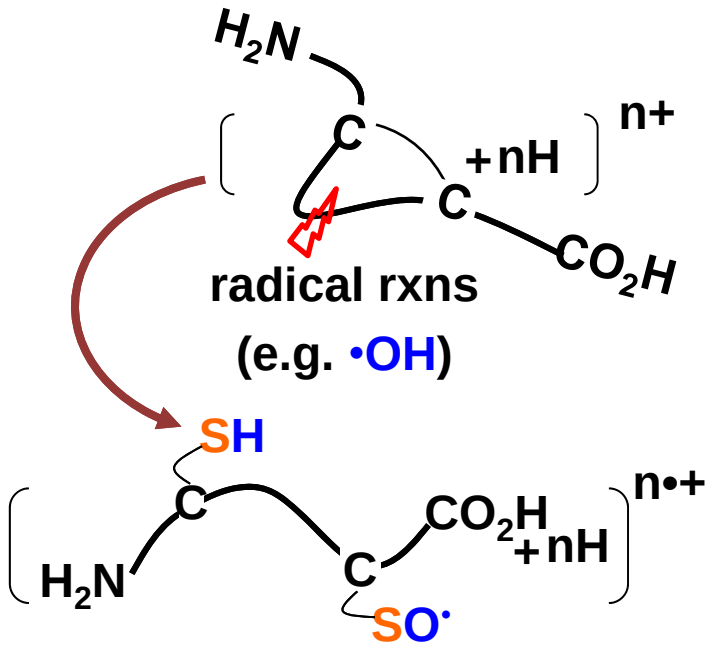
New Way to Form Sulfinyl Radical Ion



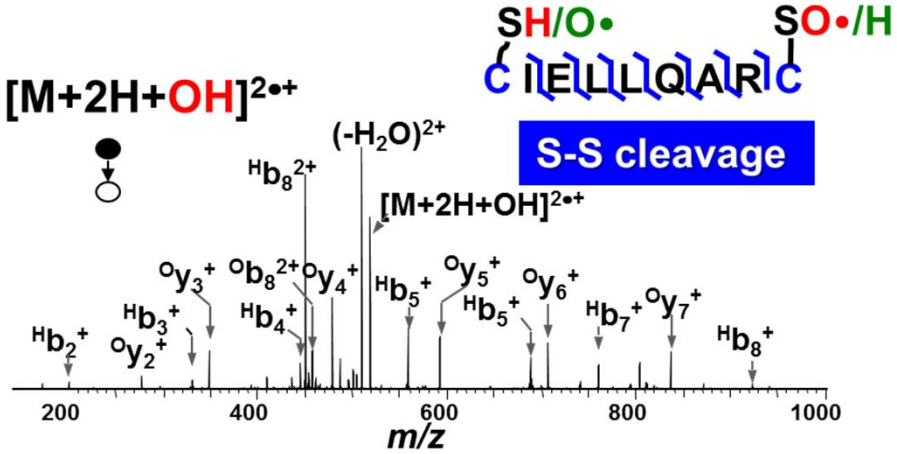


$H_2O + e^- \rightarrow {\bullet}OH + H + e^-$

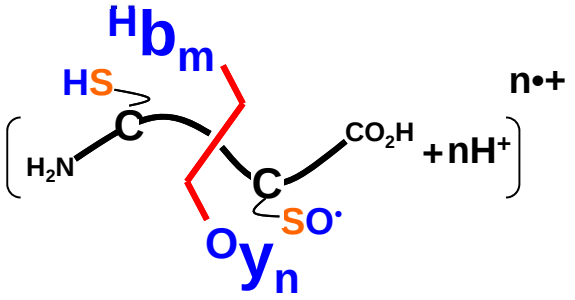
$O + H_2O \rightarrow 2\ {\bullet}OH$



Peptide Sulfinyl Radical

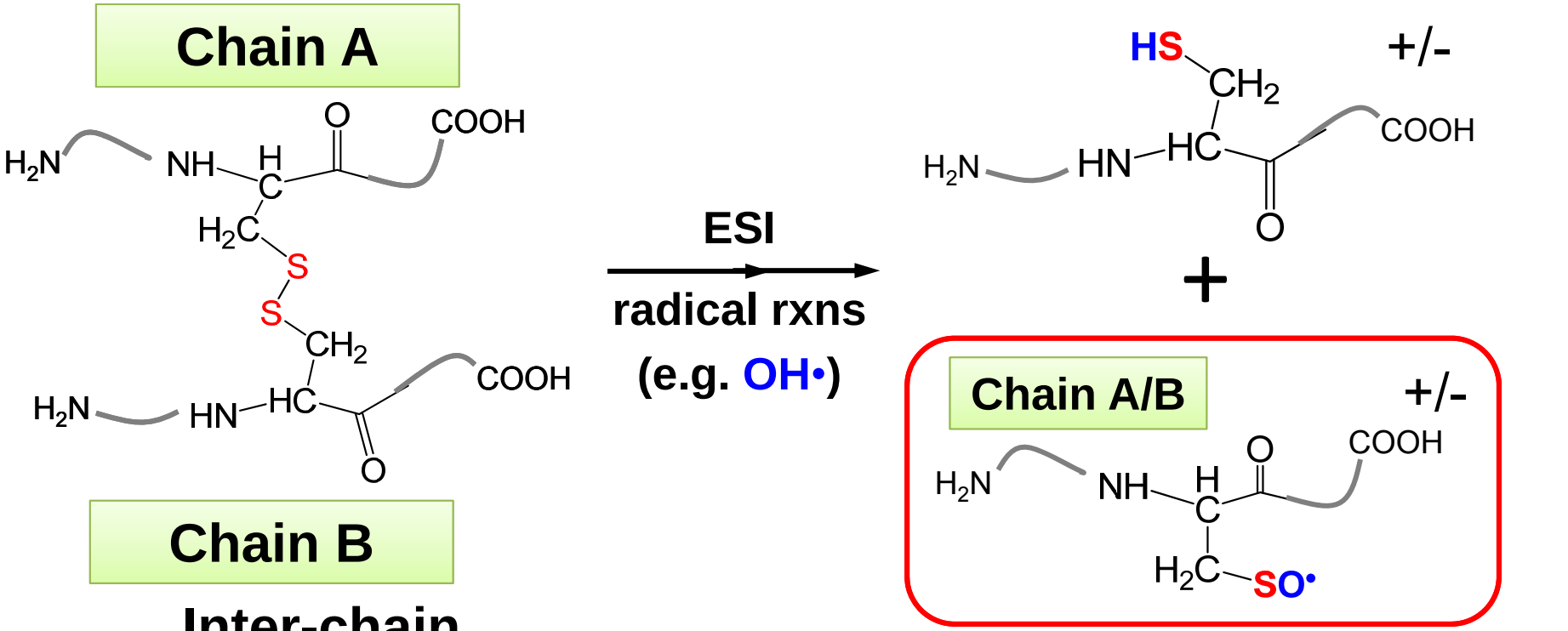


CID



Xia Y.; *Anal. Chem.*; **2010**, *82(7)*, 2856-2864
Ma X.X.; *J. Am. Soc. Mass Spectr.* **2011**, *22(5)*, 922-930

Formation of Site-Specific Sulfinyl Radical

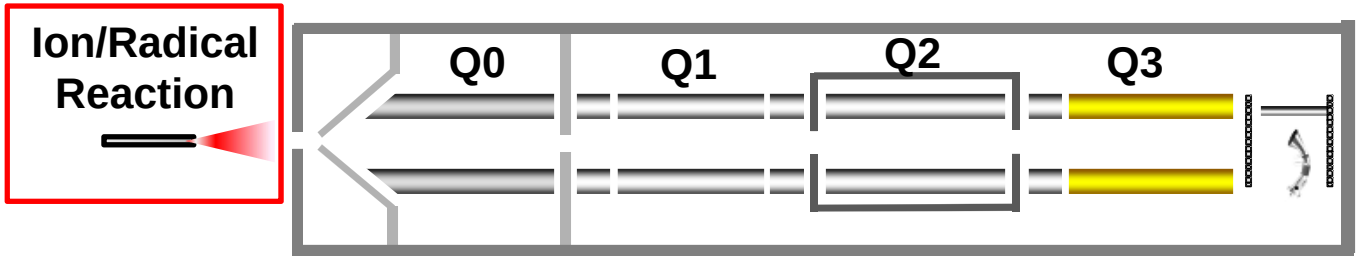


Inter-chain disulfide linked peptide

Site-Specific Peptide Sulfinyl Radical Ion

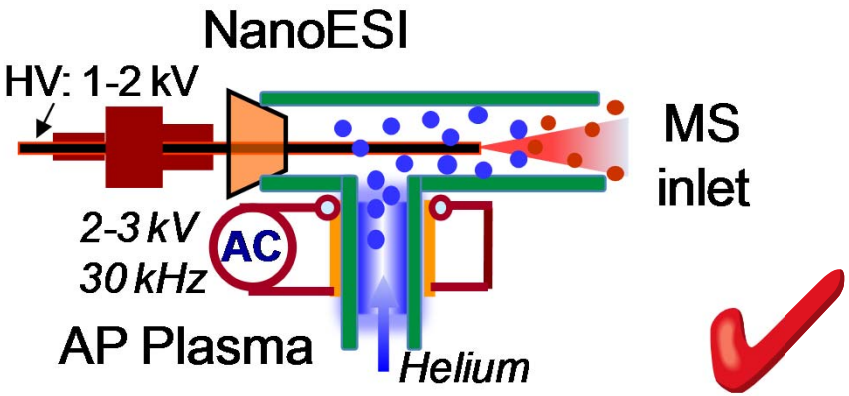
- Easy to determine the site of sulfinyl radical
- Change the polarity of ions easily.

Experiment Setup

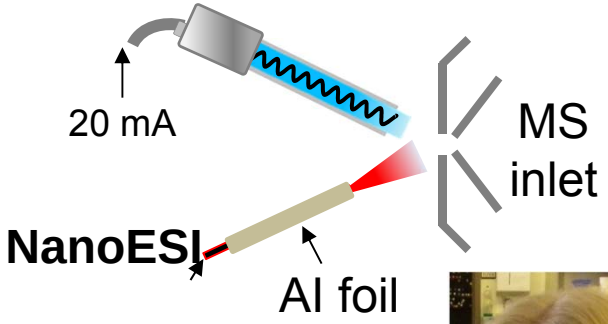


4000 QTRAP

1. Helium Atmospheric Pressure (AP) Low Temperature Plasma



2. Low Pressure Hg Lamp – 185 nm , 248 nm

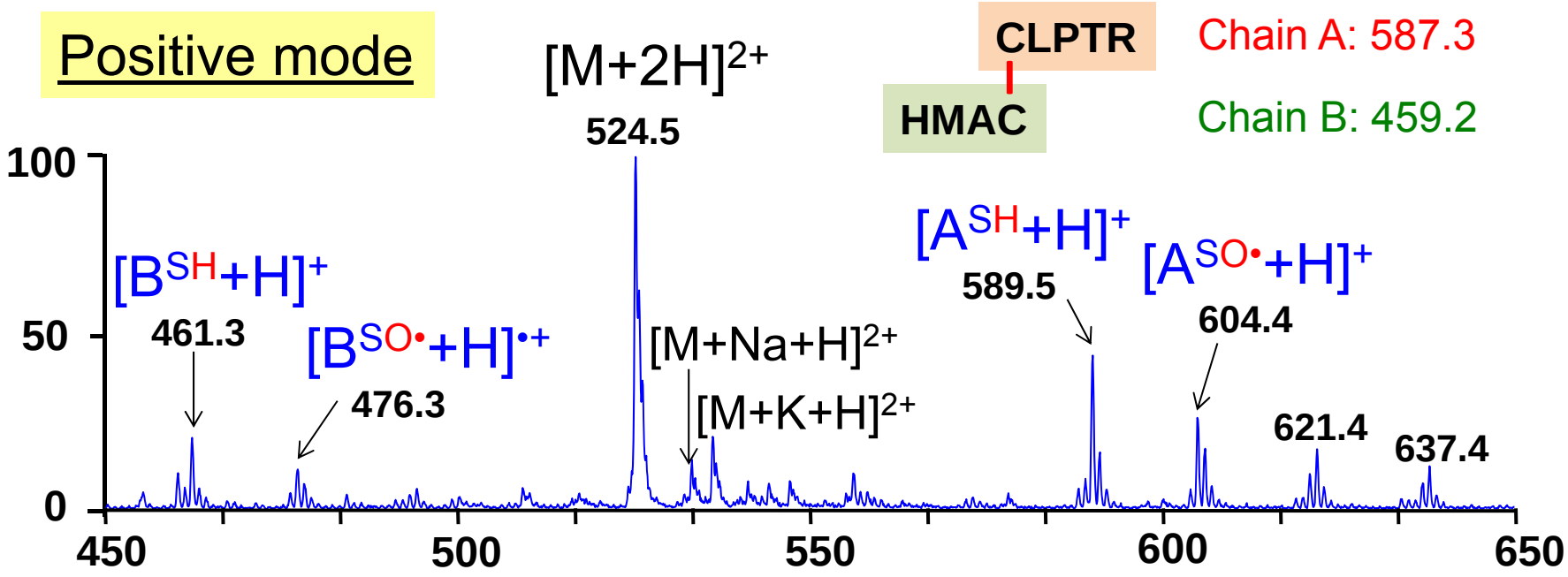


Wed. Poster
WP 760

Craig Stinson

Formation of Site-Specific Peptide Sulfinyl Radical Ions

Formation of Site-Specific Peptide Sulfinyl Ion

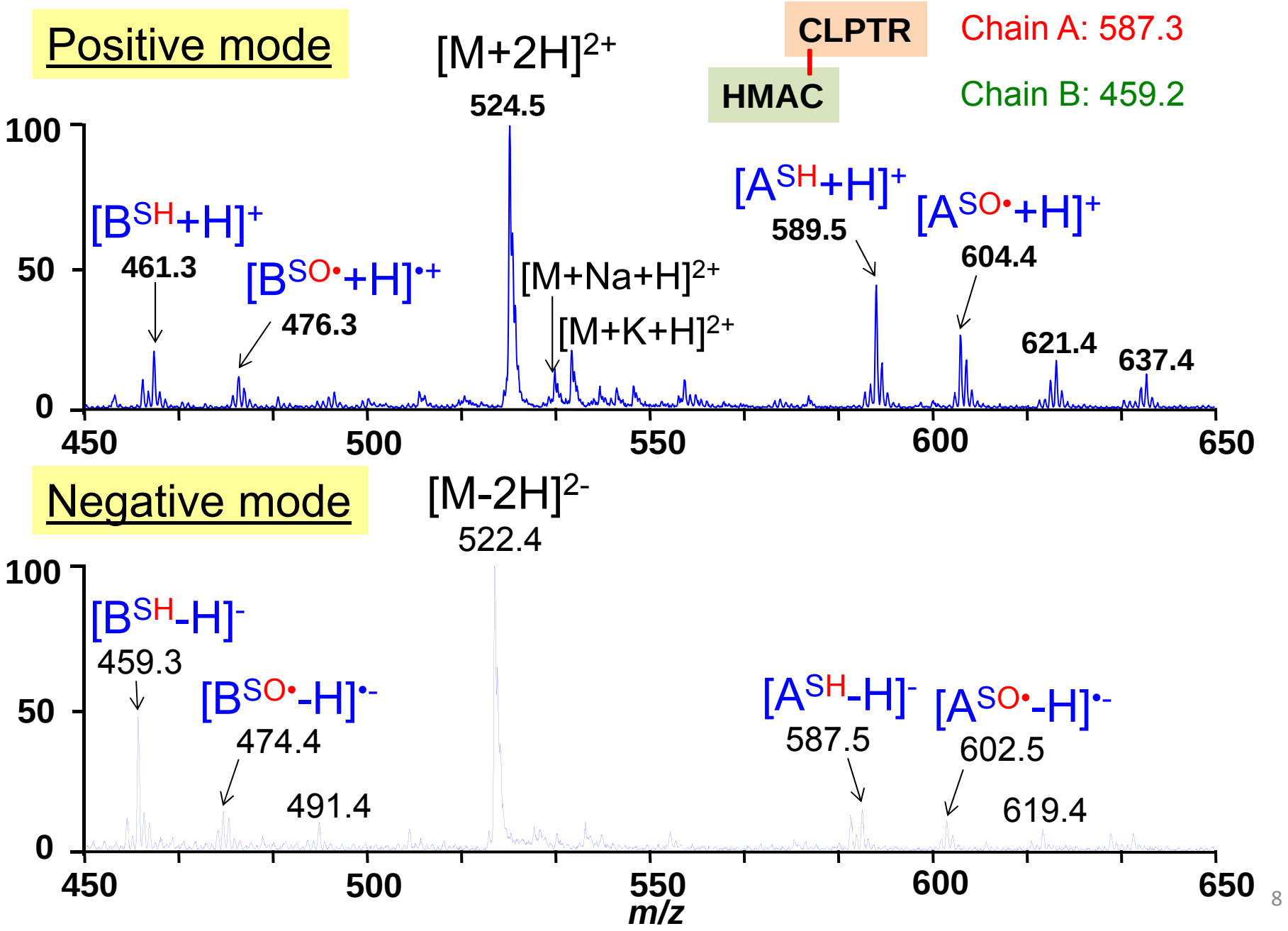


$[A^{SH}+H]^+$ $[\ CLPTR+H\ ]^{\bullet+}$ with SH

$[A^{SO\bullet}+H]^{\bullet+}$ $[\ CLPTR+H\ ]^{\bullet+}$ with $SO\bullet$

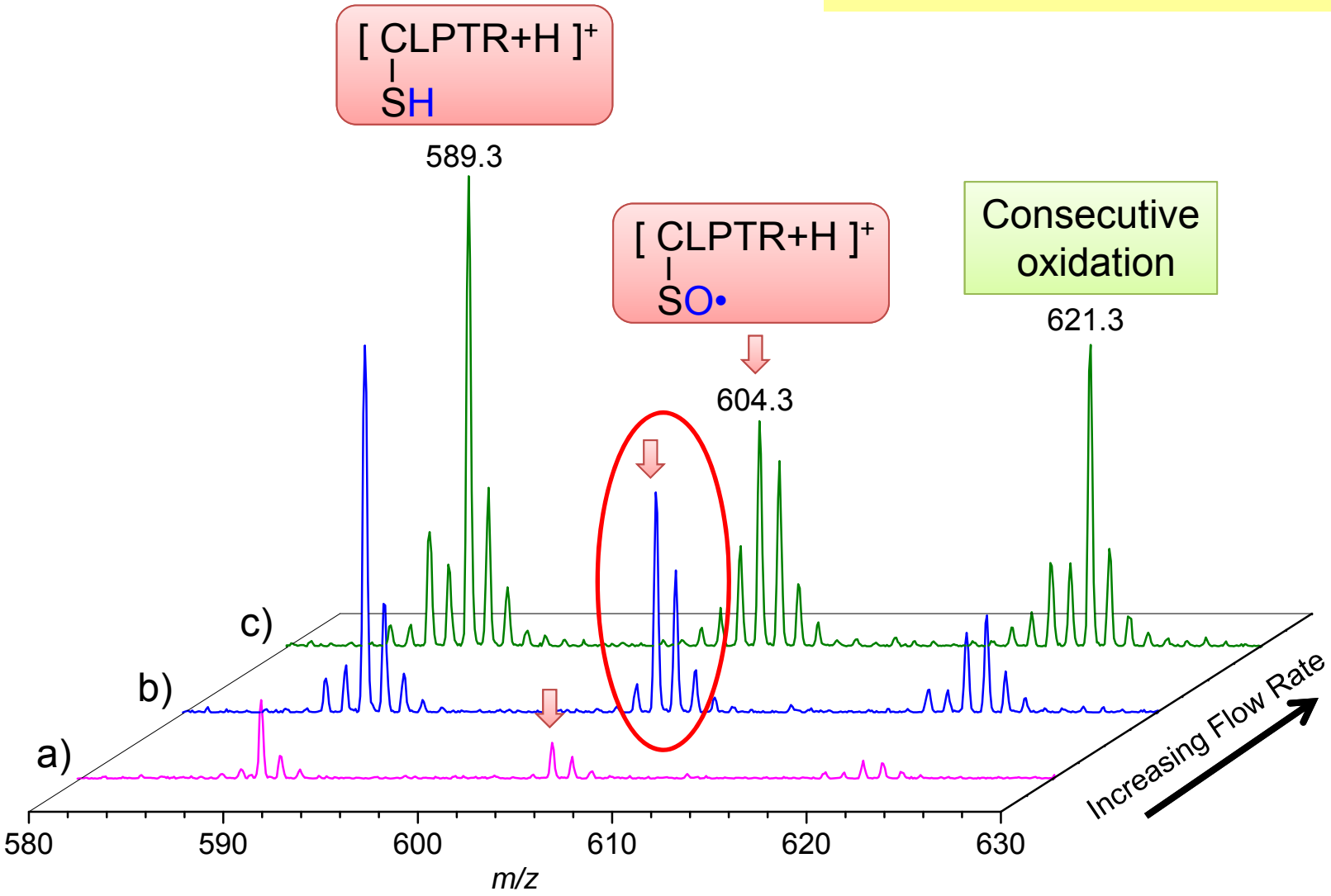
Sulfinyl Radical

Formation of Site-Specific Peptide Sulfinyl Ion

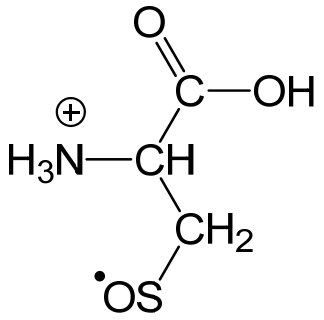


Formation of Sulfinyl Radical Ion

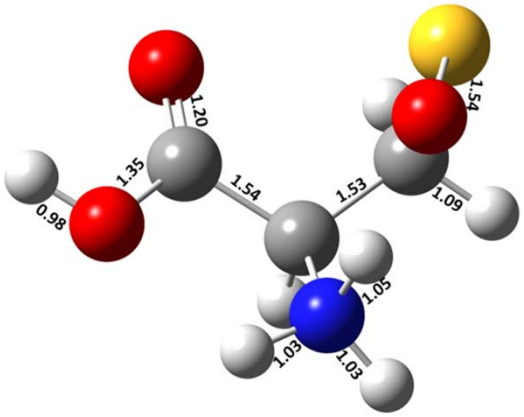
Higher Helium Flow Rate → More Intense Plasma
Higher Radical Density



Structure of Cysteine Sulfinyl Radical Ions



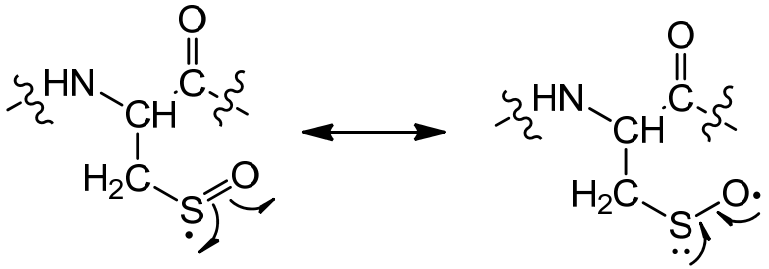
Cys-SO•, 137 *m/z*



Chasity Love Joe Francisco

Tue. Poster: TP 761

Cys-SO•	Spin densities
Neutral	S: 0.510 O: 0.488
Protonated at NH_2	S: 0.543 O: 0.456
Protonated at C=O	S: 0.552 O: 0.453



Protonation	Energy
NH_2	0 kJ/mol
C=O	+112.9 kJ/mol

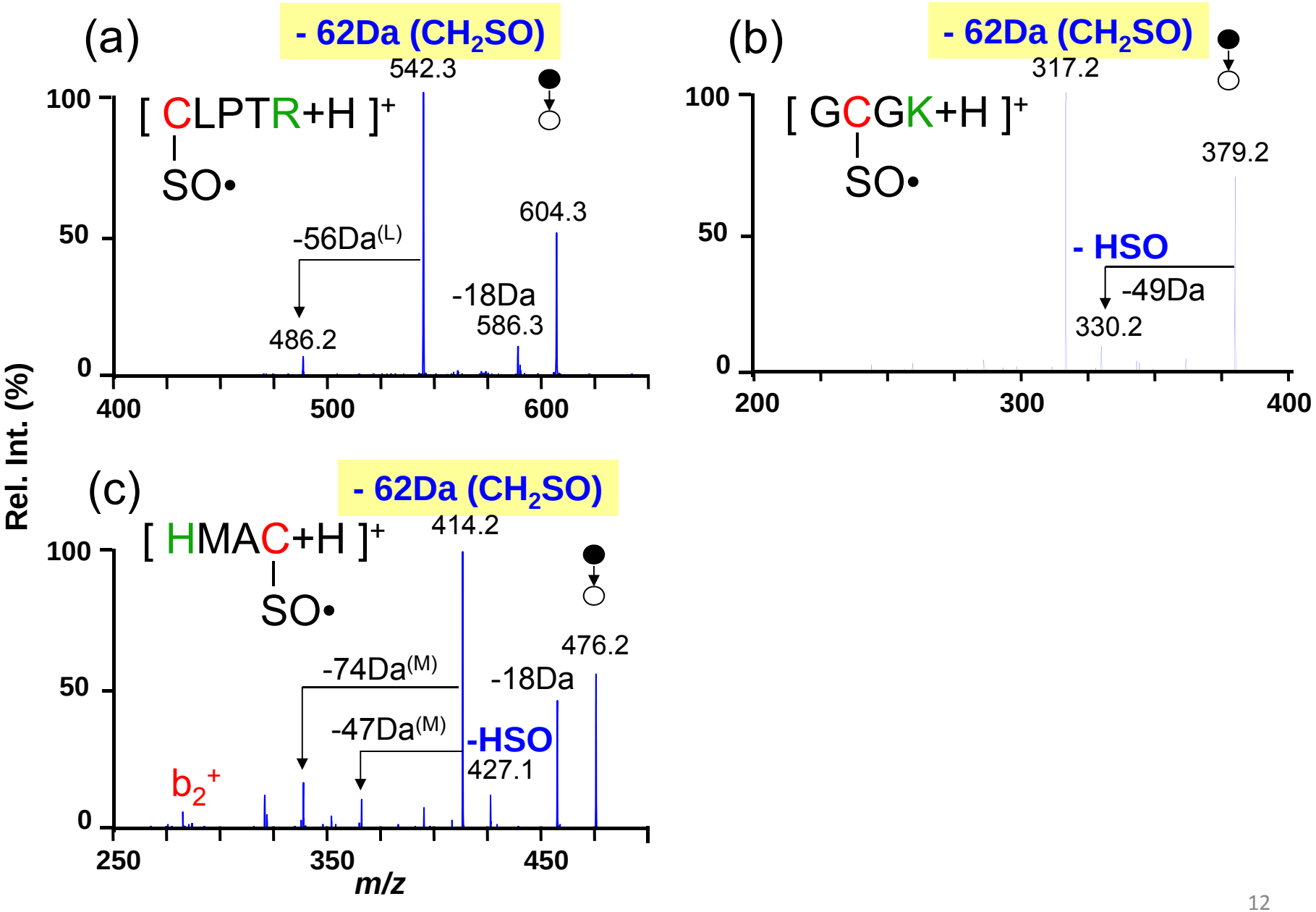
Distonic Ion!

All calculation was carried out using Gaussian, MP2/6-31G andB3LYP/6-31G*

Collisional Induced Dissociation (CID) of Peptide Sulfinyl Radical Ions

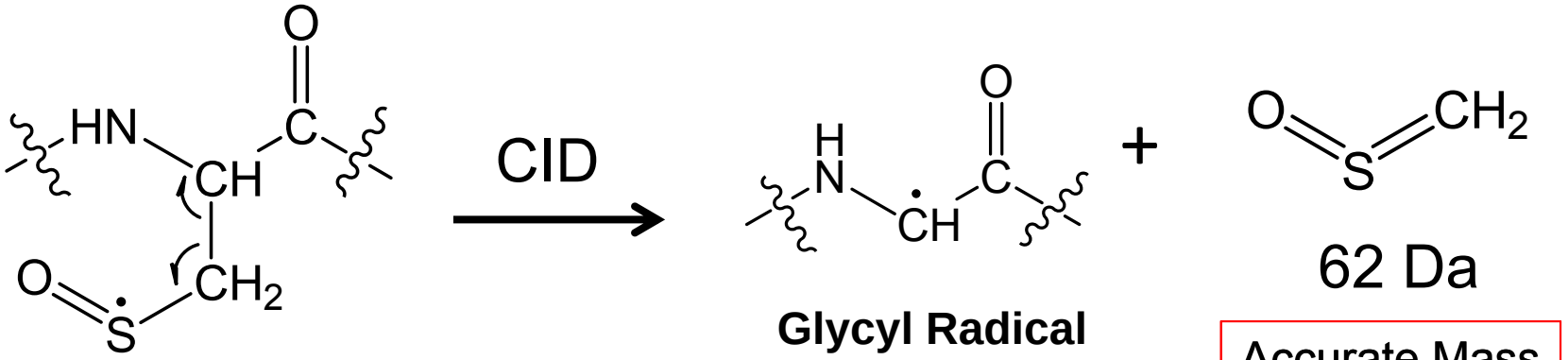
- Radical v.s. Charge Driven Dissociation

Ion trap CID of Peptide Sulfinyl Cation



Loss of 62 Da (CH_2SO)

Radical Directed Dissociation



Sulfinyl Radical

Glycyl Radical

Accurate Mass
61.9826 Da

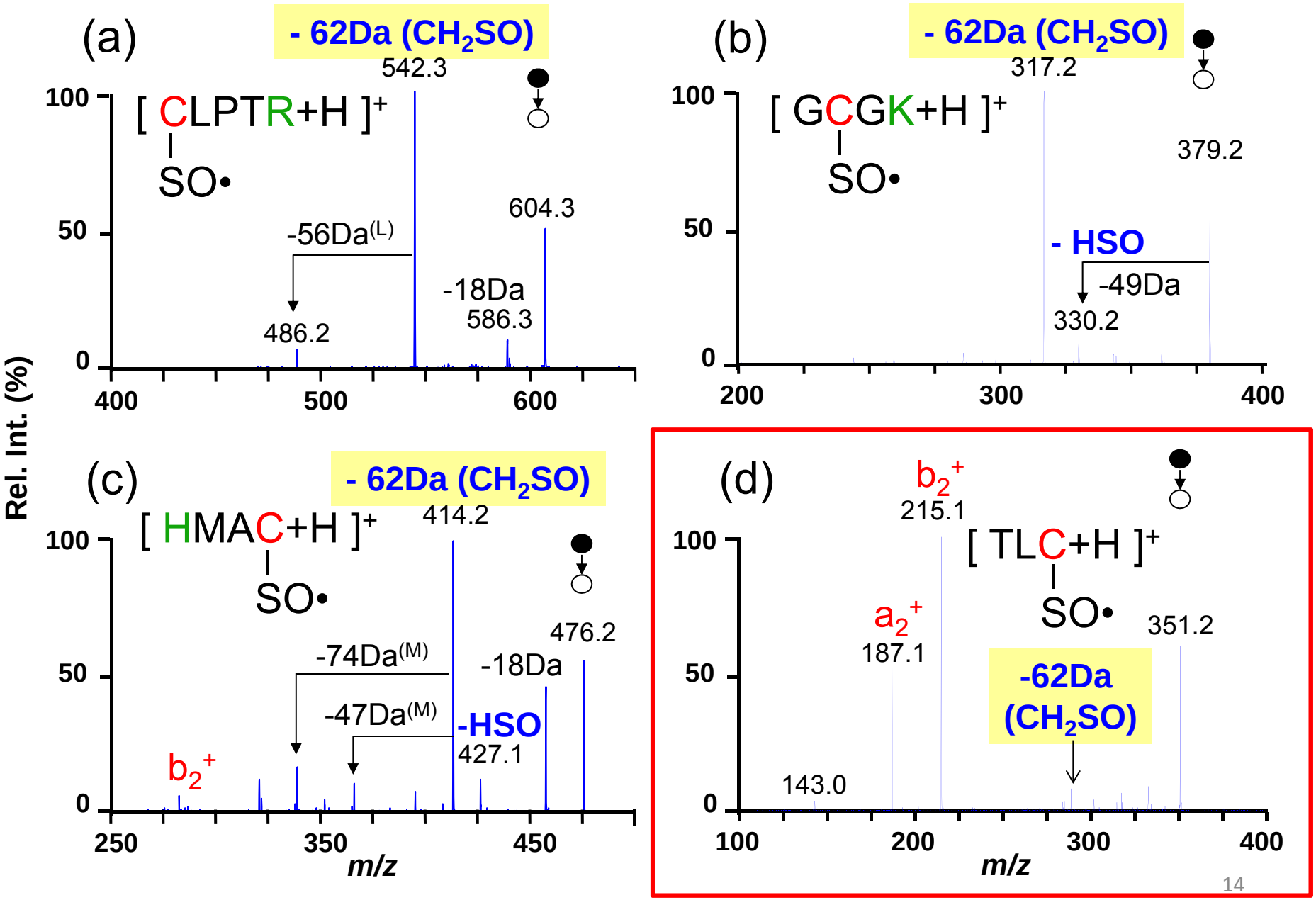
Activation energy: 38.7 ± 1.4 kcal/mol

* Calculation based on neutral cysteine sulfinyl radical

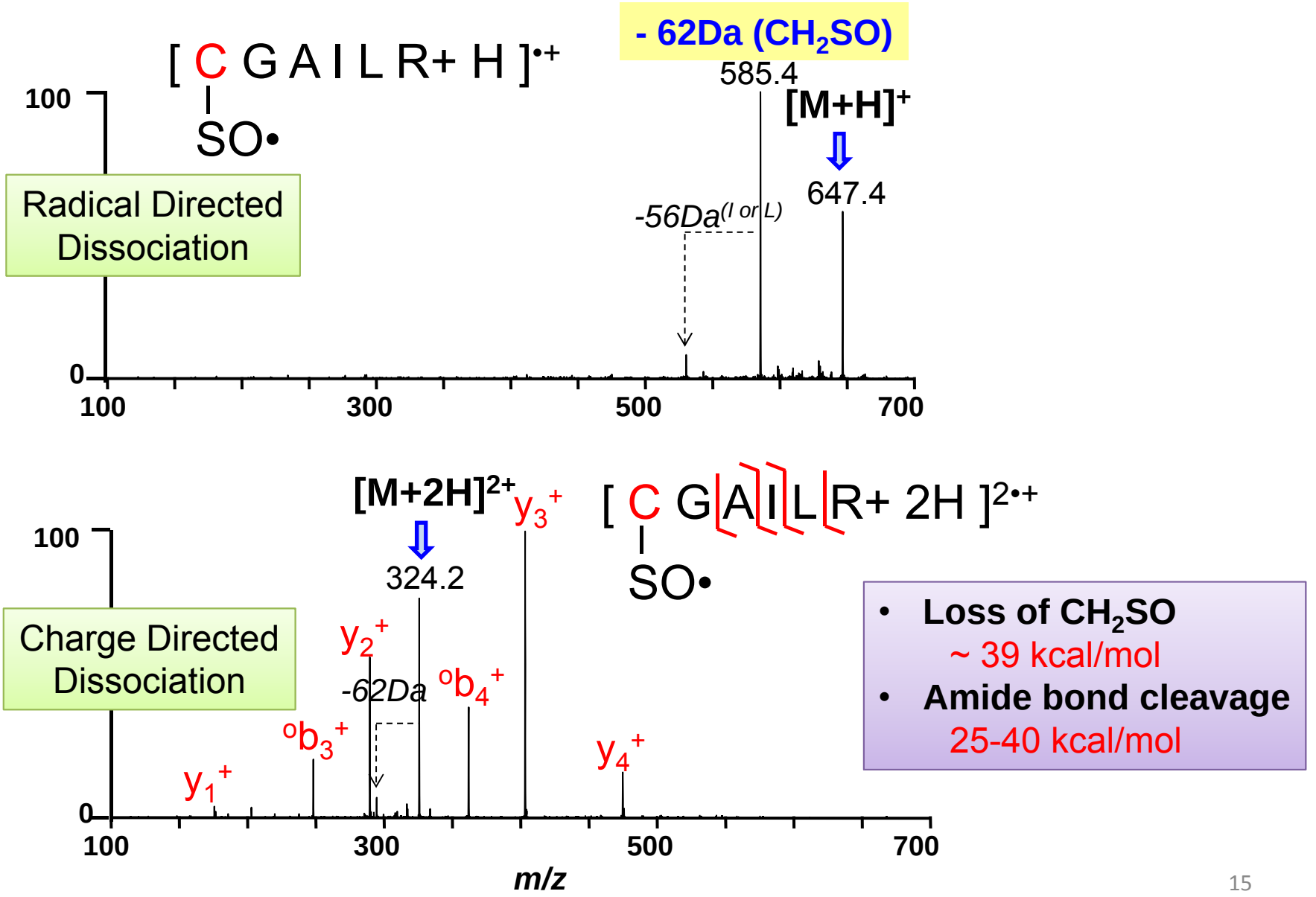
Activation energy for amide bond cleavage: 25-40 kcal/mol

Lioe H.; *J. Am. Soc. Mass Spectr.* **2007**, *18,* 1109-1123

Ion trap CID of Peptide Sulfinyl Cation

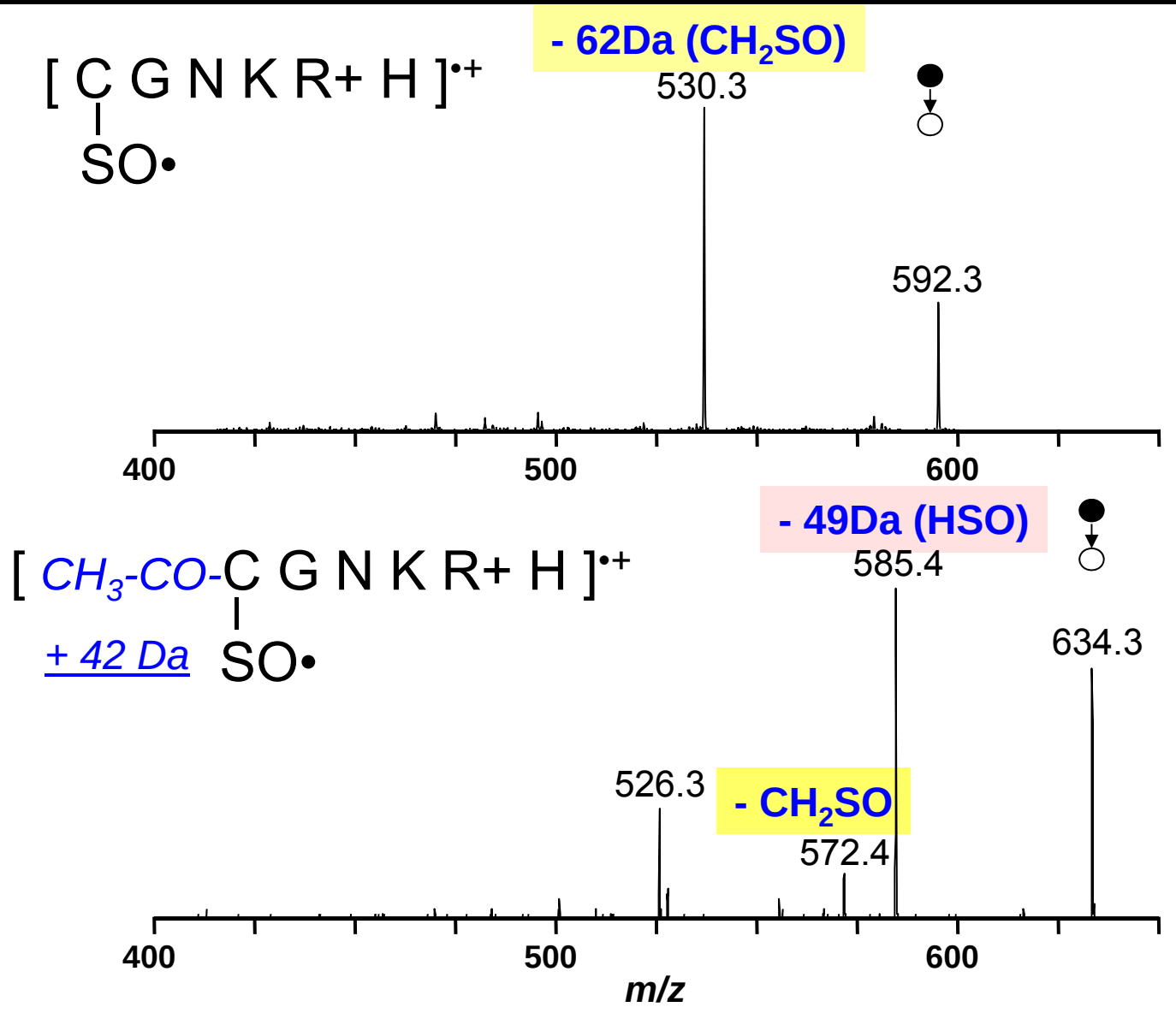


Radical v.s. Charge Directed Dissociation
- Charge States



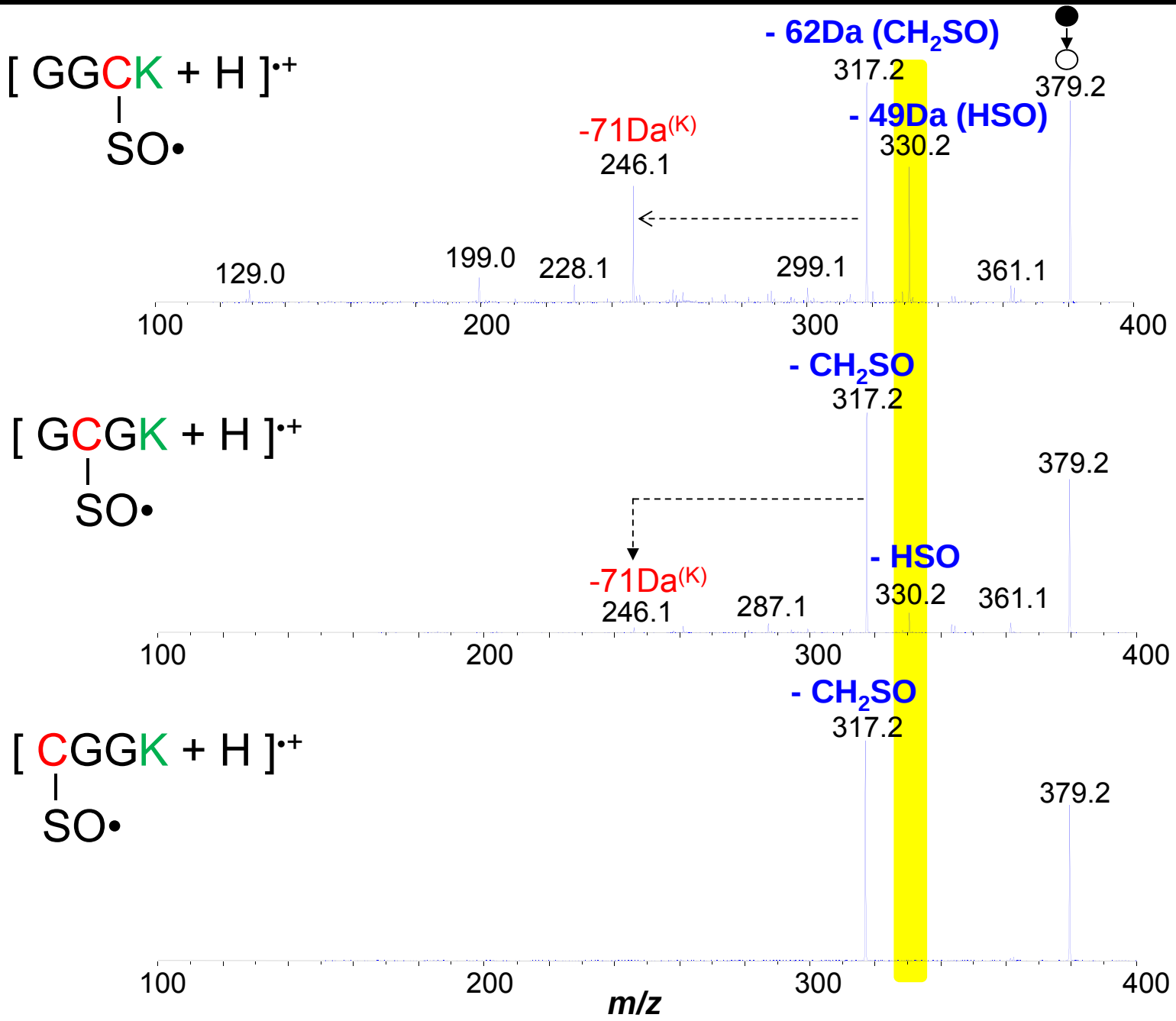
- **Loss of CH_2SO**
  ~ 39 kcal/mol
- **Amide bond cleavage**
  25-40 kcal/mol

N-terminal Acetylation

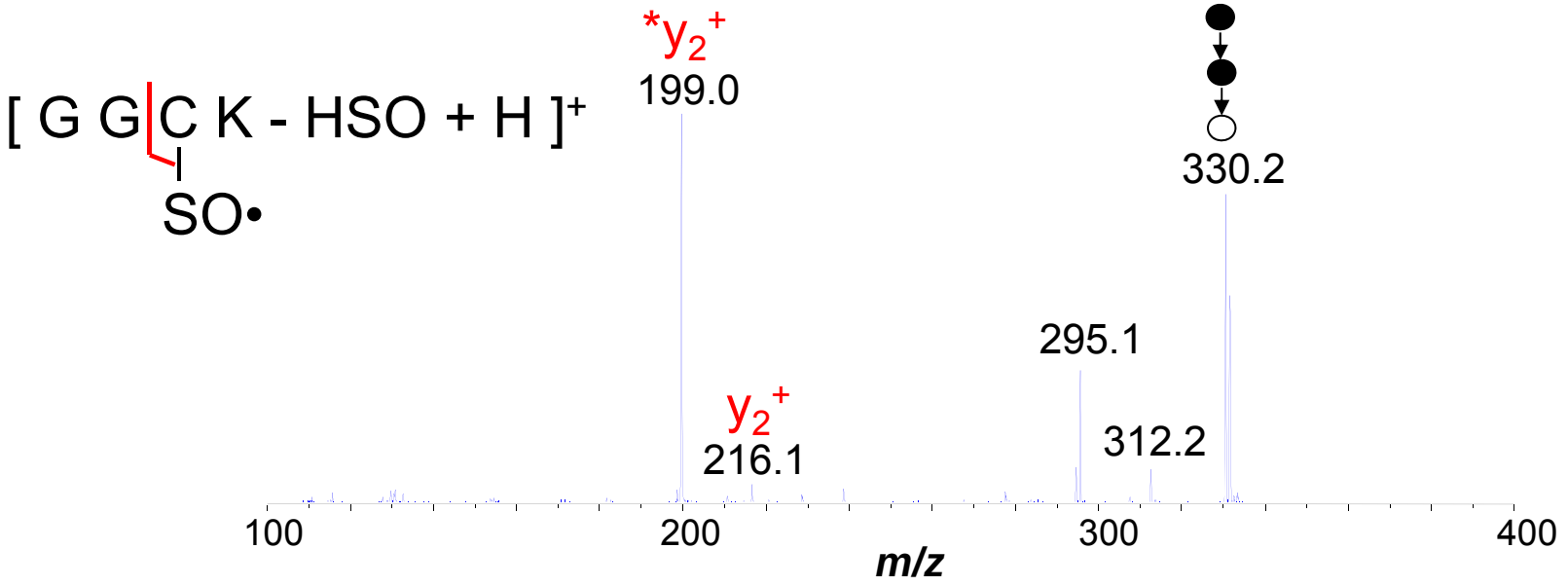


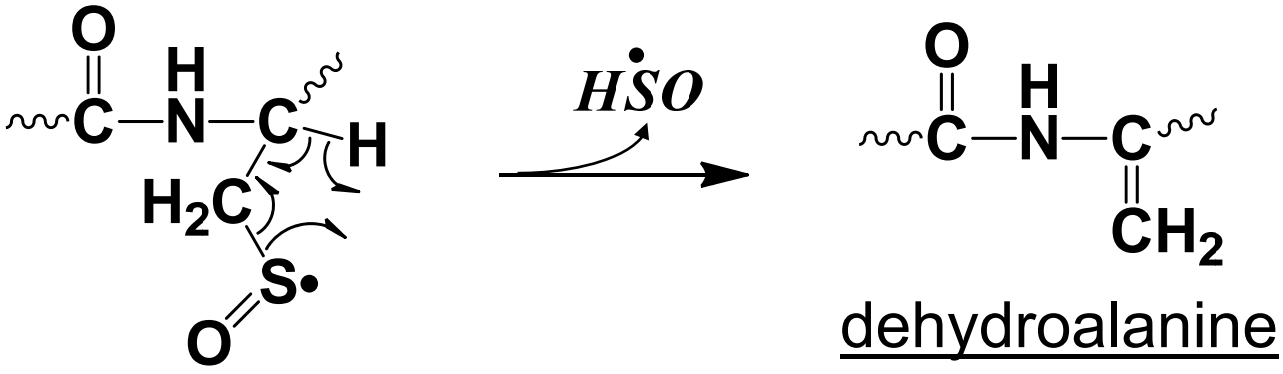
Acetylation can promote 49Da (HSO) loss!

Charge/Radical Location



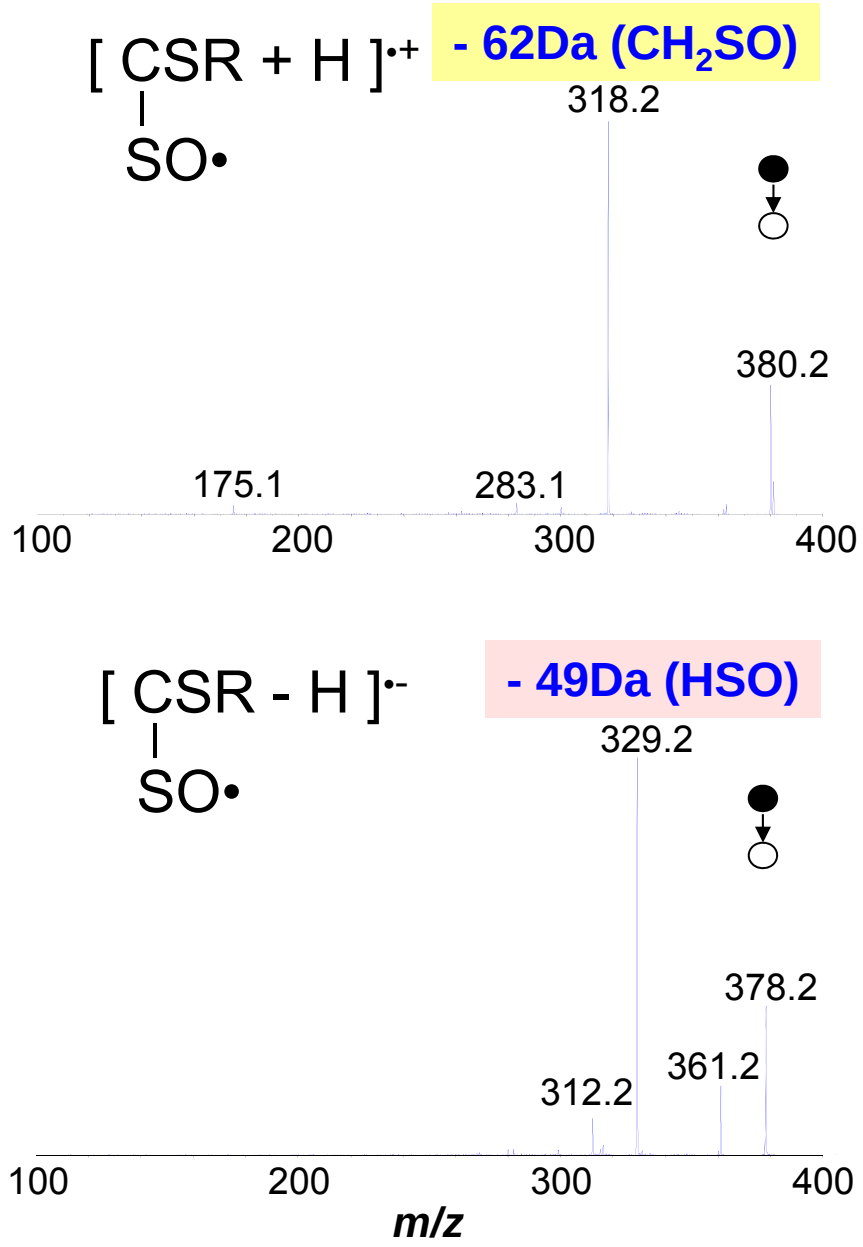
Loss of 49Da (HSO•)





But somehow affected by charge…

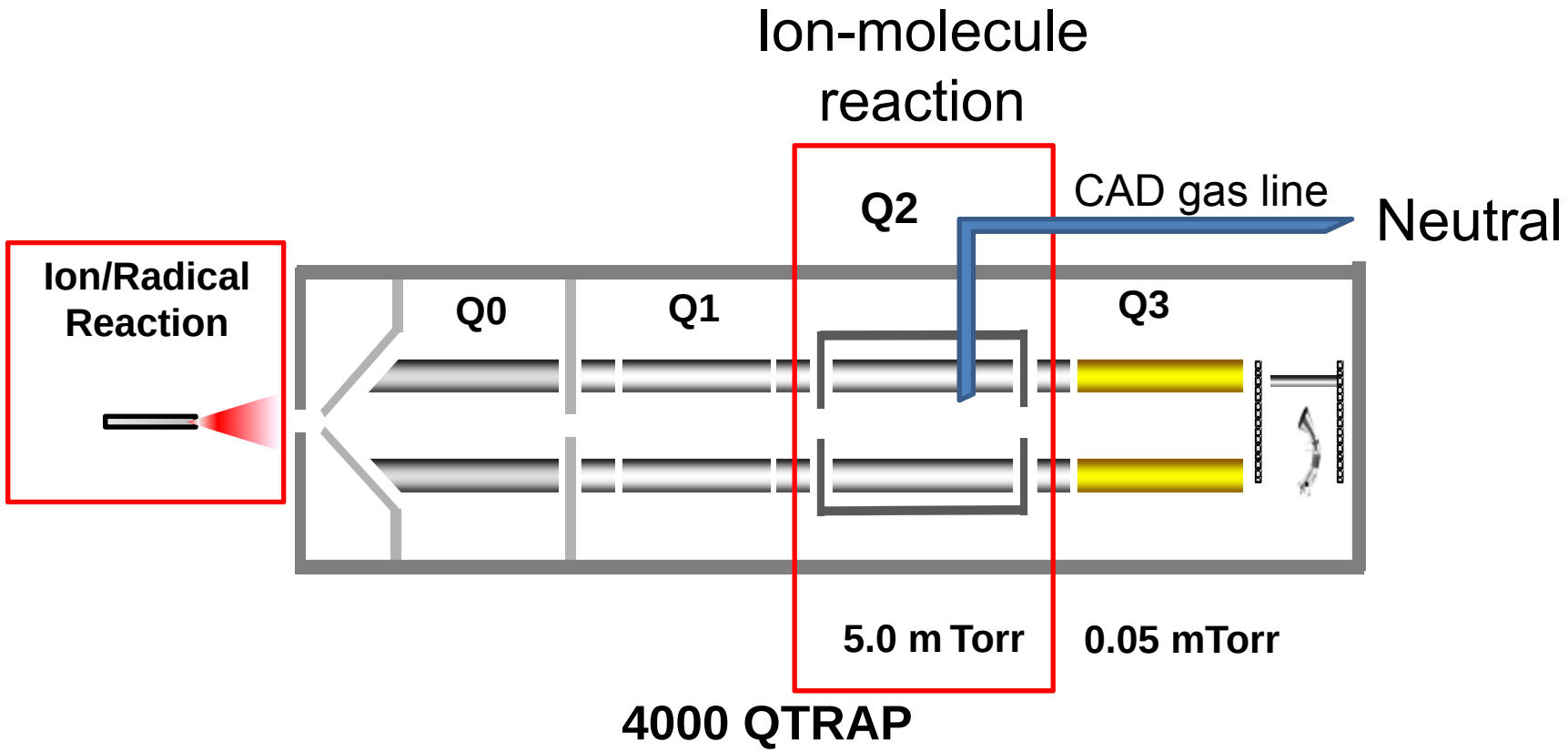
Charge Polarity



Reactivity of Sulfinyl Radical

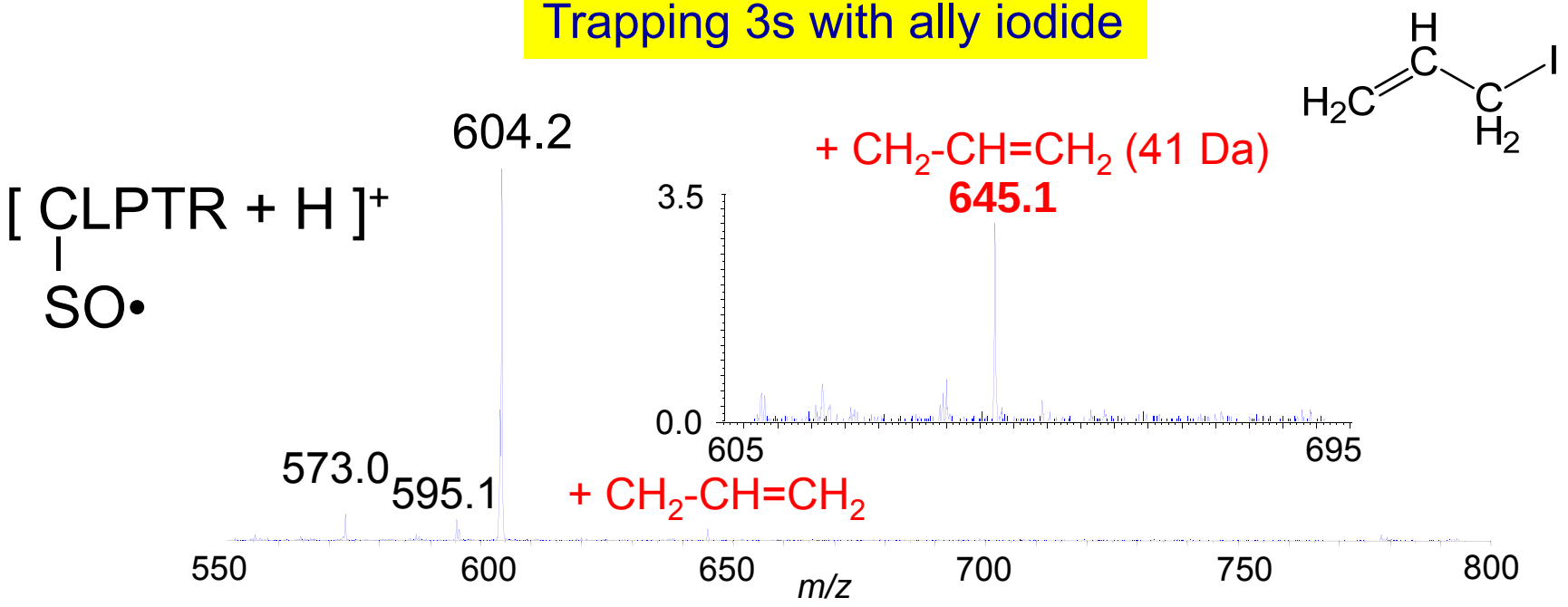
- The fate of sulfinyl radical
- Ion/molecular reaction

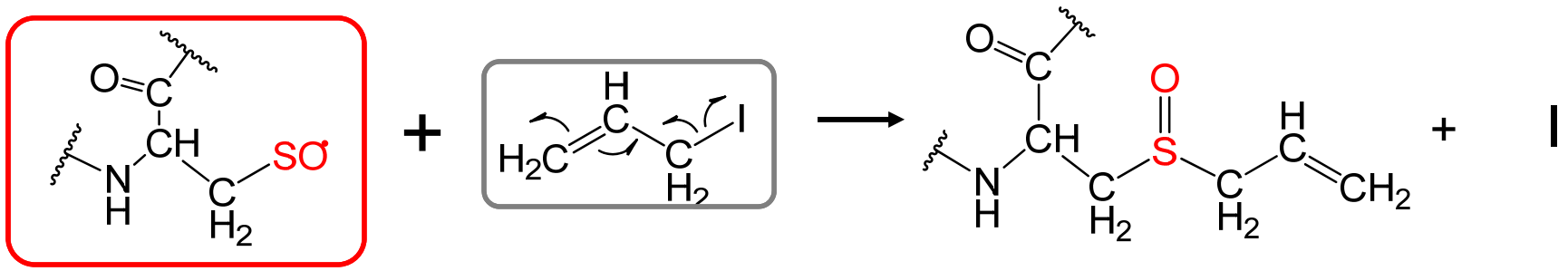
Experiment Setup



Ion-Molecule Rxns of Peptide Sulfinyl Radical Ions

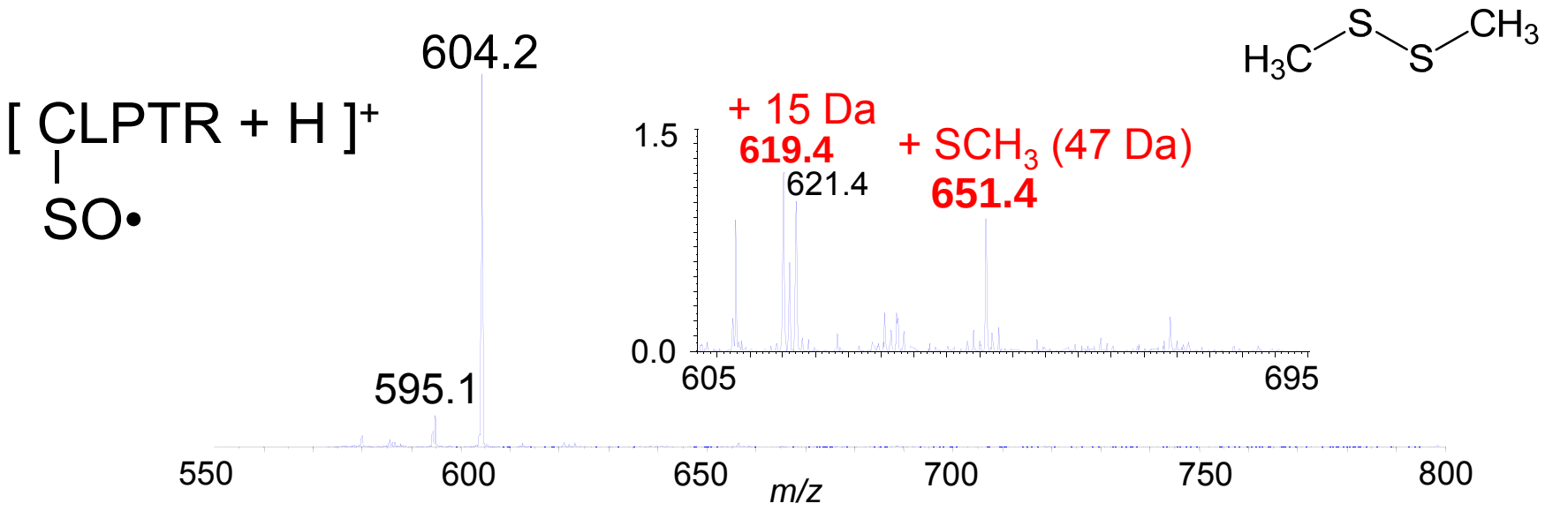
Trapping 3s with ally iodide

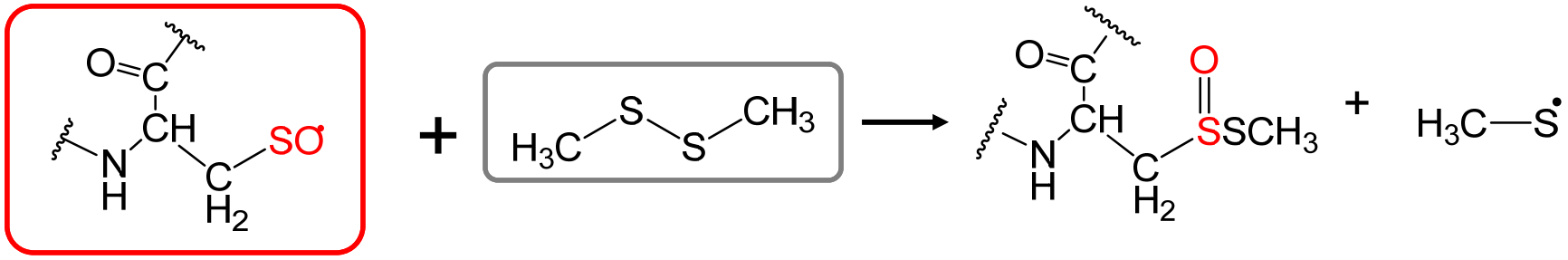




Ion-Molecule Rxns of Peptide Sulfinyl Radical Ions

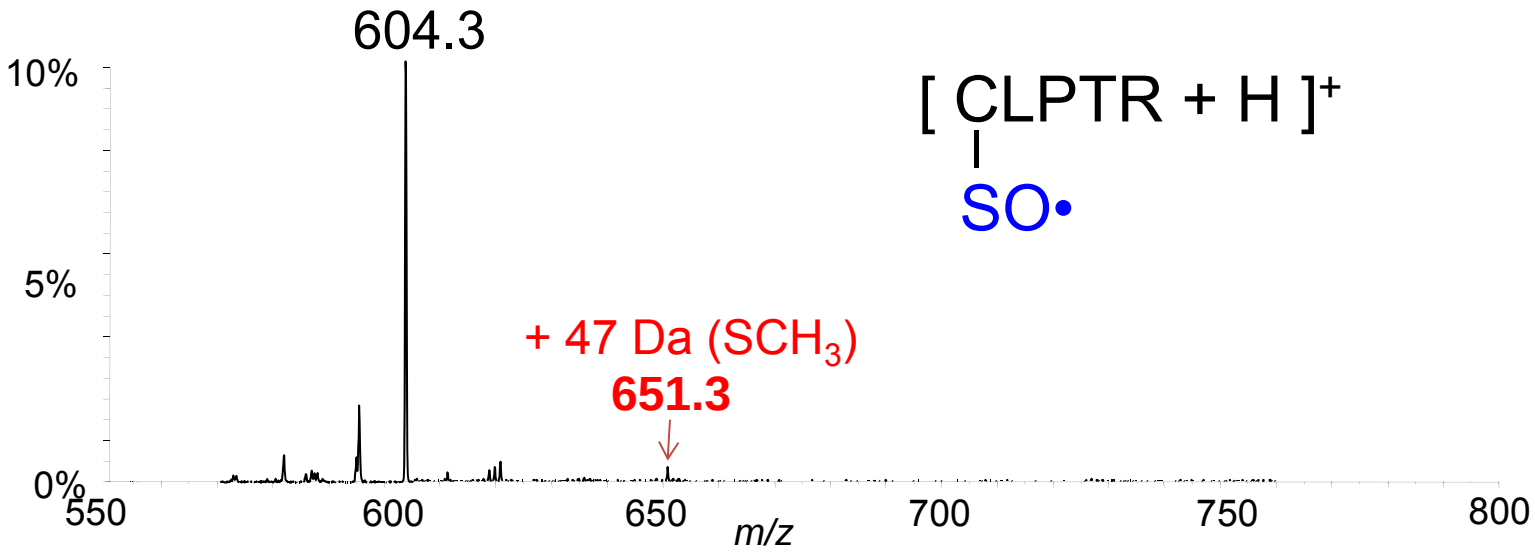
Trapping 3s with dimethyl disulfide

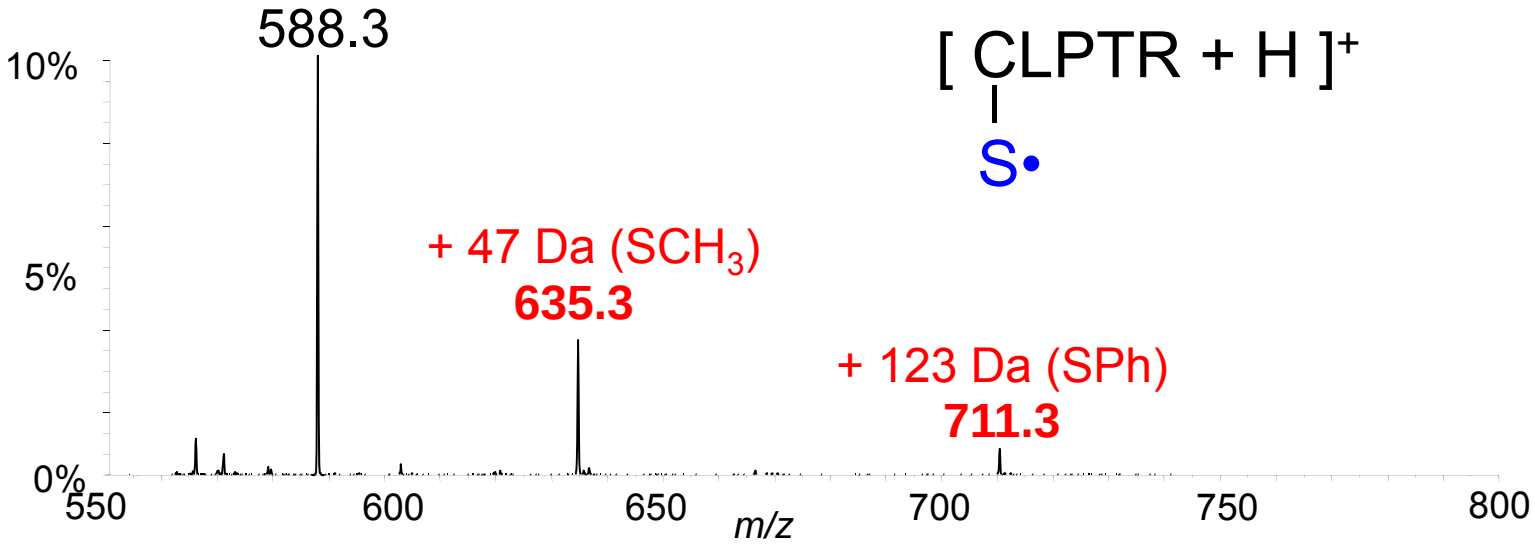




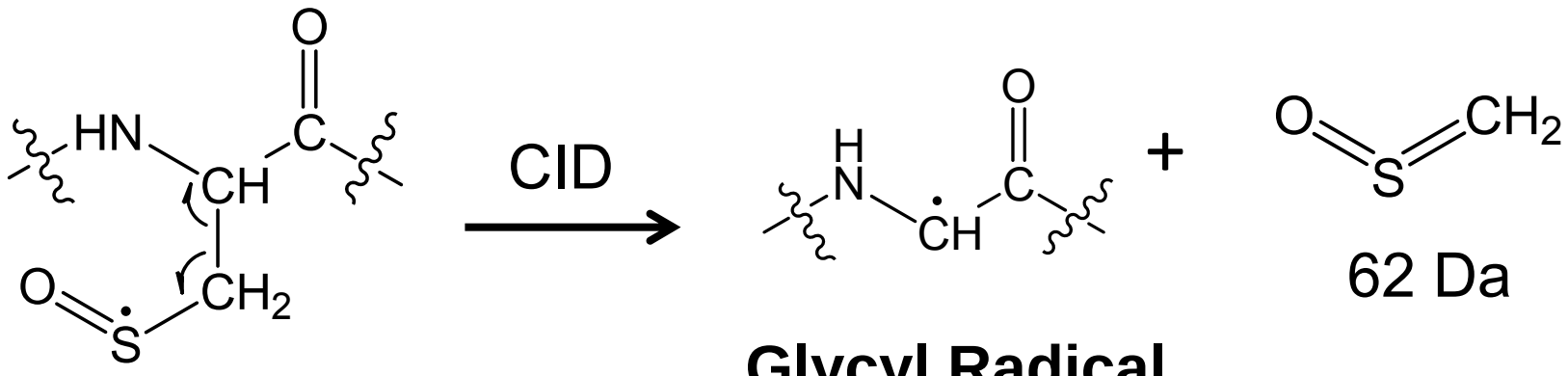
Ion-Molecule Rxns: Sulfinyl v.s. Thiyl

Trapping 3 s with CH_3-S-S-Ph





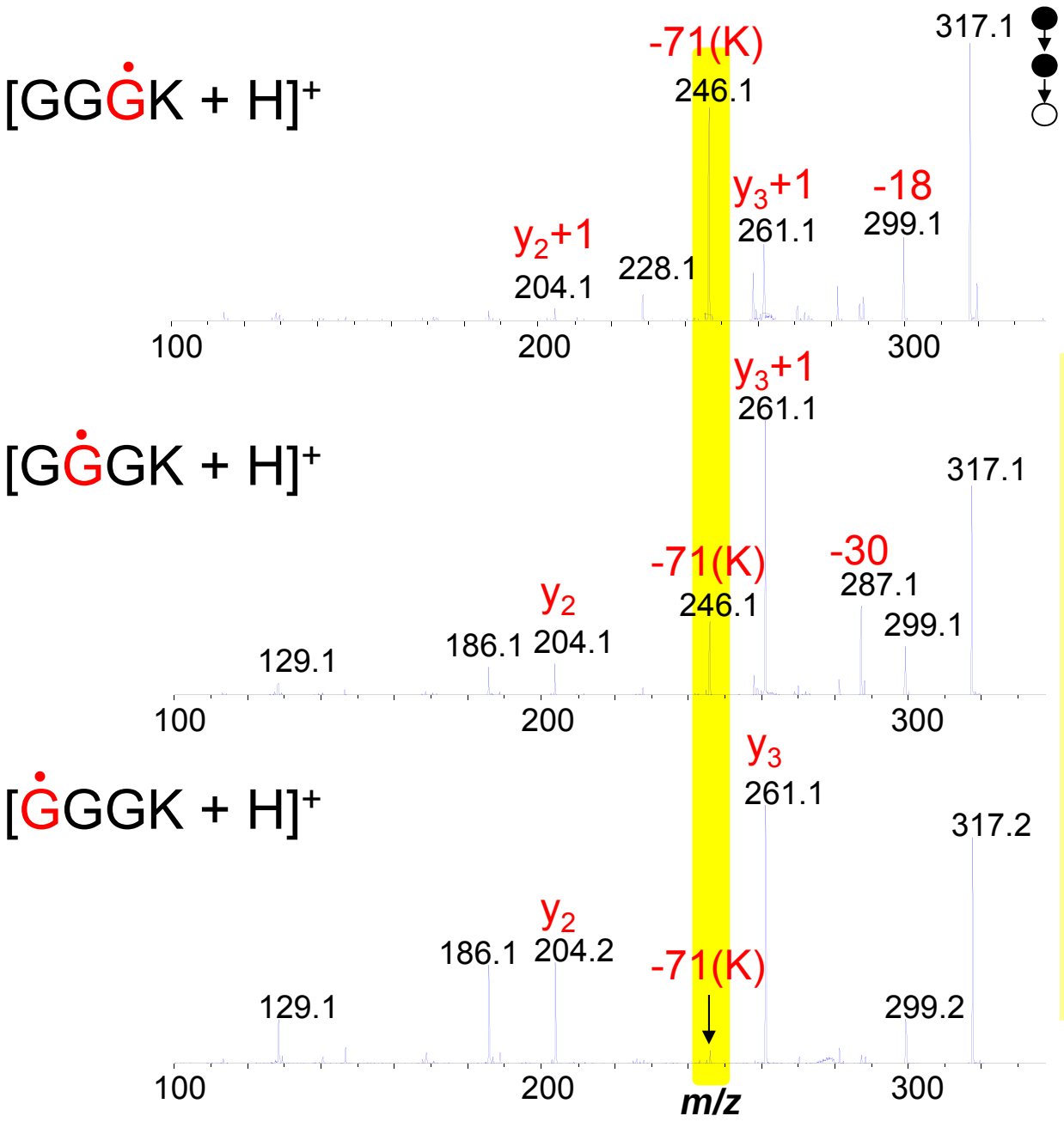
Formation of Site-Specific Glycyl Radical



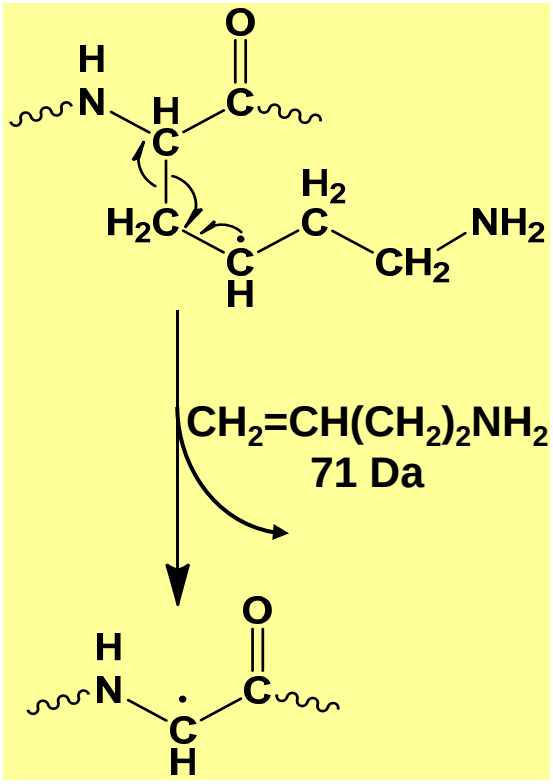
Sulfinyl Radical

Glycyl Radical

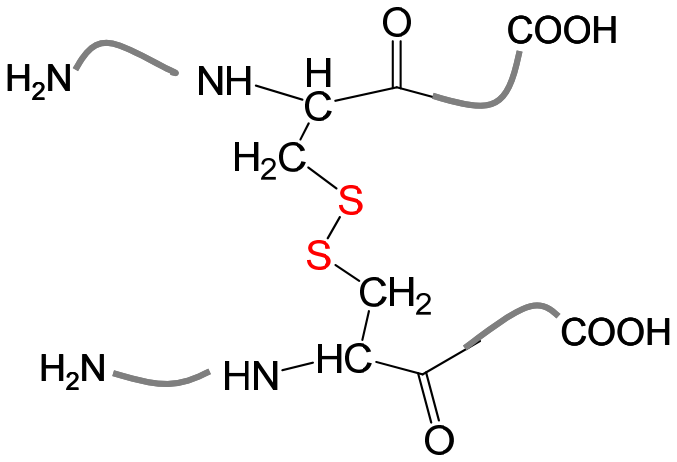
Tracking Radical Migration



Sulfinyl Radical
↓ CID
Glycyl Radical
↓ CID



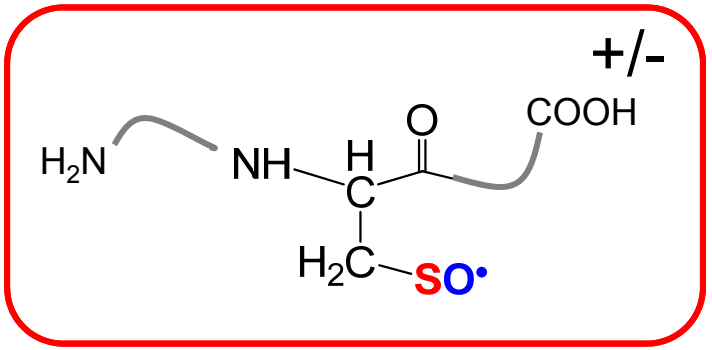
Summary



ESI

radical rxns

(e.g. OH•)



Sulfinyl Radical

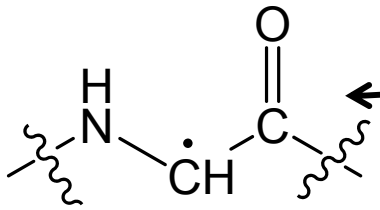
Ion-molecule reaction

CID

- -S-S-
- CH_2=CH-CH_2-I

Low reactivity

- CH_2SO



Glycyl Radical

- Basic amino acid
- Charge state
- Charge location
- Charge polarity

Acknowledgement

PURDUE
RESEARCH FOUNDATION

Dr. Larry Campbell
Dr. Jim Hager
Dr. Joe Francisco