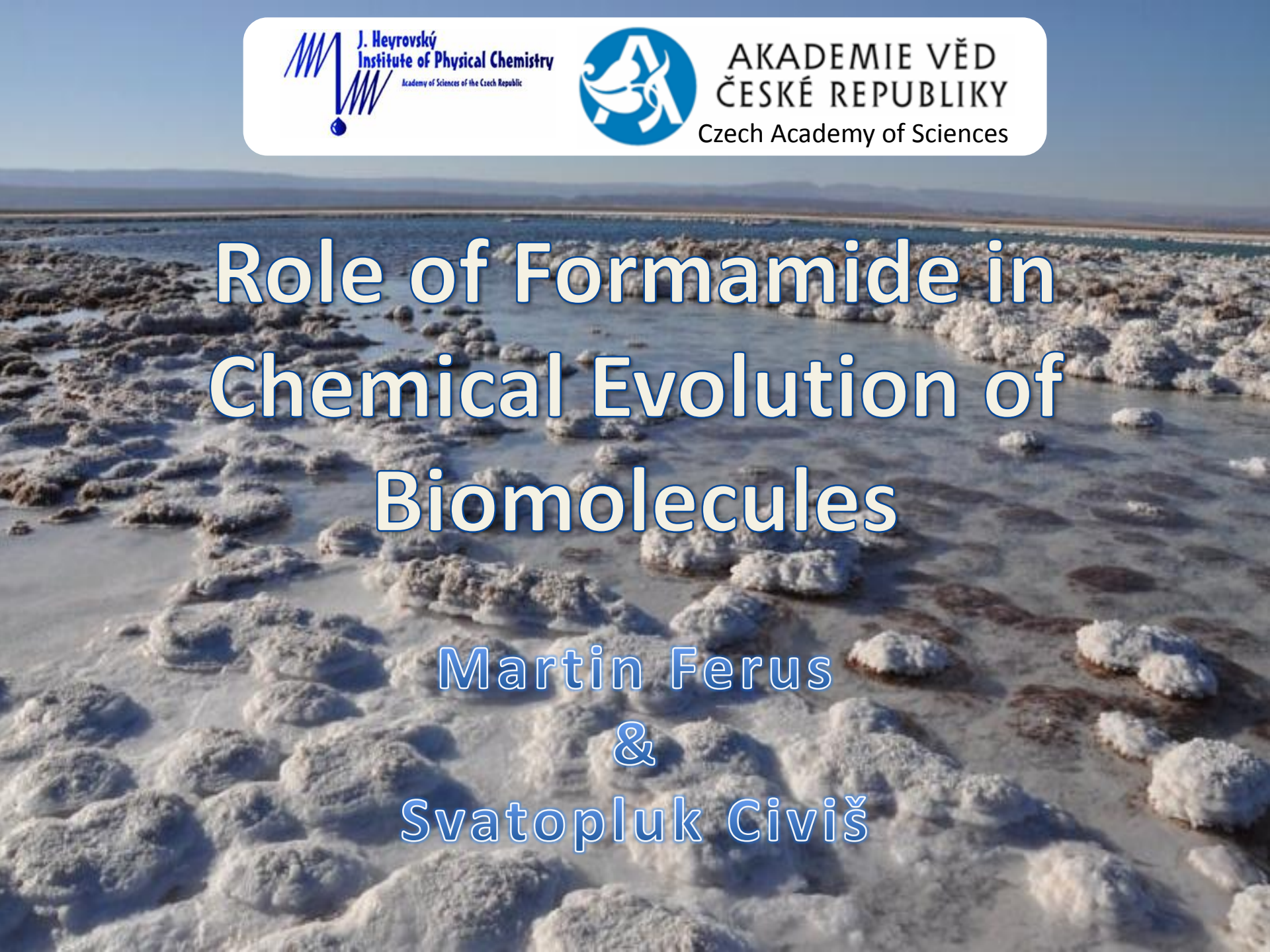
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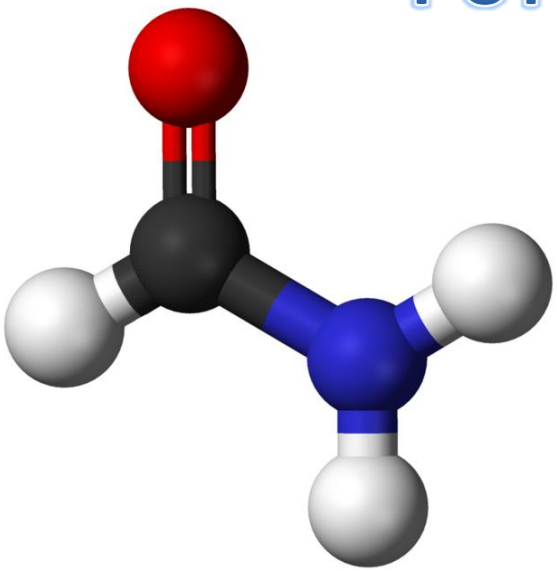
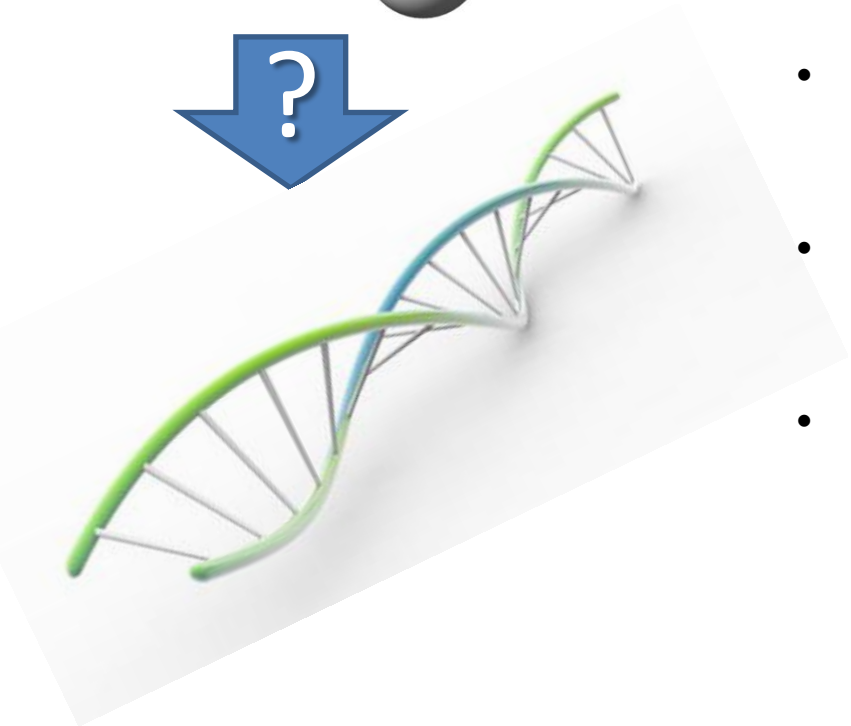
AKADEMIE VĚD
ČESKÉ REPUBLIKY
Czech Academy of Sciences
Role of Formamide in Chemical Evolution of Biomolecules
Martin Ferus
&
Svatopluk Civiš

Formamide Molecule



?



„Molecule with a prebiotic potential“

WHY?

- This molecule contains all the esential heteroatoms important for life.
- The structure represents the simplest model of a peptide bond.
- It is sufficiently reactive upon UV, shock waves, protons, discharges (details later).
- Without presence of radiation or other energy sources, it is a stable liquid.

First Steps

1956 Hellmut Bredereckef — **Neue Pyrimidin-Synthese aus β-Dicarbonyl-Verbindungen und Formamid**

Formamid-Reaktionen: Eine Neue Pyrimidin-Synthese

1972 Hiroshi Yamada — **One Step Synthesis of Purine Ring from Formamide**

2001 Raffaele Saladino — **A possible prebiotic synthesis of purine, adenine, cytosine, and 4(3H)-pyrimidinone from formamide: Implications for the origin of life**

Proposed Scenario:

Formamide is related to HCN chemistry.
It might be produced by HCN hydrolysis in water, concentrated by evaporation and then react being heated, exposed to UV (….. or to other sources of sufficiently high energy).

Formamide Heating

160°C + selected catalysts

Mechanism is likely (heat flux on early Earth was sufficient).

First experiments: Silica, Alumina: purine, adenine, cytosine, pyrimidinone
Current Experiments: Meteorites: nucleic bases, sugars, some aminoacids (Saladino)
No catalyst: All the canonical nucleic bases (Ferus, Civiš)

Formamide + UV Radiation

130°C and 254 nm (Barks et al.)

Mechanism is maybe not so likely (heavy clouds and dust in the atmosphere).

Guanine, Adenine, and Hypoxanthine

Formamide + Cosmic radiation

Simulation of Solar Wind by a Proton Flux

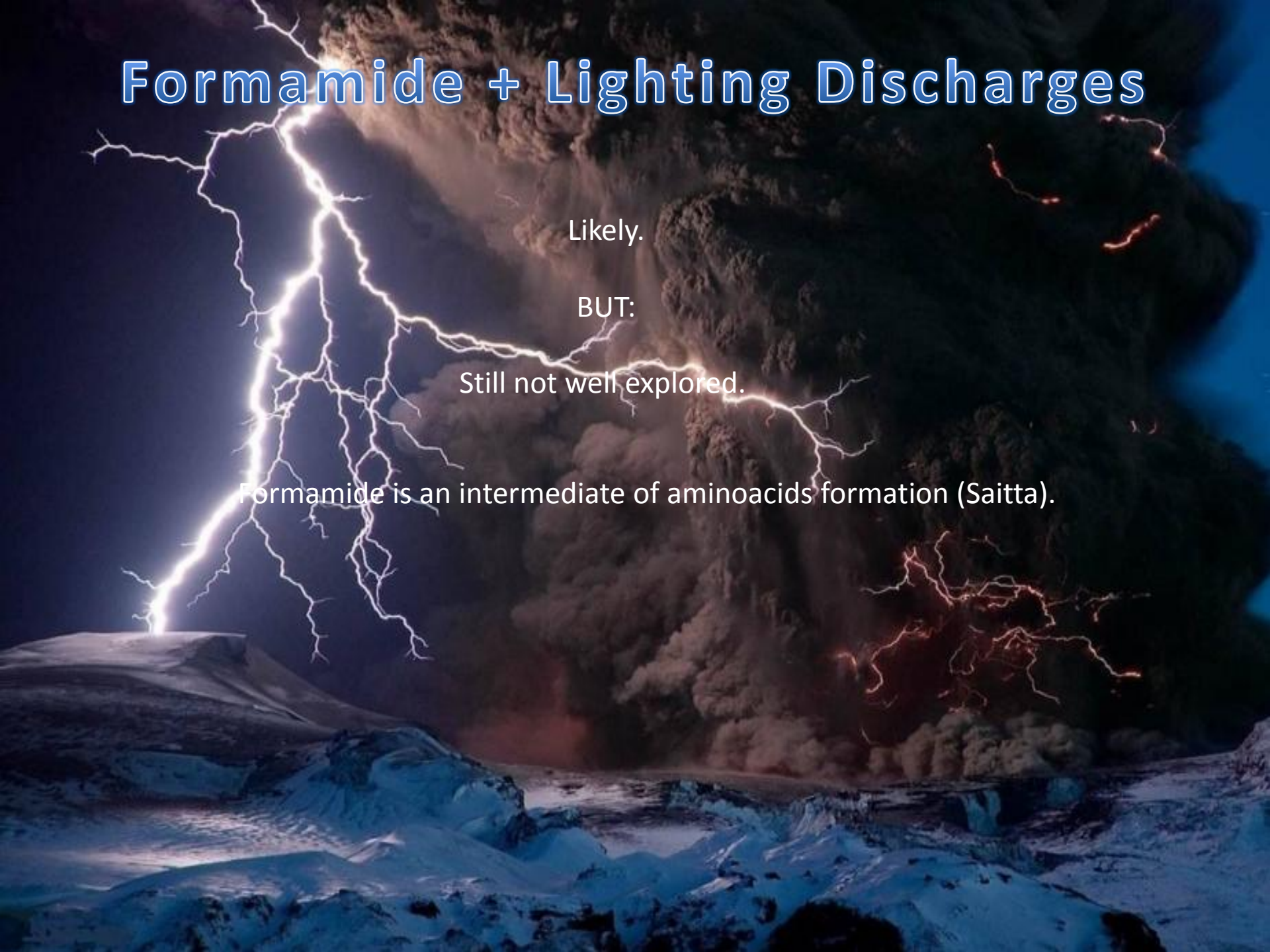
In presence of meteorites: Formation of all the canonical nucleic bases, sugars and selected aminoacids (Saladino).

Extraterrestrial source of biomolecules (chemical panspermia).

Formamide + Impact Shock Waves

Simulation using a large laser facility

Formamide + Lighting Discharges



Likely.

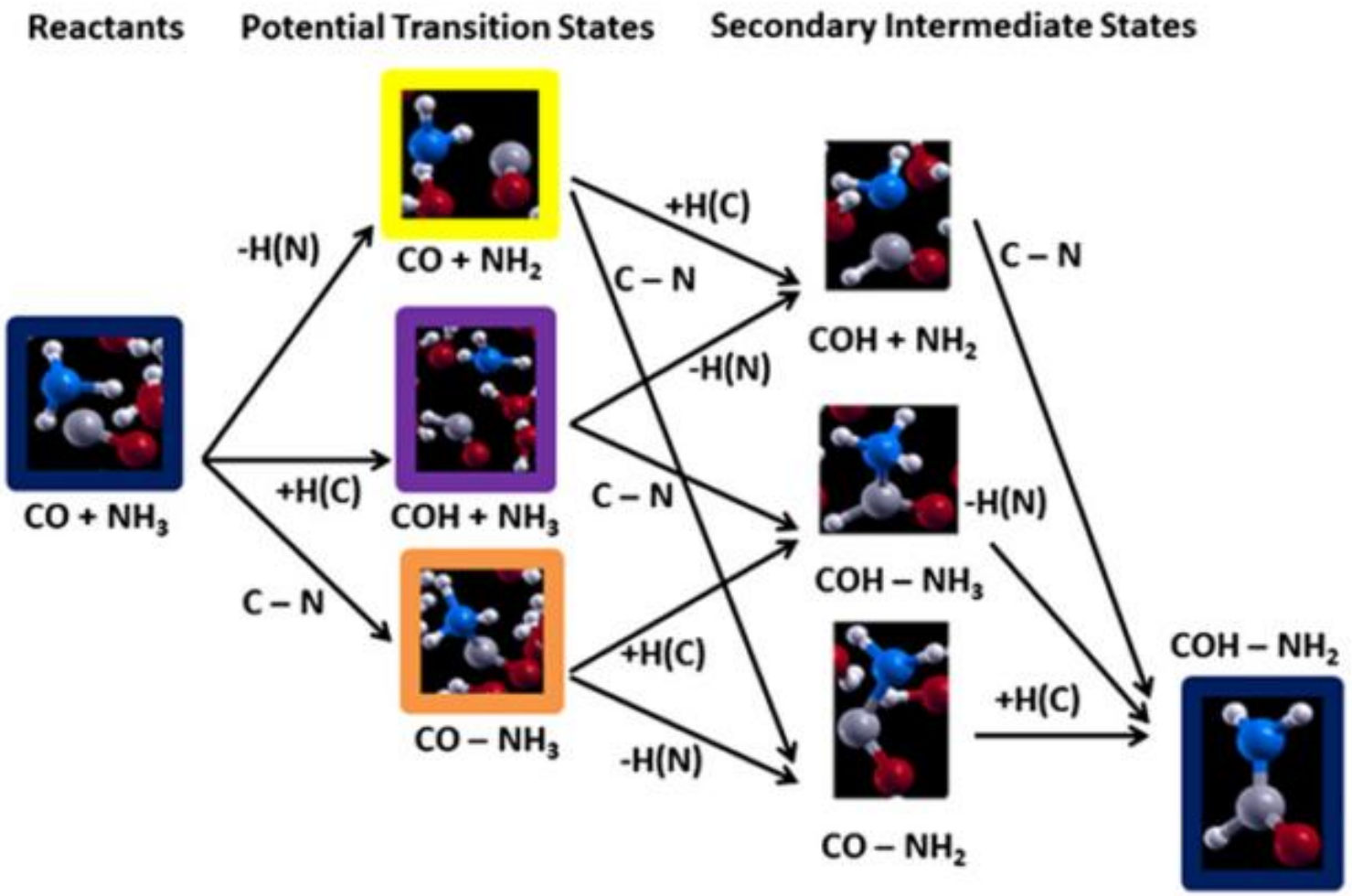
BUT:

Still not well explored.

Formamide is an intermediate of aminoacids formation (Saitta).

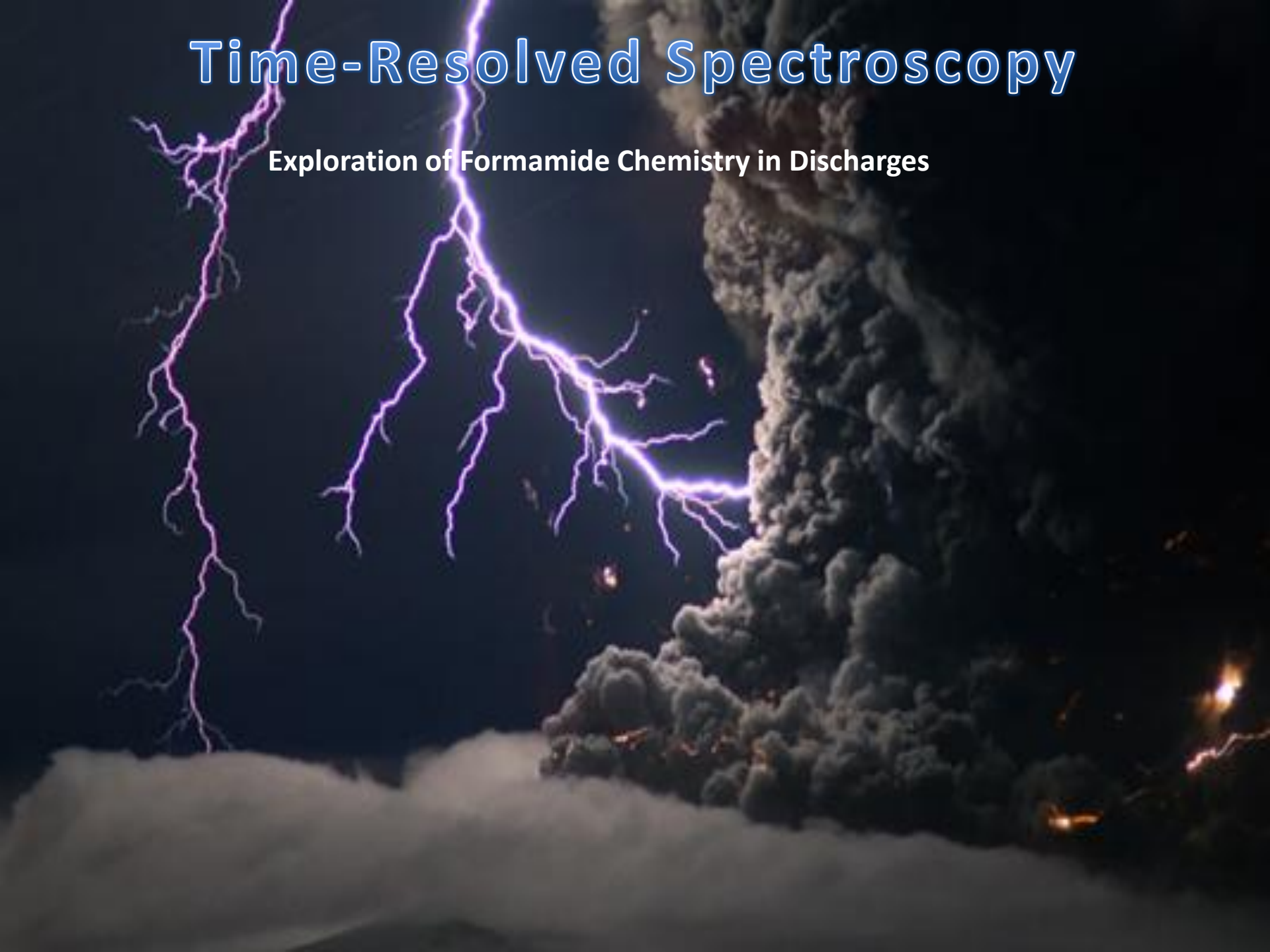
Formation of Aminoacids

Theoretical calculations on Miller – like Experiments (Saitta et al.)
Formamide is an intermediate of aminoacids formation

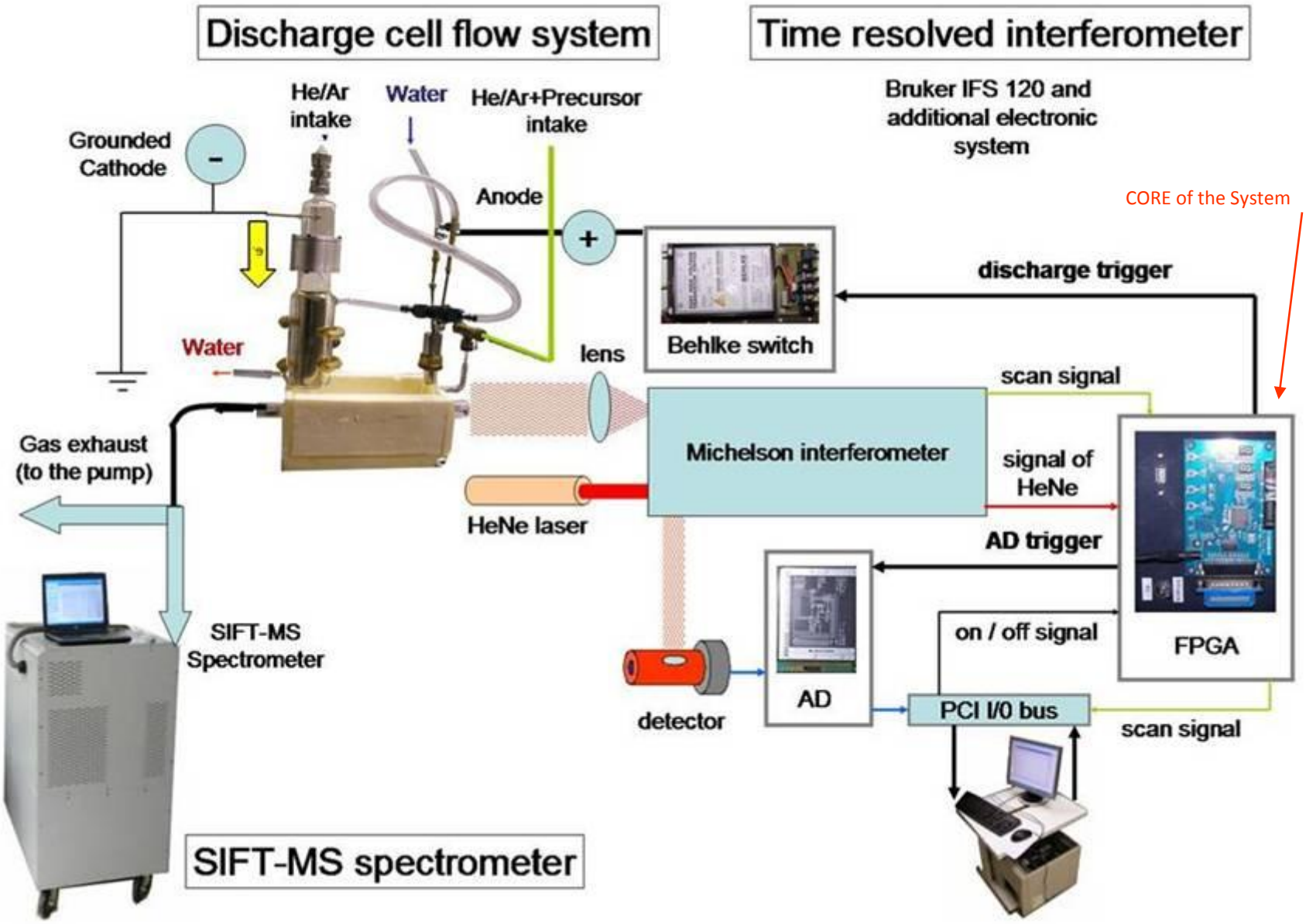


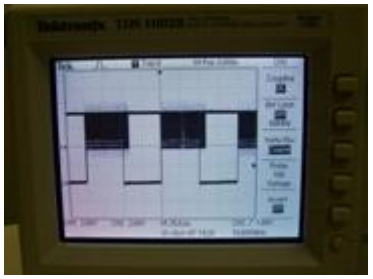
Time-Resolved Spectroscopy

Exploration of Formamide Chemistry in Discharges



Electronic set-up





SCAN

Movement of mirror - HeNe fringes – digital signal

> 100 µs

HeNe

Discharge Trigger – pulsed discharge

AD Trigger – 30 to 60 signals from the detector

OPD 1

OPD 2

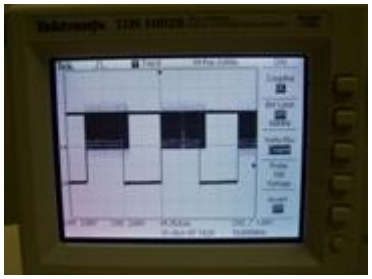
OPD 3

OPD *n*

Intensity

OPD

Interferogram nr. 1 for the first microsecond



SCAN

HeNe fringes – digital signal

> 100 µs

HeNe

Discharge Trigger – pulsed discharge

AD Trigger – 30 to 60 signals from the detector

OPD 1

OPD 2

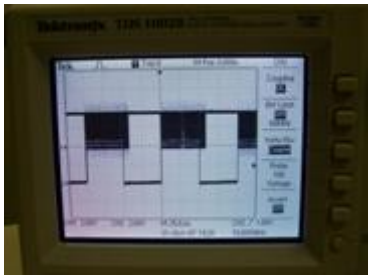
OPD 3

OPD *n*

Intensity

OPD

Interferogram nr. 2 for the second microsecond



SCAN

HeNe fringes – digital signal

> 100 µs

HeNe

Discharge Trigger – pulsed discharge

AD Trigger – 30 to 60 signals from the detector

OPD 1

OPD 2

OPD 3

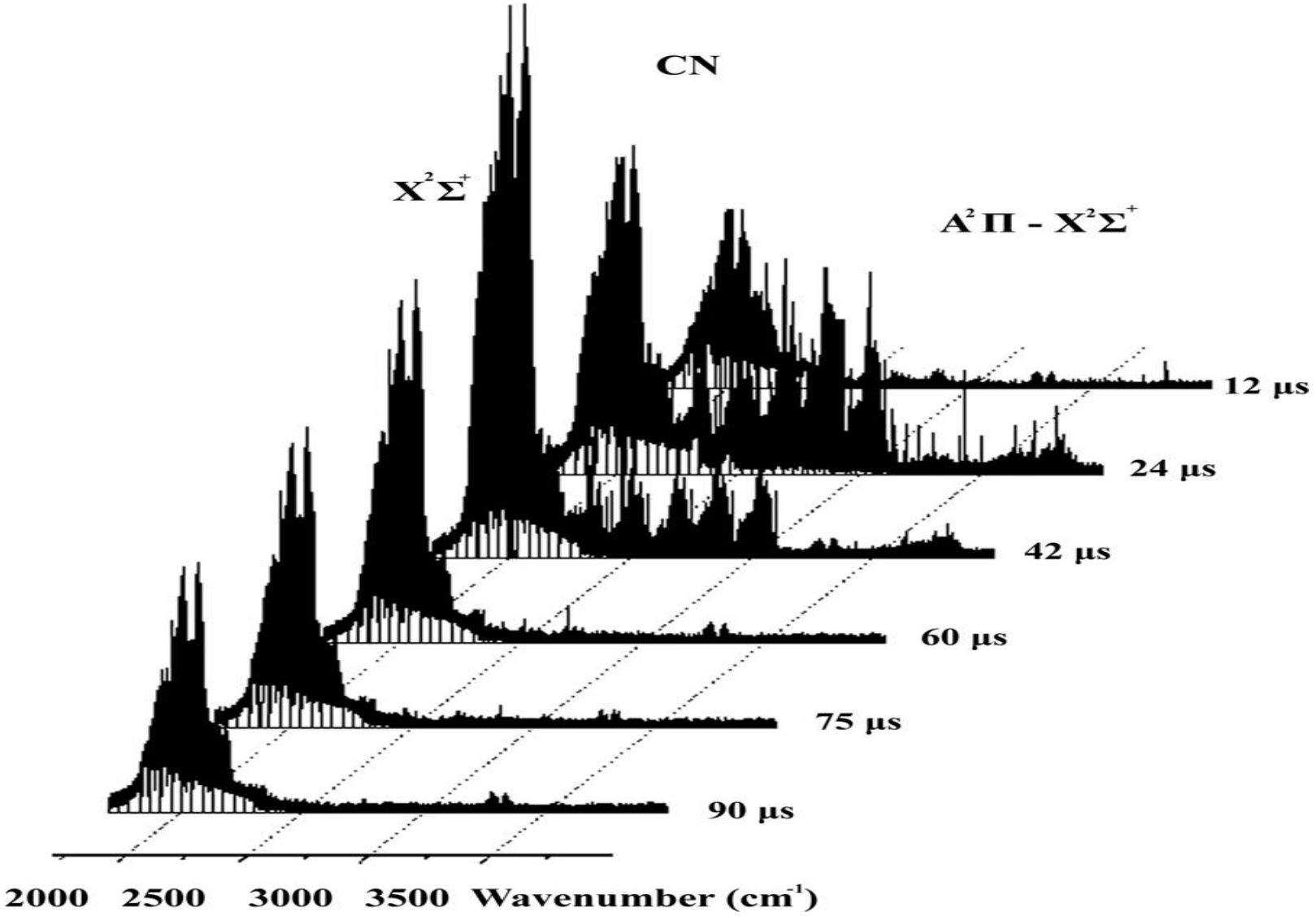
OPD *n*

Intensity

OPD

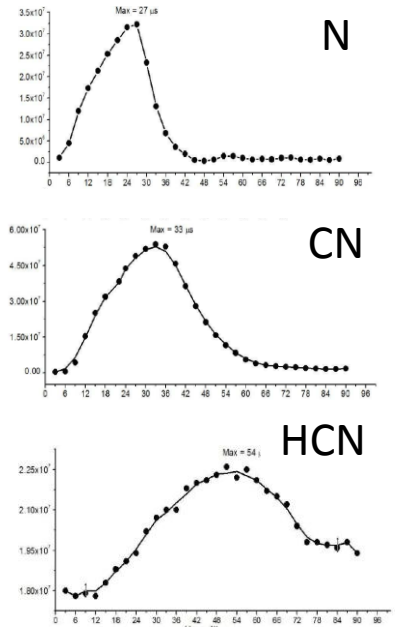
Interferogram nr. 3 for the third microsecond

Time resolved data – one continual scan



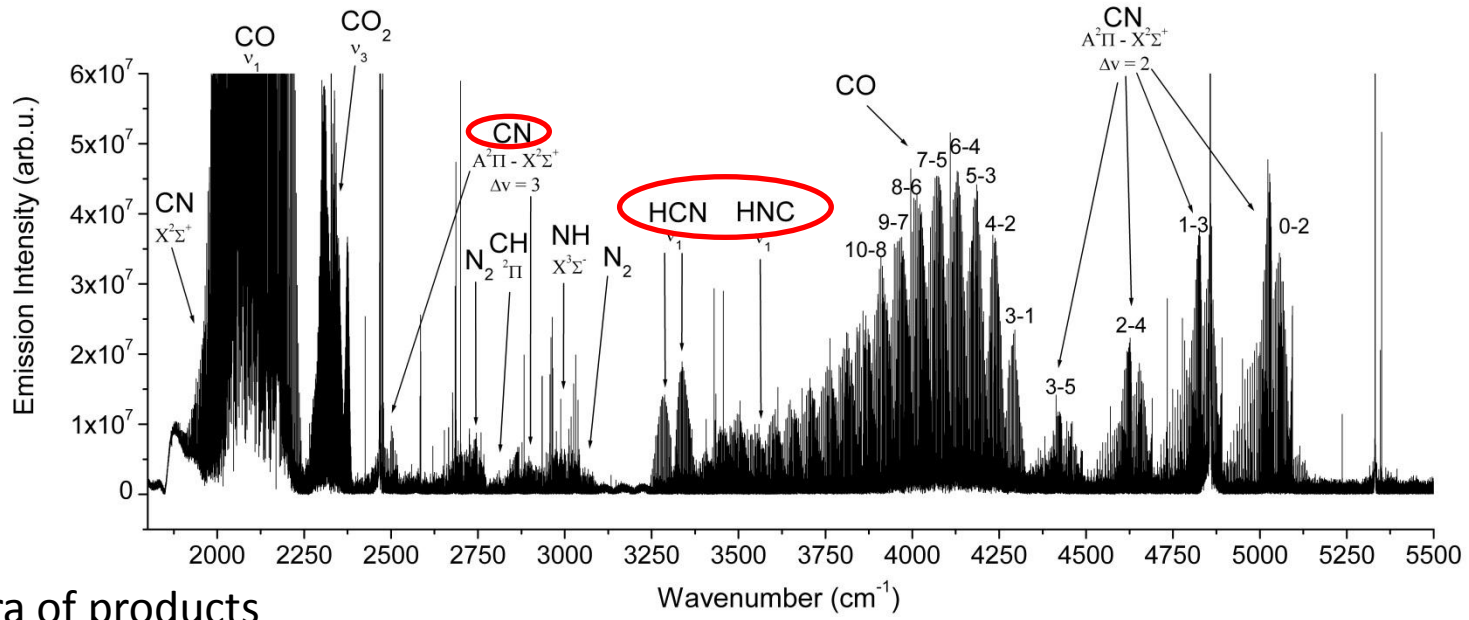
The time-resolved emission FT spectrum from a pulsed discharge in a $(CN)_2$ and He mixture. The discharge pulse duration was 20μs. The 30 time-resolved spectra were collected from t = 0–90 μs with a step of 3 μs. The spectra of C_2H_2 and C_2 were observed at 3300 and 3600 cm^{-1}.

Formamide Discharge

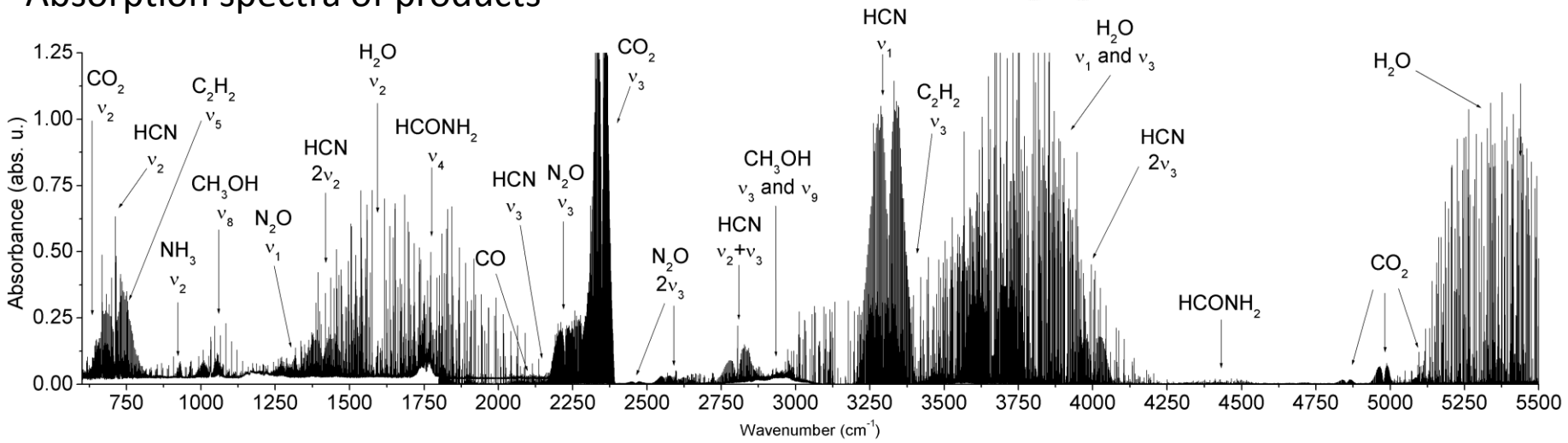


Emission spectra

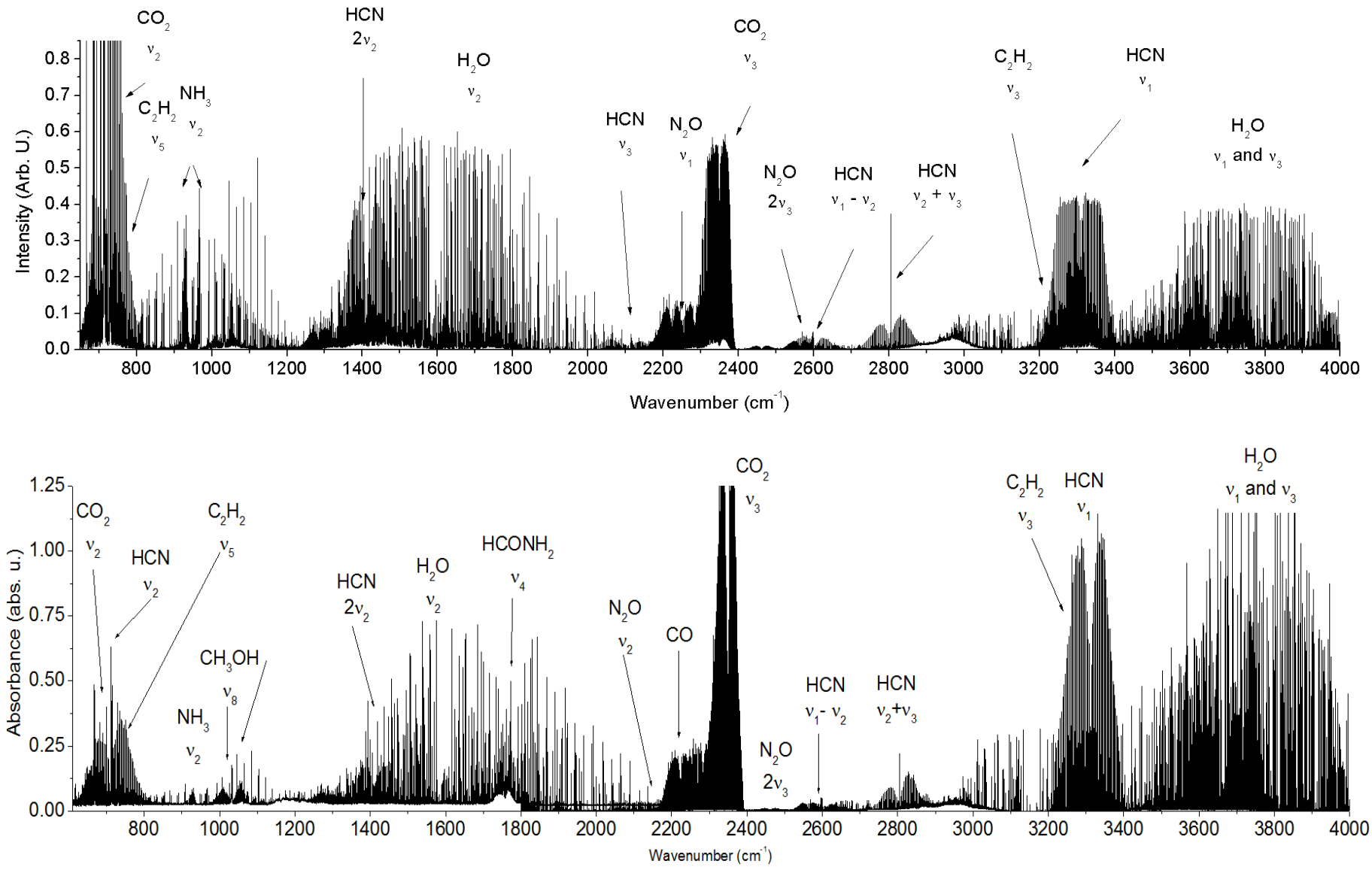
Detection of radicals and ions and their energetical states



Absorption spectra of products

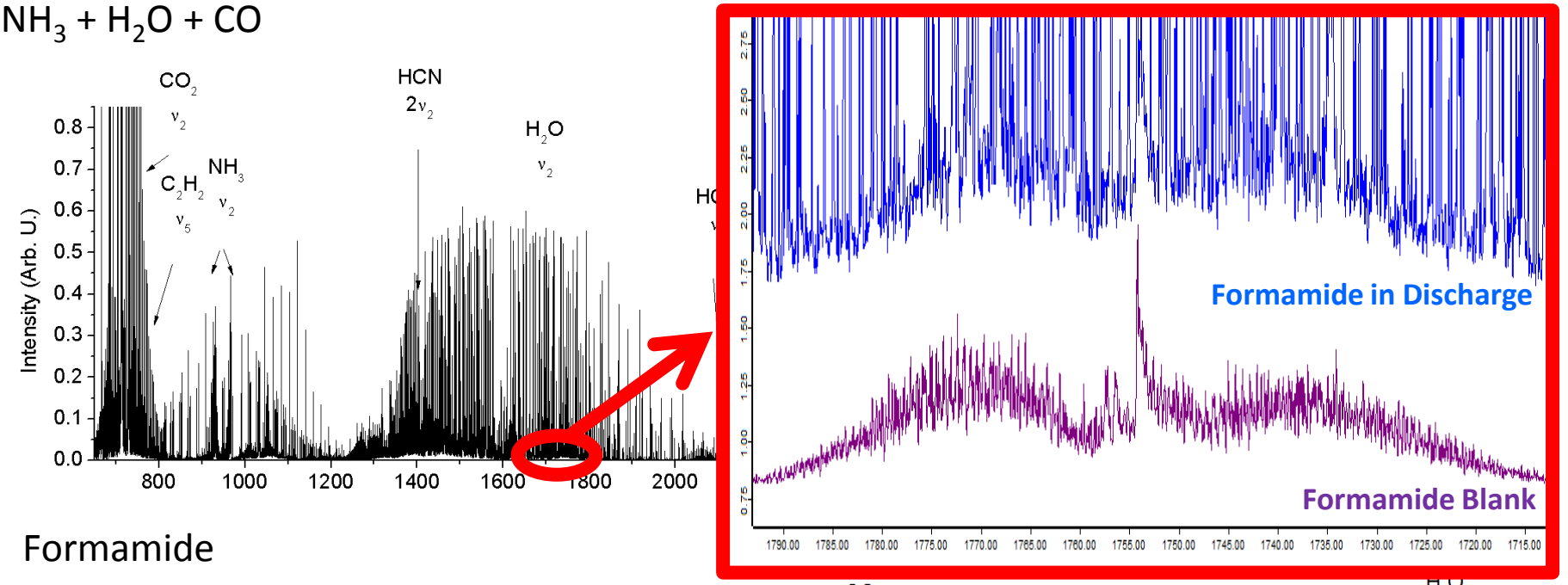


Formamide Discharge

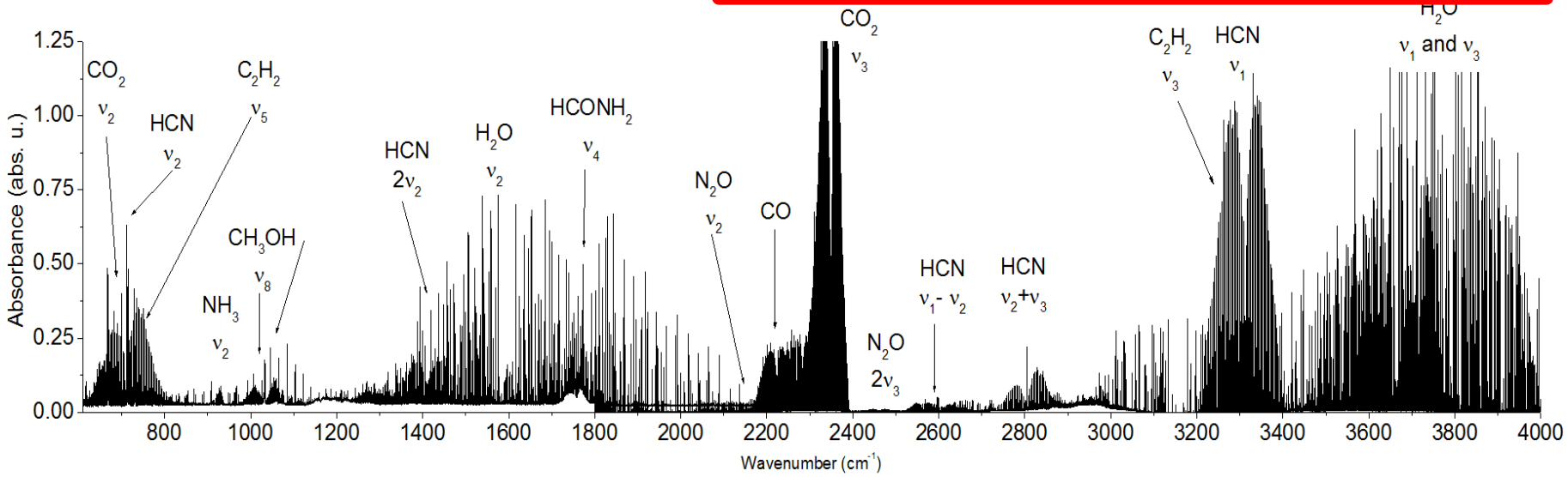


Formamide Discharge

$NH_3 + H_2O + CO$

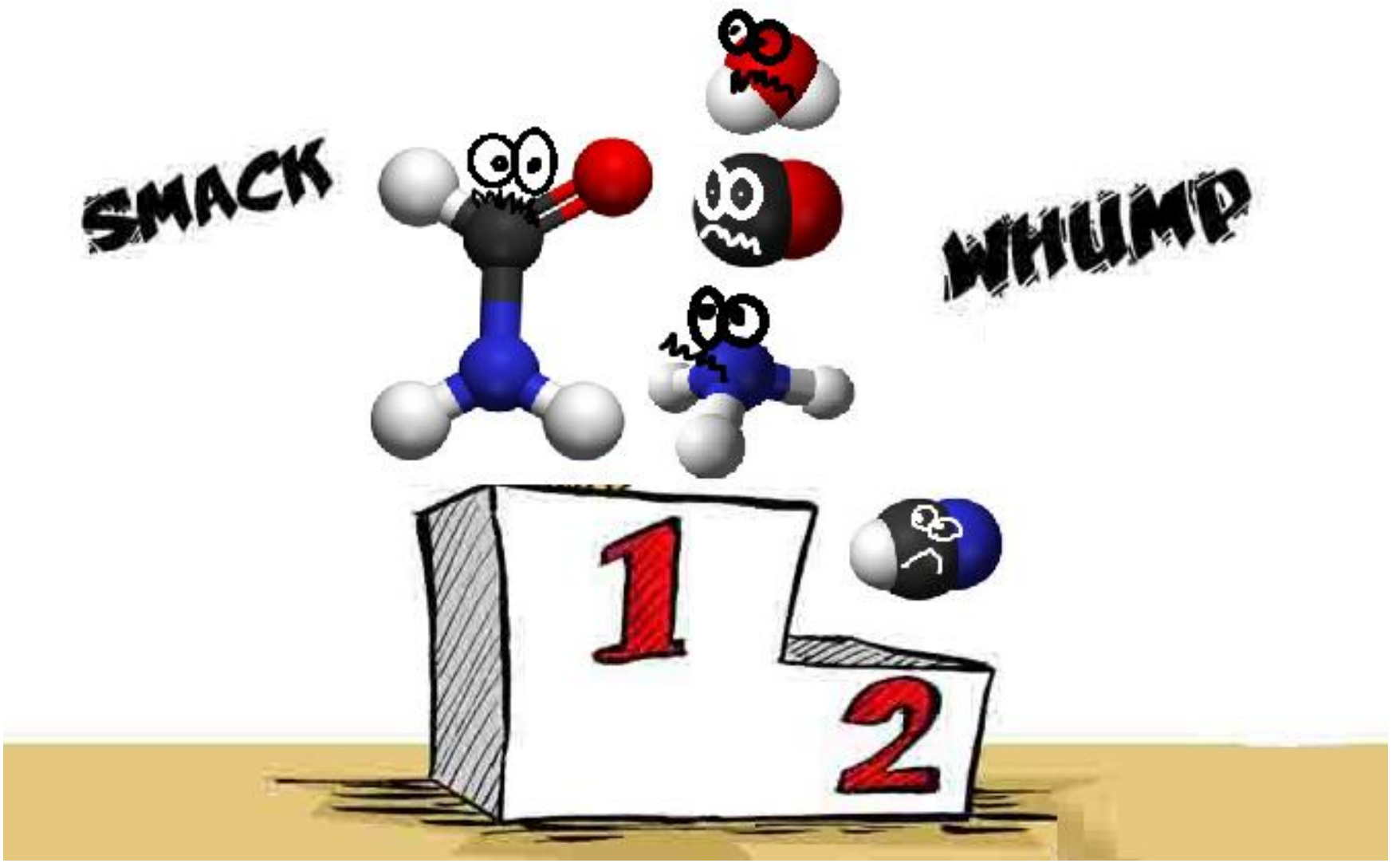


Formamide



THE OLD CHICKEN AND EGG PROBLEM ...

THE OLD CHICKEN AND EGG PROBLEM ...



Discharge Chemistry

Mutual Conversion in Complicated Reaction Chains leads to Formation of Biomolecules.

Formamide Plays an Important Role of Reactive Substrate (Urey-Miller) or Parent Compound (Saladino).

Fundamental role is played by CN, CO, NH_2

U

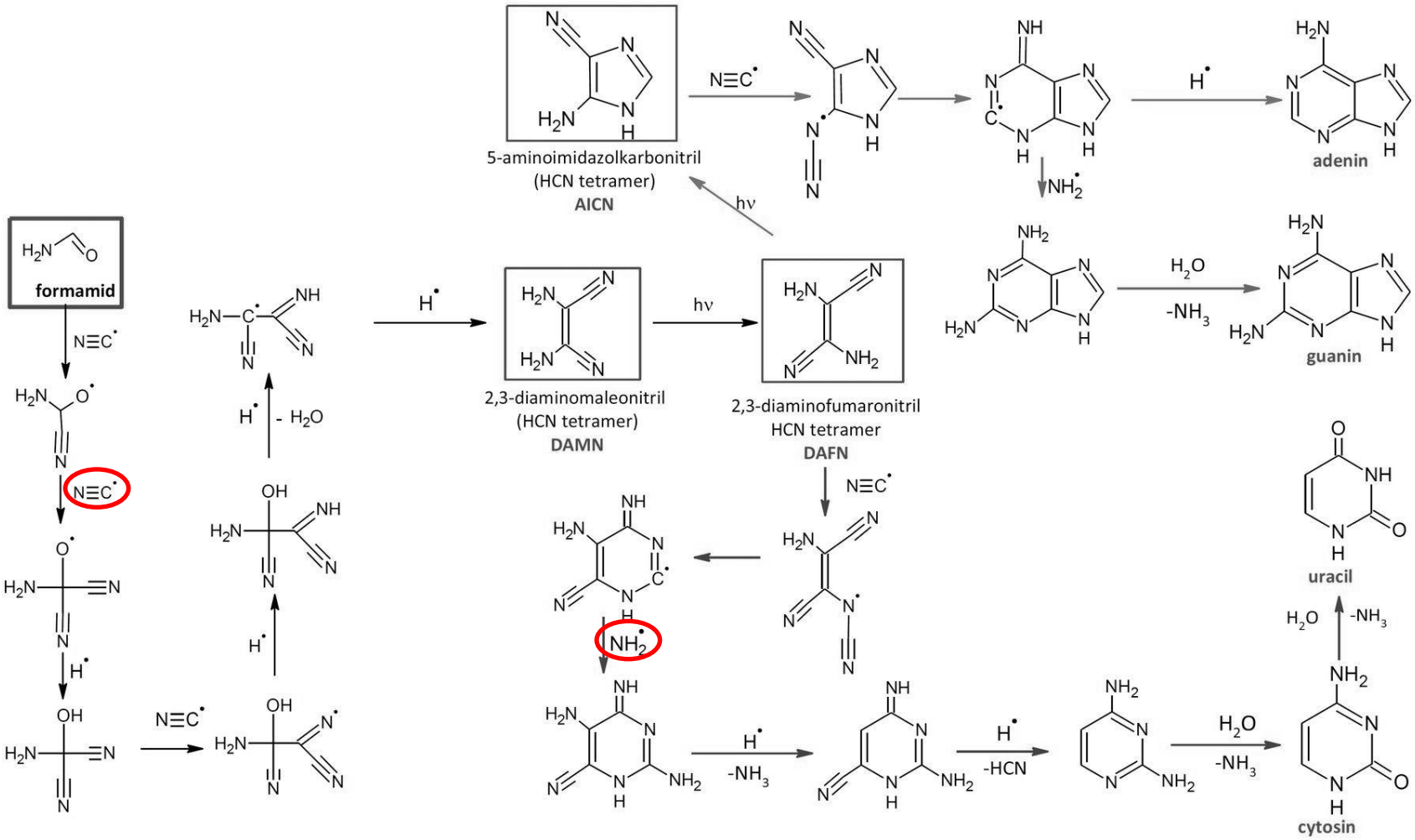
T

A

G

C

Cyano Radical Mechanism



Cyanide Mechanism