Université de Montréal et du monde.

Pulsed nanosecond air discharge in contact with water

Influence of voltage polarity, amplitude, pulse width, and gap distance

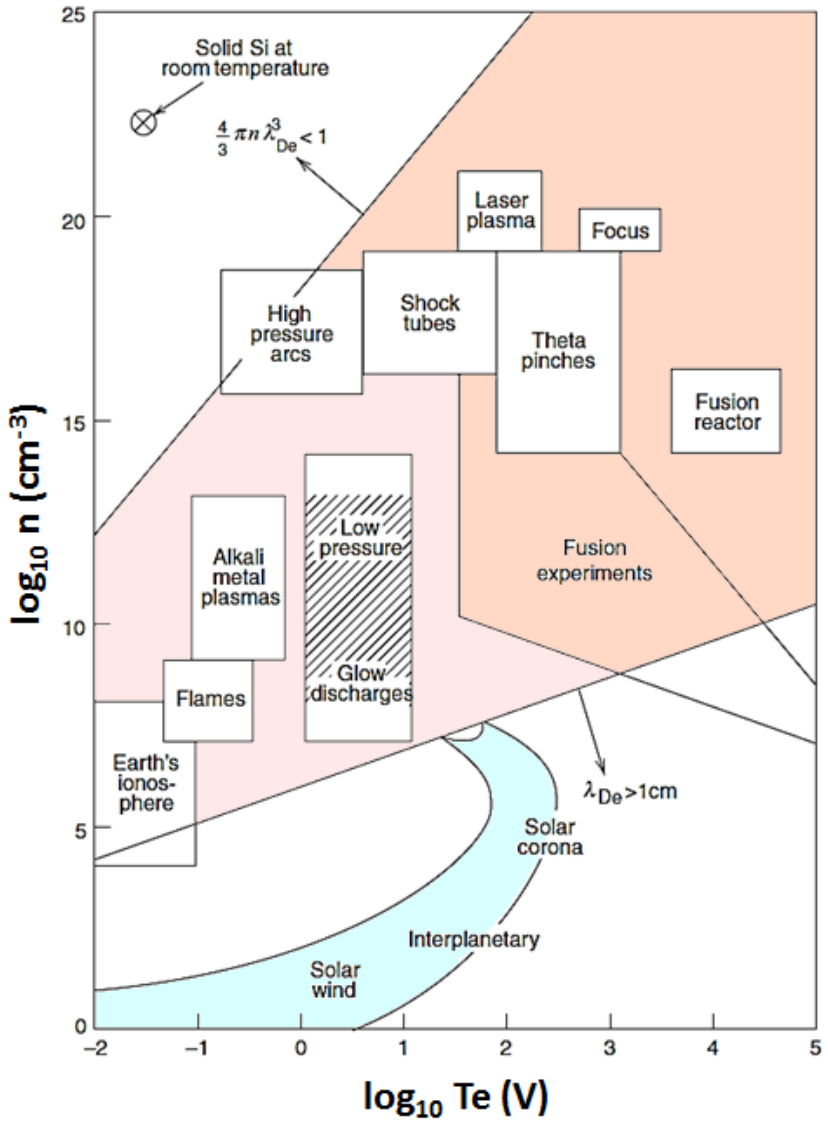
James Diamond and Ahmad Hamdan

Groupe de physique des plasmas, departement de Physique, Universite de Montreal, Qc, Canada

Outline

- Introduction
- Experimental Setup
- Results and discussion
- Conclusion

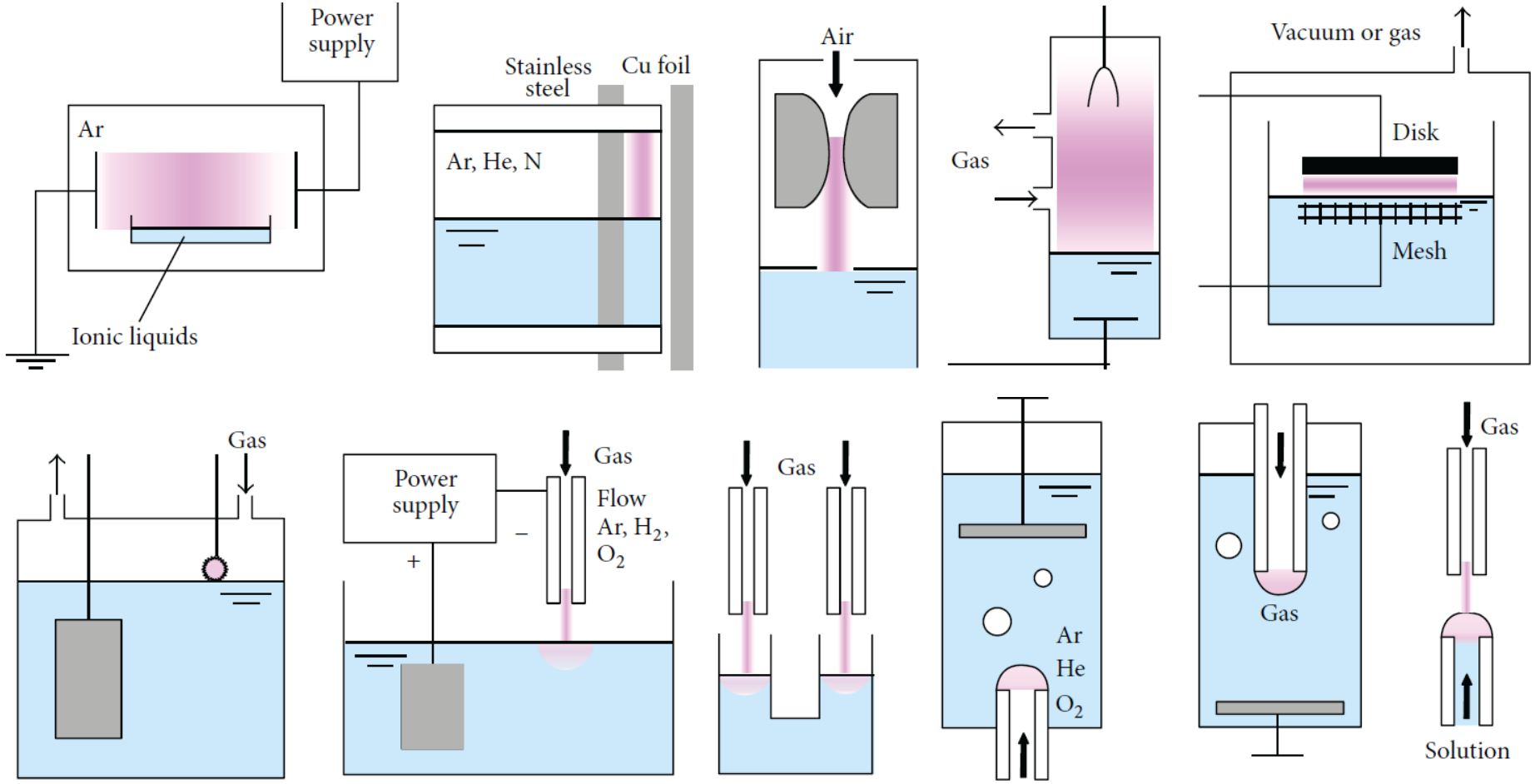
Introduction



non-equilibrium plasma at atmospheric pressure
→ For liquid processing, including water treatment

Plasma in-contact with liquids

- Countless configurations to produce a plasma in-contact with liquids



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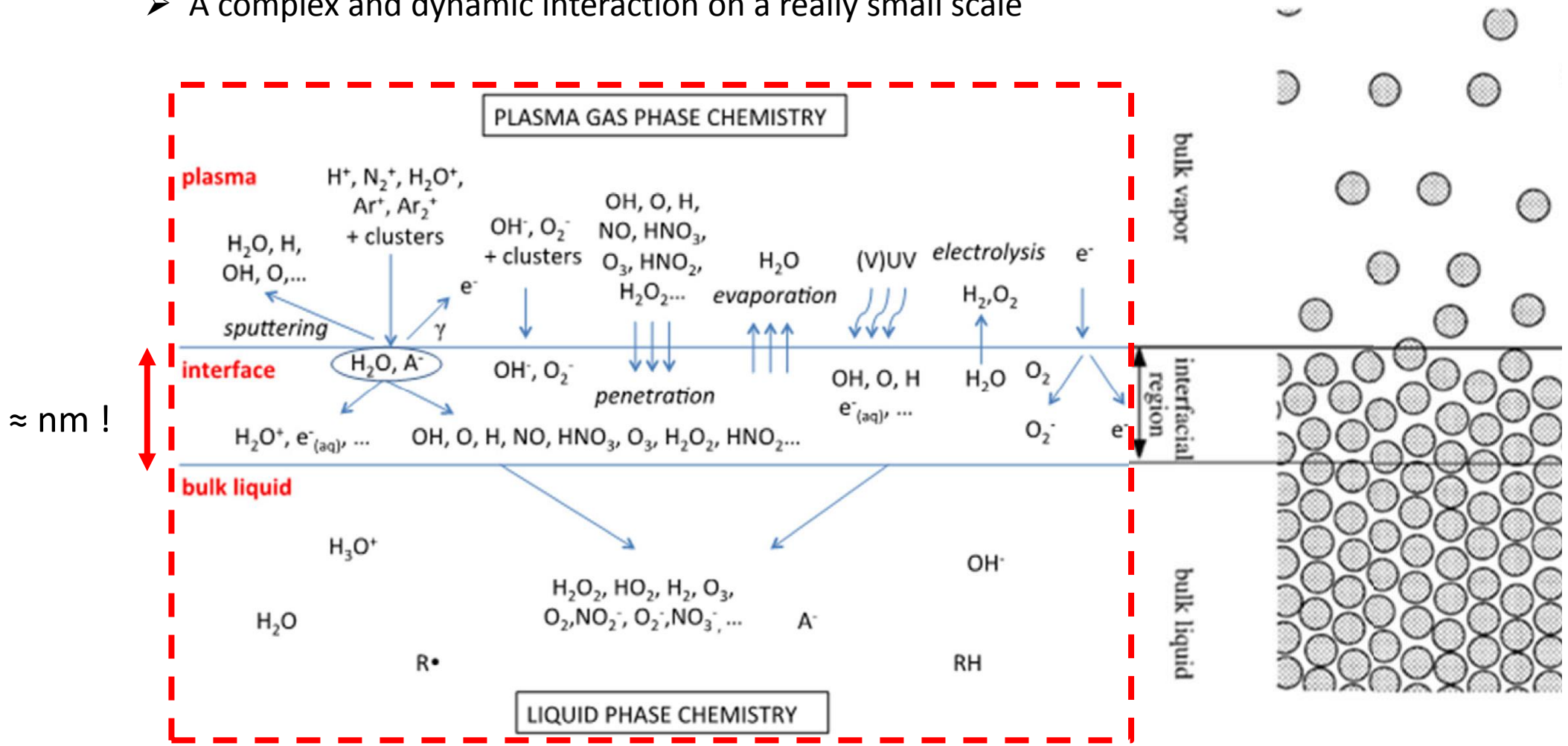
Plasma in-contact with liquids

- A complex and dynamic interaction on a really small scale



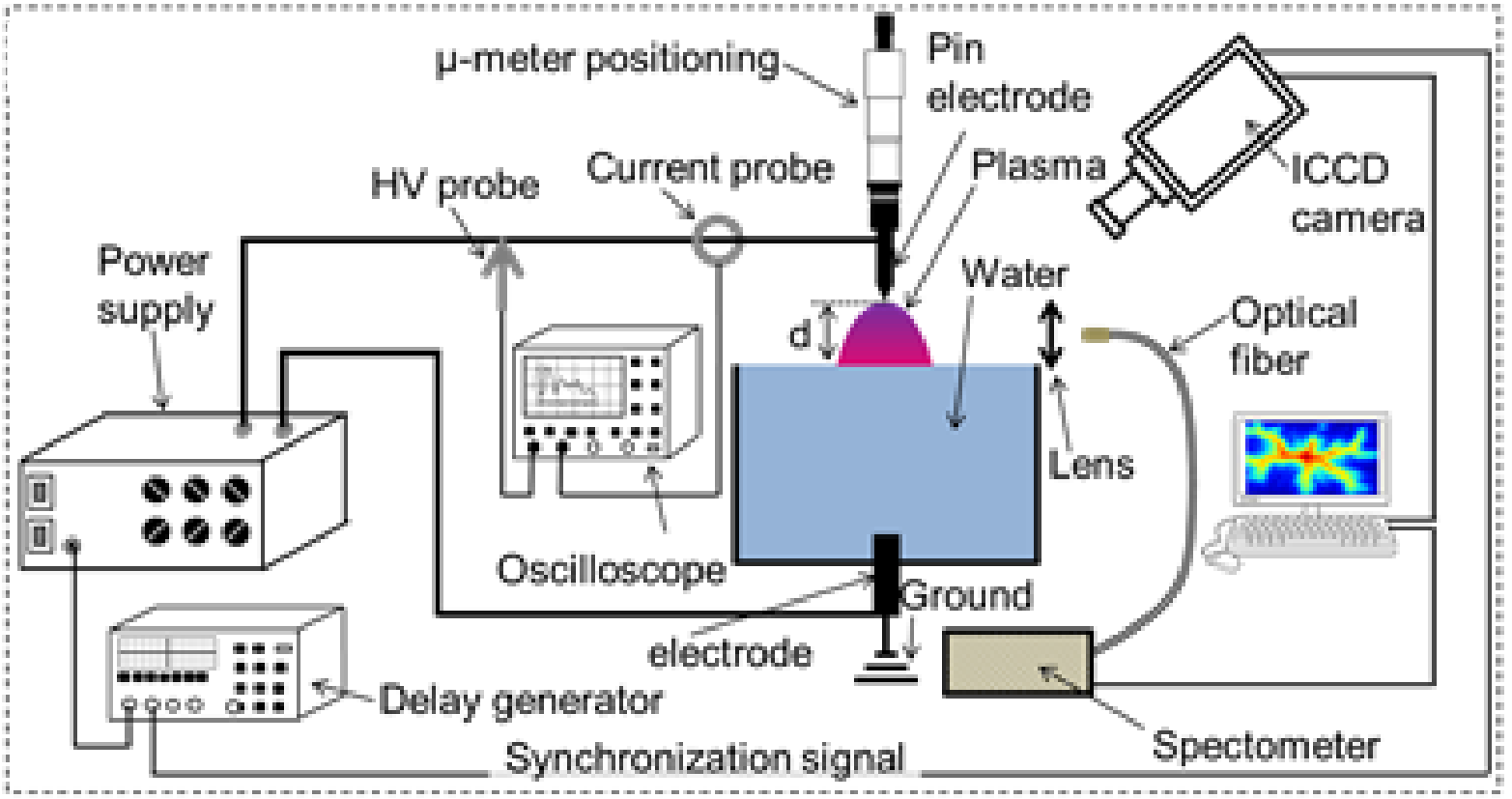
Plasma Sources Sci. Technol. ***25*** *(2016) 053002*

Obejectives

1. What are the differences between the positive and negative air discharge in contact with water?

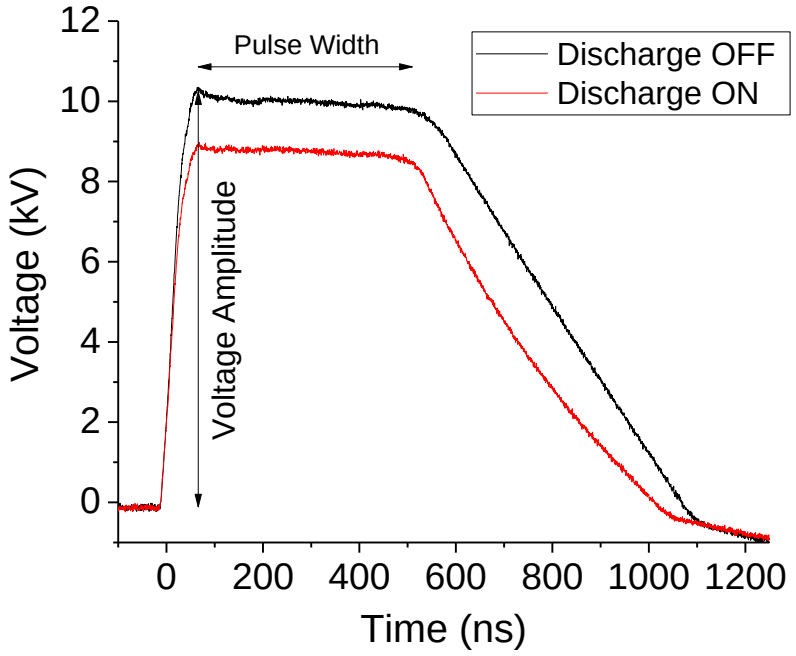
2. What is the influence of discharge parameters (polarity, gap distance, pulse width….) on the degradation of an organic pollutant (methylene blue)?

Experimental setup



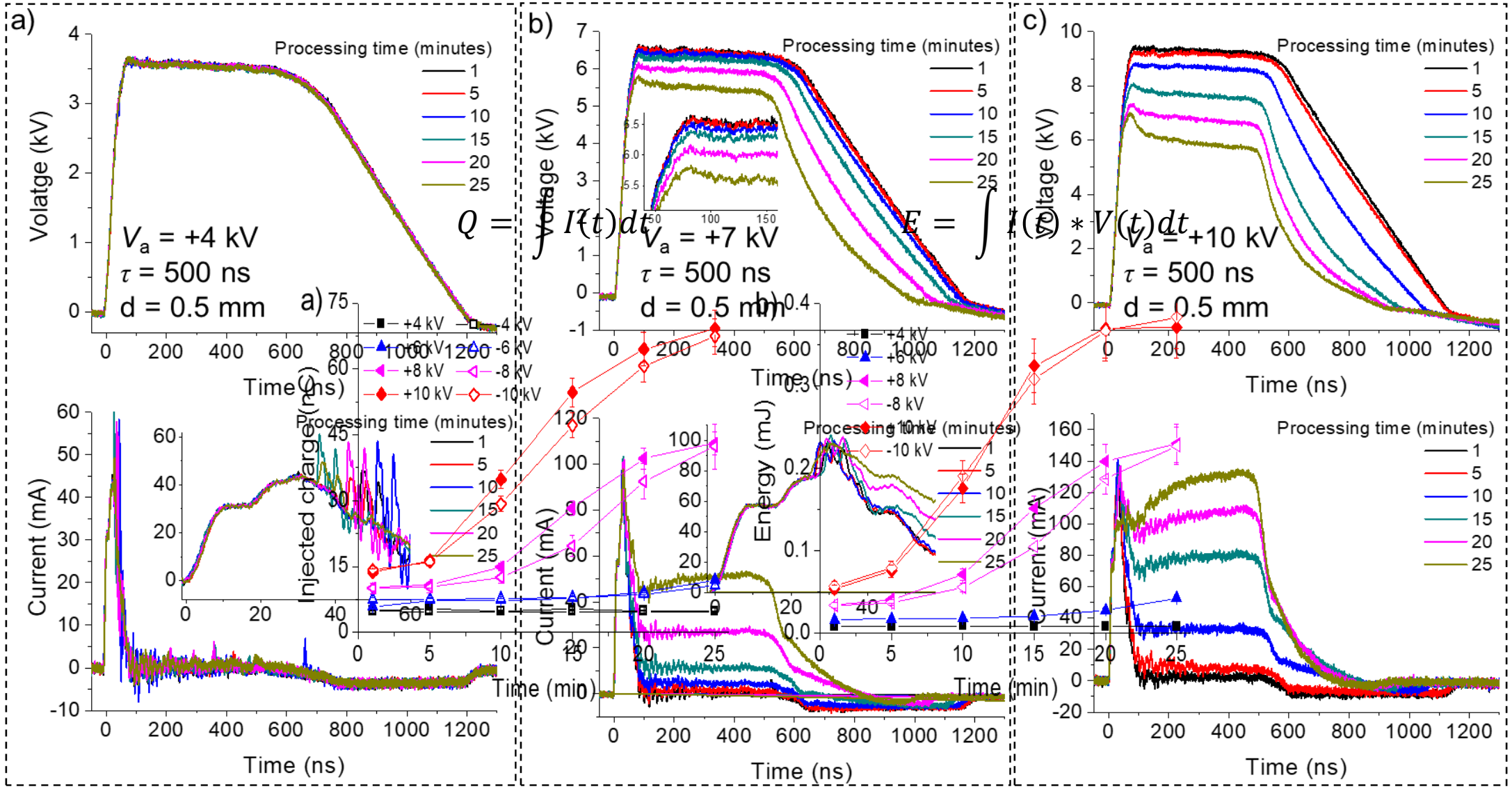
Parameters:

1. Voltage polarity (+, -)
2. Voltage amplitude (kV)
3. Pulse width (ns)
4. Gap Distance (d, in mm)



Results : Electrical Characteristics

V_a positive



Results : Imaging the surface

Voltage amplitude:

Positive polarity:

- 4 kV: Small spot at the tip
- 6kV – 8kV: plasma spot + organised filaments
- 10 kV: High intensity filaments with less organisation

Negative polarity:

- Disc-like shape with no filaments
- Diameter increases with higher voltage

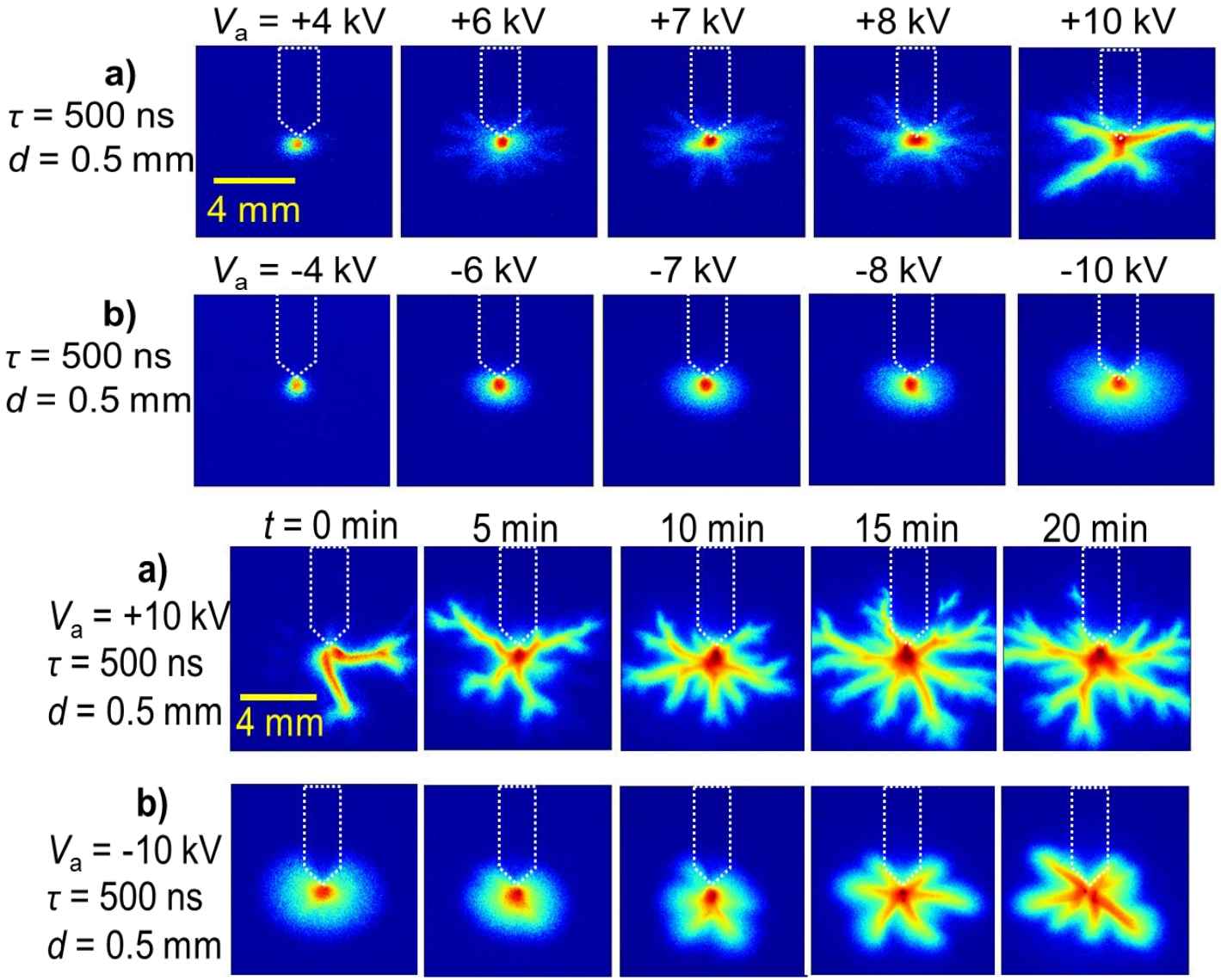
Processing time evolution:

Positive polarity:

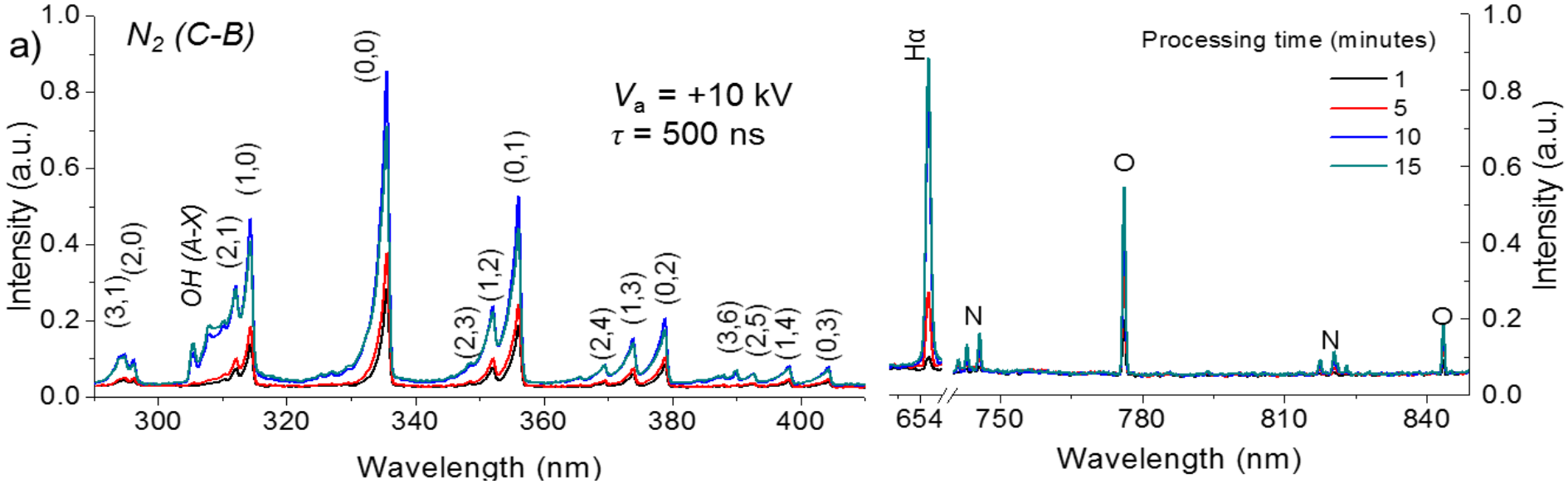
- Number and length of filaments increases

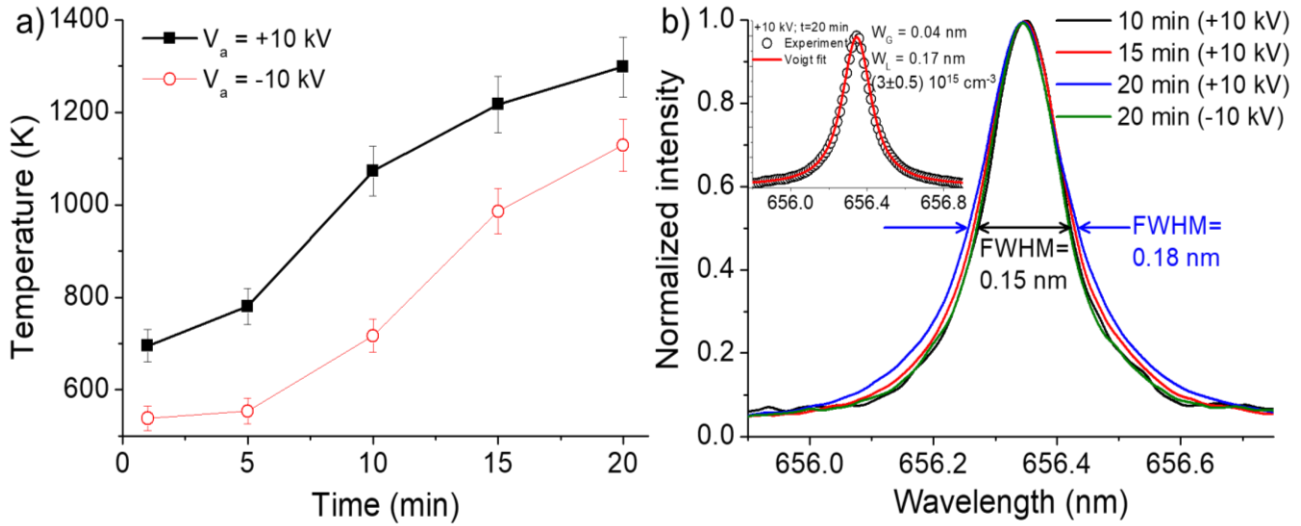
Negative polarity:

- Disc-like evolve into a filament structure
- Number is smaller and Filaments are shorter and wider than positive polarity



Results : Spectroscopy

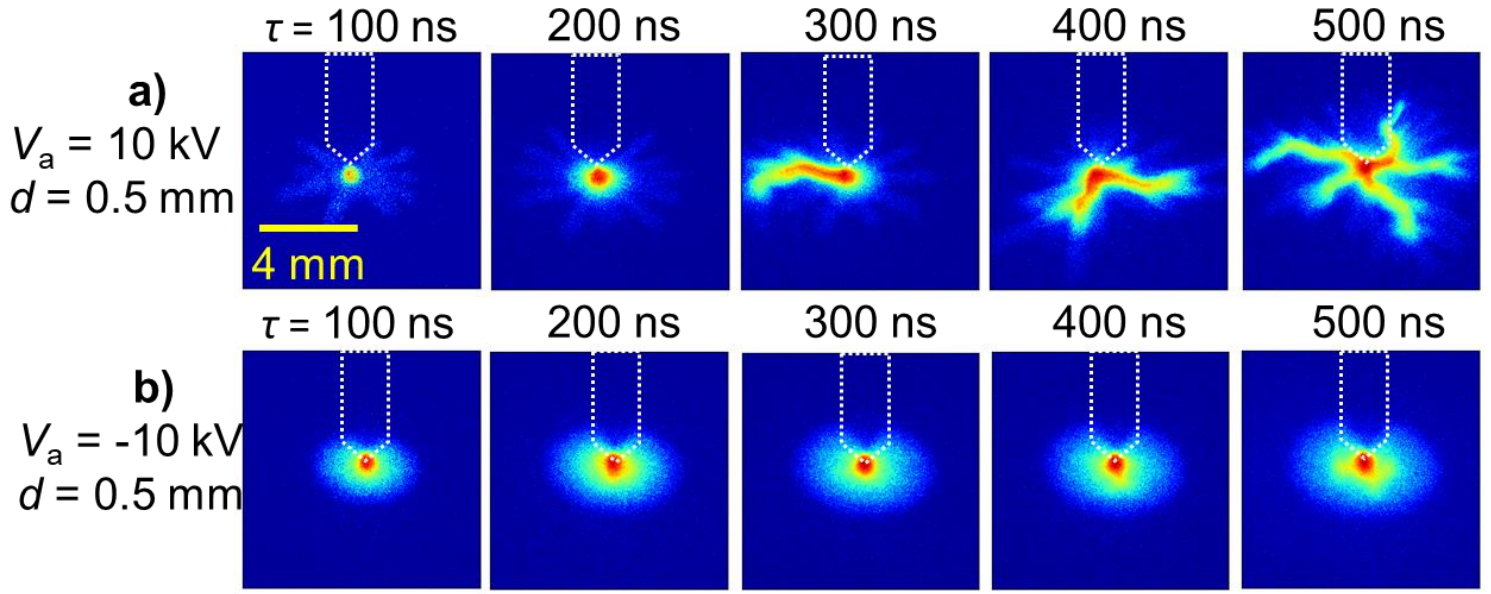


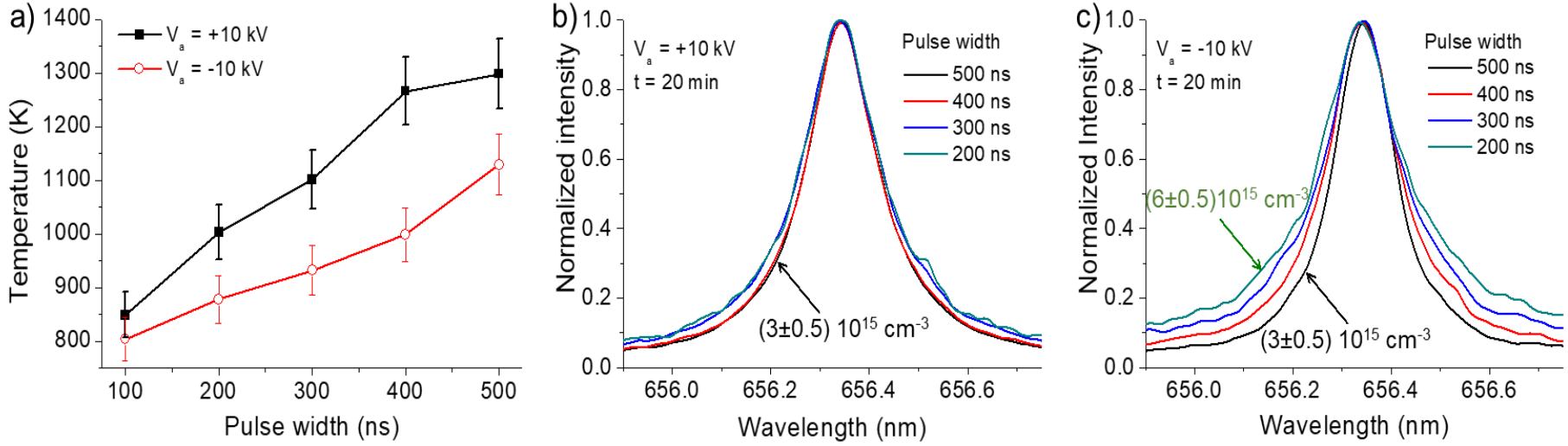


- Calculated from N_2 (C-B) 336 nm without NH

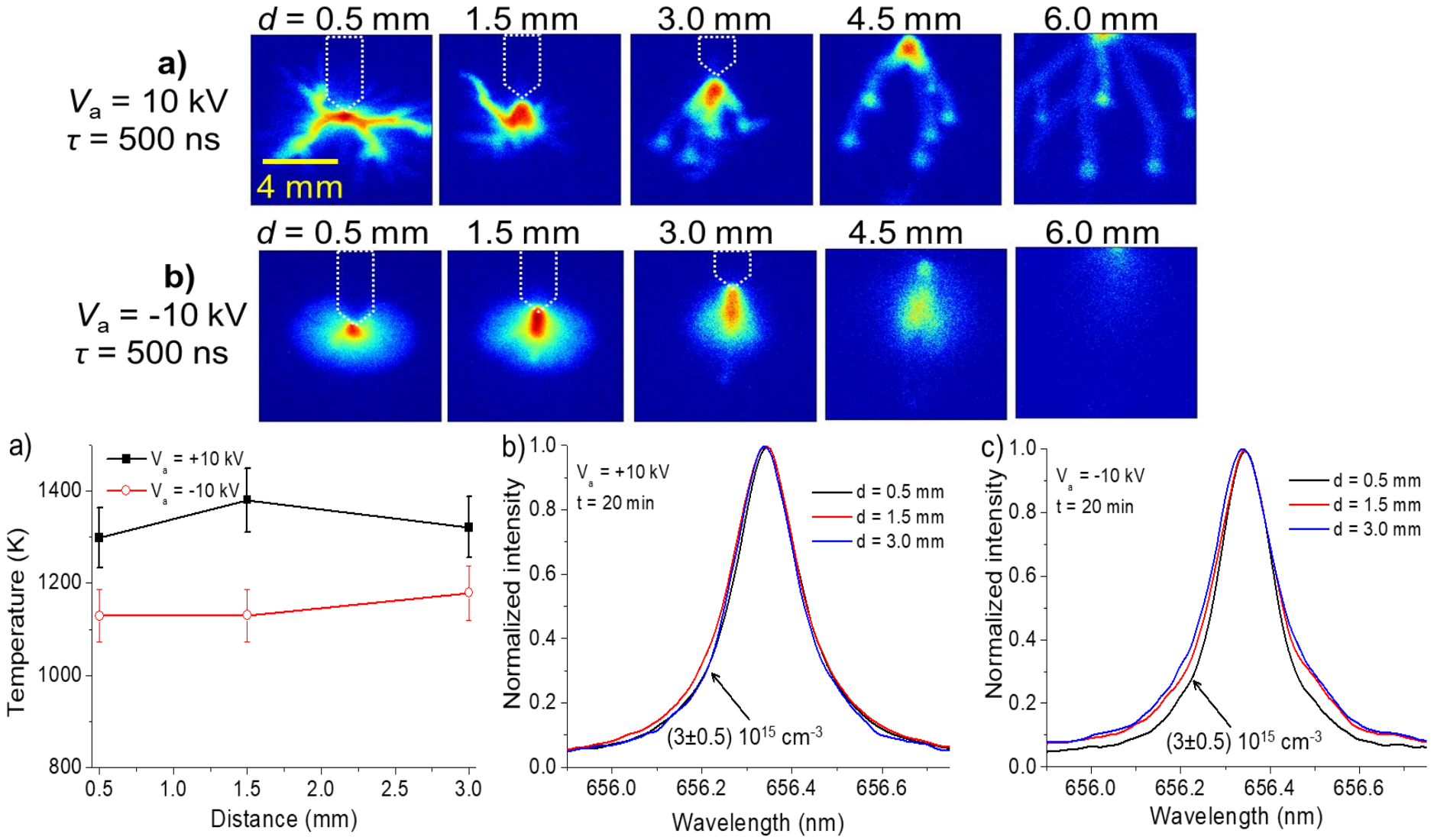
- Stark Broadening (3.0±0.5) x 10^{15} cm^{-3}

Results : Pulse Width

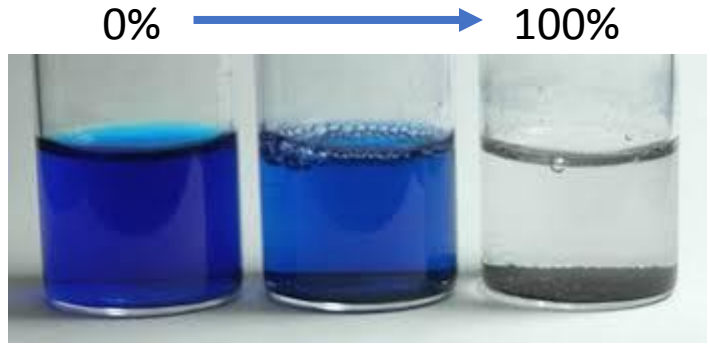


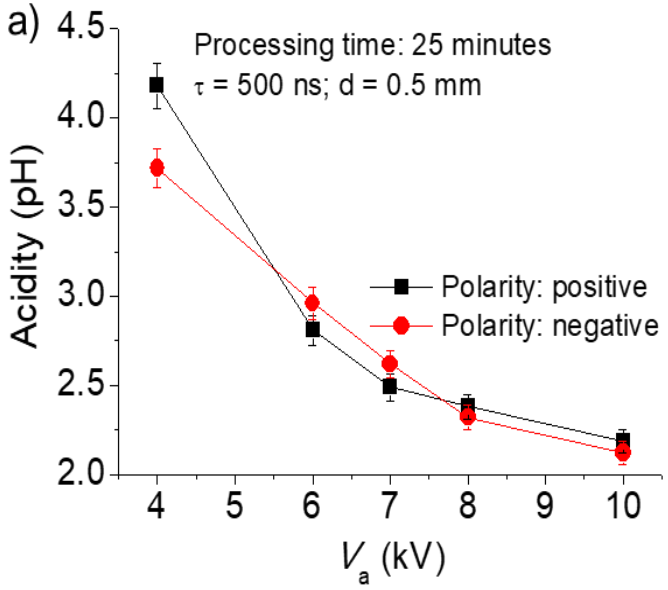


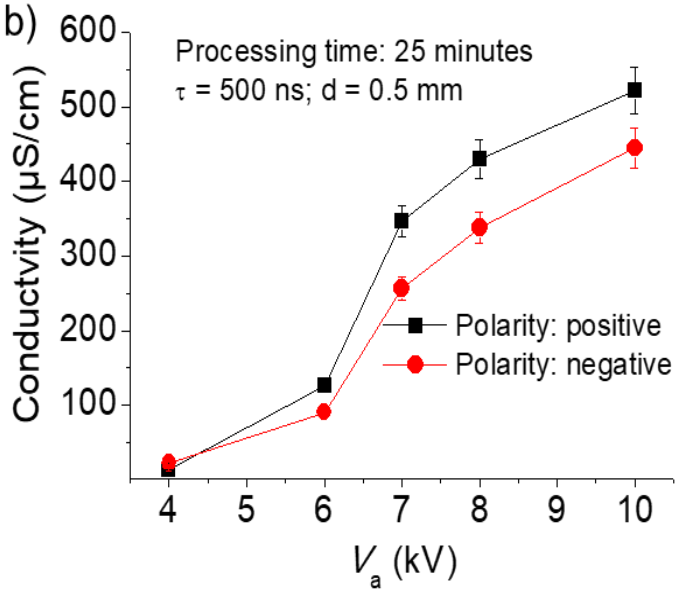
Results : Electrical Characteristics

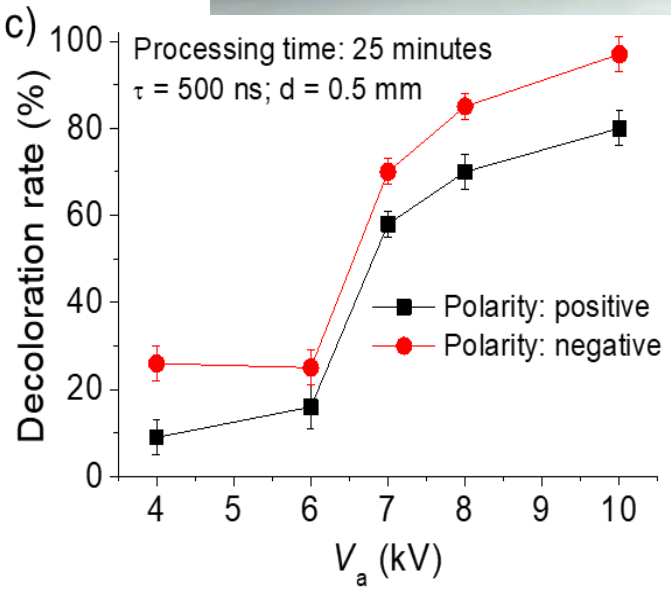


Results : Liquid properties







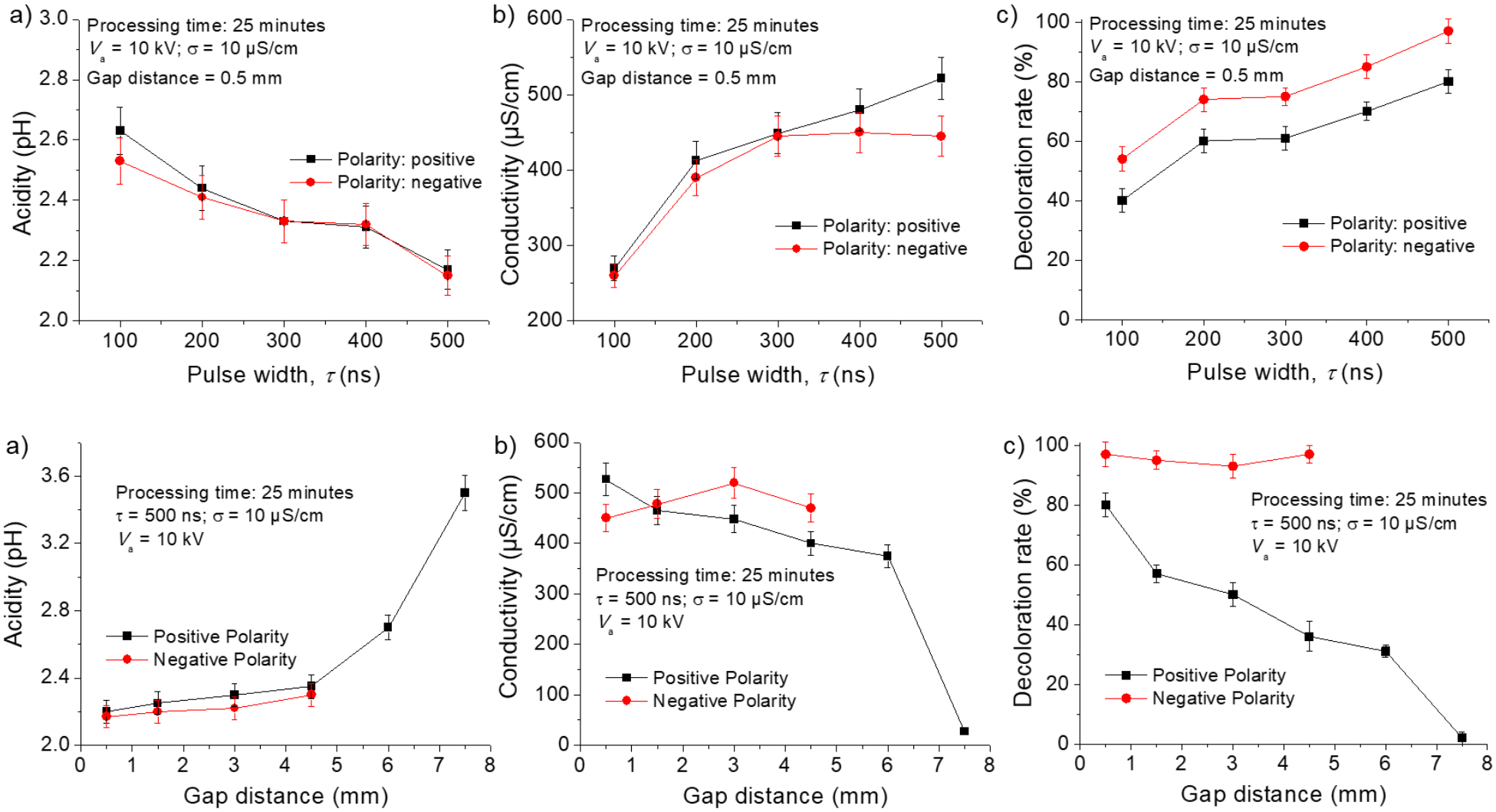


$$Acidity\ (pH) = -\log_{10}[H^+]$$

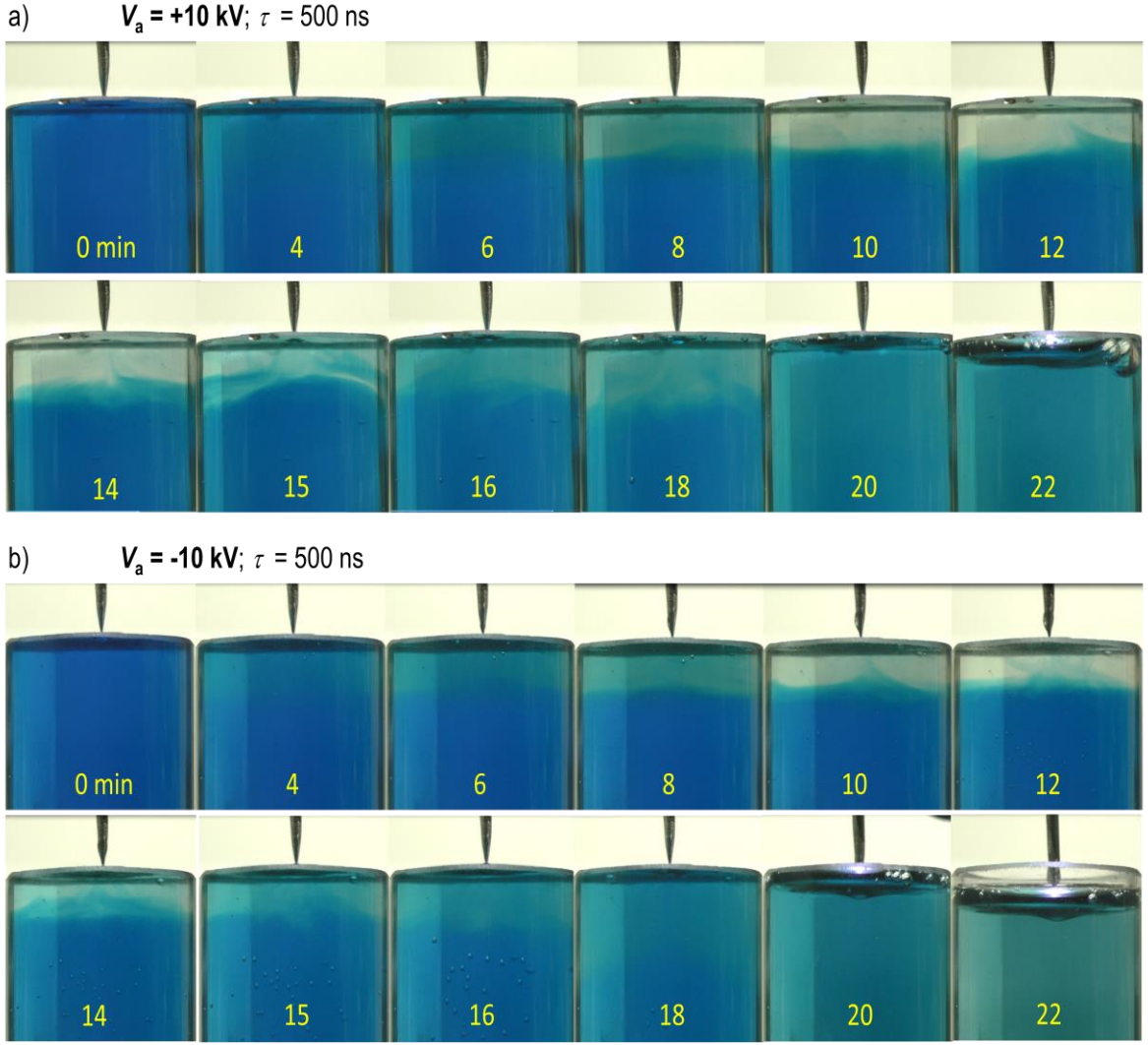
$$Conductivity\ (\frac{\mu S}{cm}) = \sum_i \lambda_i * C_i$$

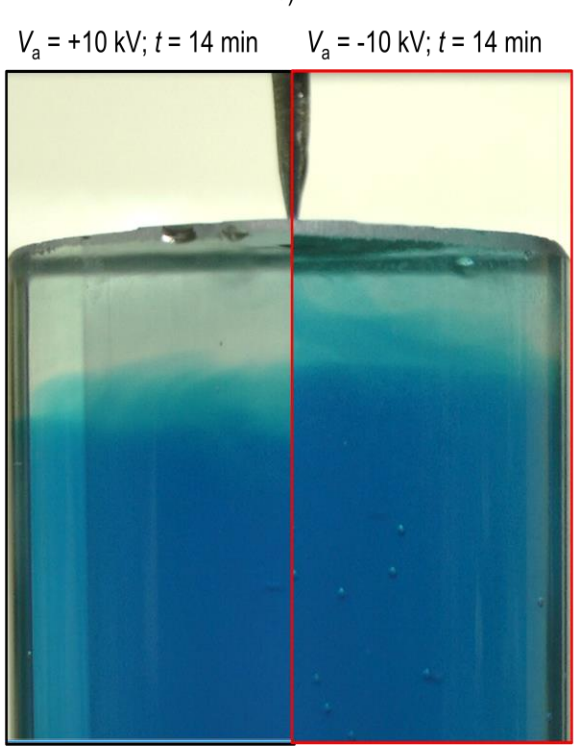
Ions: OH^-, H^+, NO_2^+, NO_3^-, ONO_2^-, NO^-, NO_2^-, …

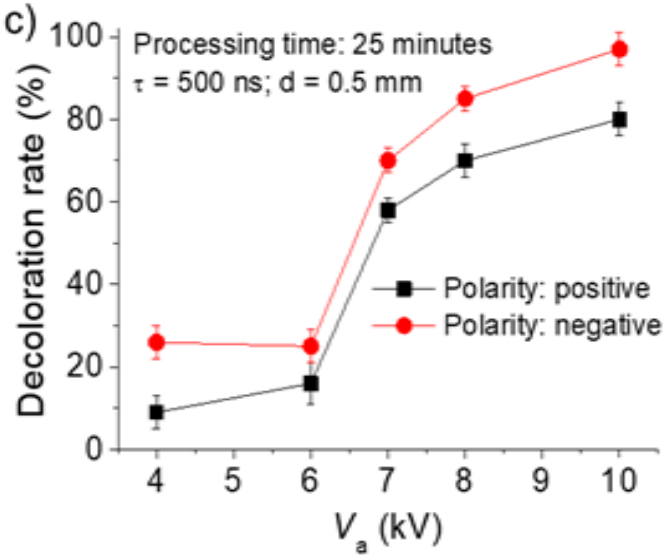
Results : Liquid properties



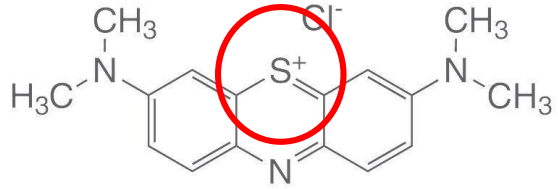
Results : Electrical Characteristics







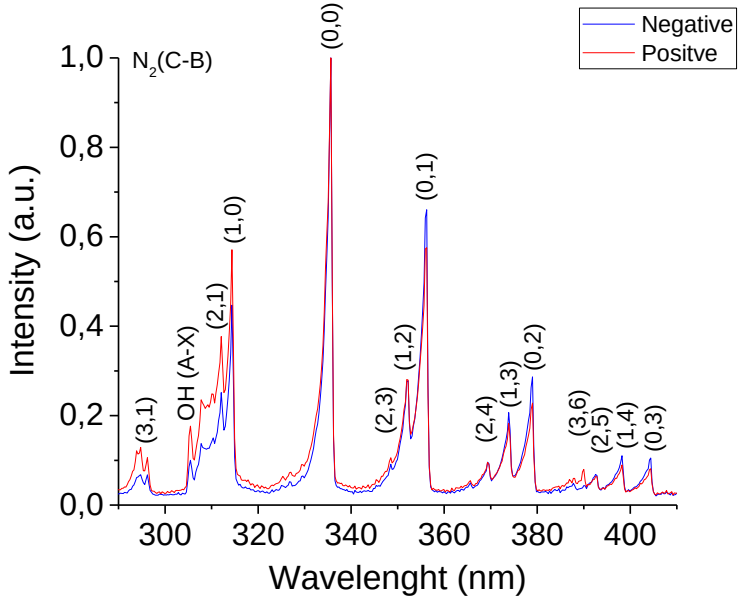
Electically positive molecule



Conclusion

- Our results show:
  - The parameters for an optimal methylene blue decoloration are:
    - Negative polarity
    - Higher voltage amplitude
    - longer pulse width
    - Shorter gap distance
  - The reason behind higher efficiency for negative polarity is:
    - Methylene blue is a electrically positive molecule
    - The higher flow of the untreated solution
    - N2 Vibrational temperature !

    (Matthew J Pavlovich *et al* 2013 *J. Phys. D: Appl. Phys.* **46** 145202)



Thank you

More details can be found here:
Hamdan A, Ridani DA, Diamond J and Dagrir R, “ Pulsed nanosecond air discharge in contact with water: influence of voltage polarity, amplitude, pulse width, and gap distance”, J. Phys. D. Appl. Phys. , 2020, doi: 10.1088/1361-6463/ab8fde