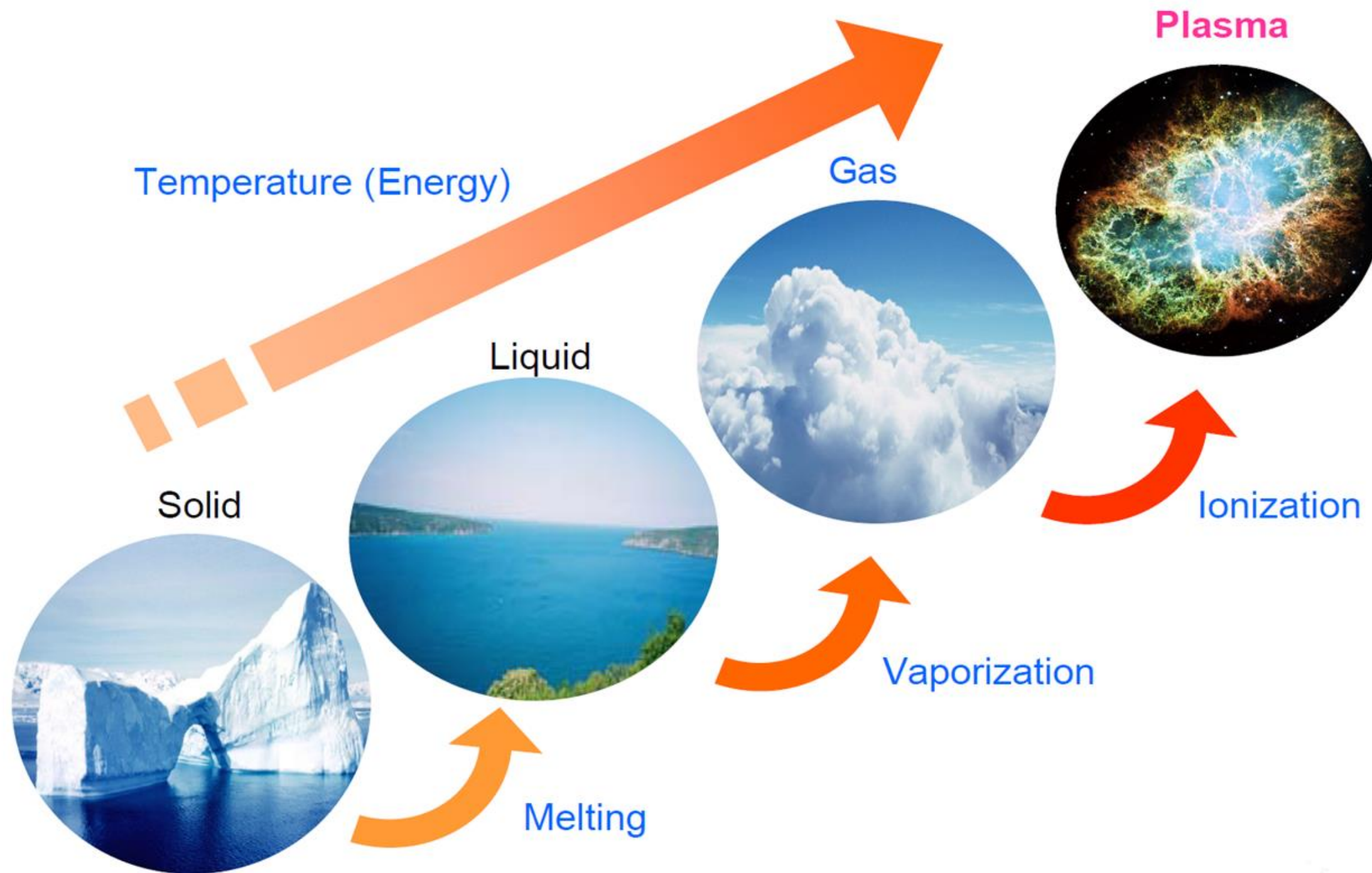


PLASMA CATALYSIS FOR VOC ABATEMENT

OUTLINE

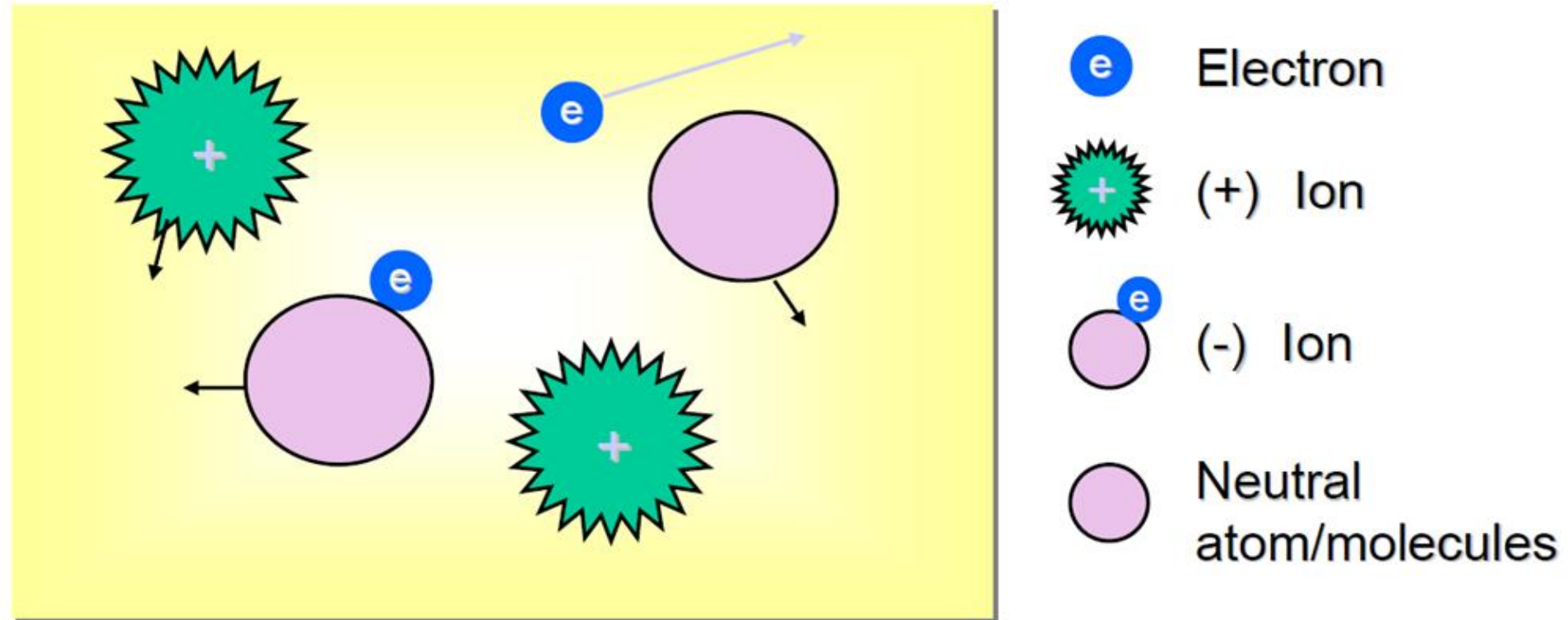
- ❑ **What is a non-thermal plasma (NTP)?**
- ❑ **Non-thermal plasma for VOC abatement**
- ❑ **Plasma-catalysis for improving NTP systems**

THE STATE OF MATTER

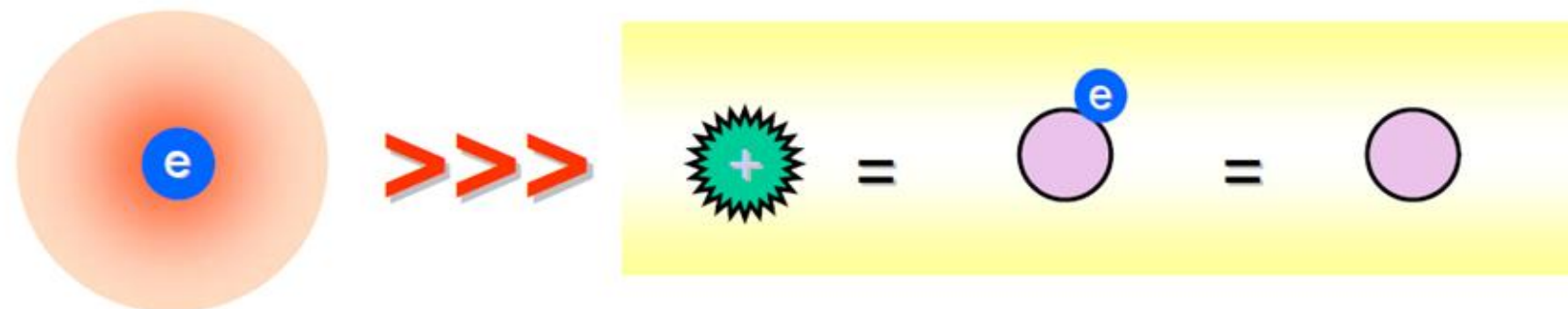


NON-THERMAL PLASMA

Nonthermal Plasma = Non-equilibrium Plasma = Cold Plasma
= Low-Temperature Plasma



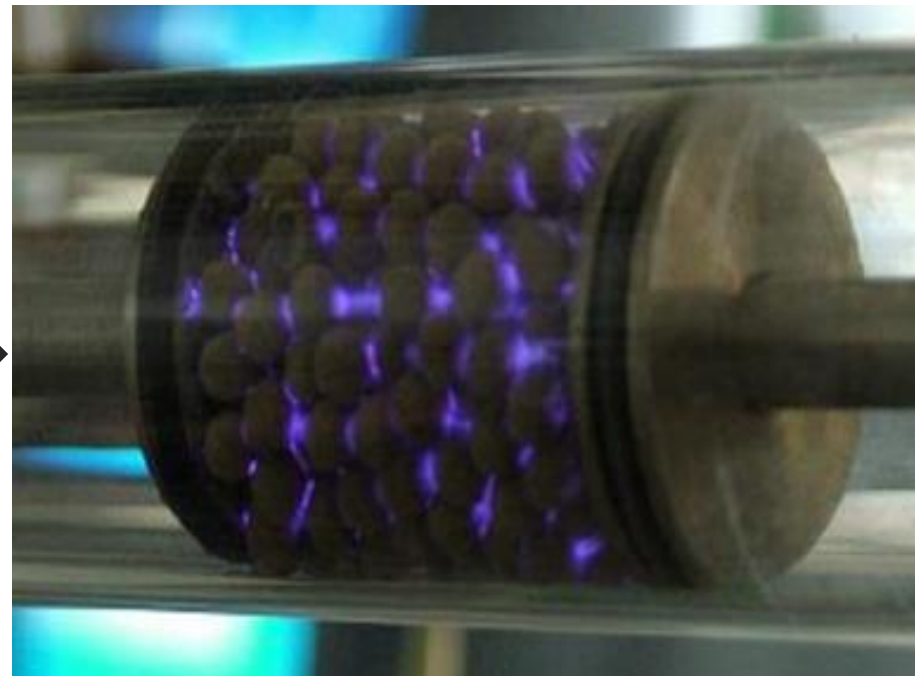
- **Nonthermal Plasma** : 「The energy of electron is higher than those of ions and neutrals」



NON-THERMAL PLASMA FOR AIR CLEANING

INLET CONDITION

- Temperature
- Humidity
- Gas flow rate
- Inlet concentration



OUTLET CONDITION

- Outlet concentration
- By-products

EVALUATION PARAMETERS

- Decomposition efficiency (conversion)
- Carbon balance (aerosols, polymeric deposition)
- CO₂-selectivity (CO formation)
- Energy efficiency (g/kWh)

NON-THERMAL PLASMA FOR AIR CLEANING

Advantages:

- ❑ Removal of **low concentrations** (< 1000 ppm) of pollutants from waste gases
- ❑ Simultaneous treatment of **different pollutants**
- ❑ Fast adjustments to **changes in influent**
- ❑ Suitable for **wide range of flow rates**
- ❑ Easily integrated with **other technologies**
- ❑ Low operating **costs**

Disadvantages:

- ❑ By-product formation, Poor selectivity, Scalability

PLASMA-CATALYSIS

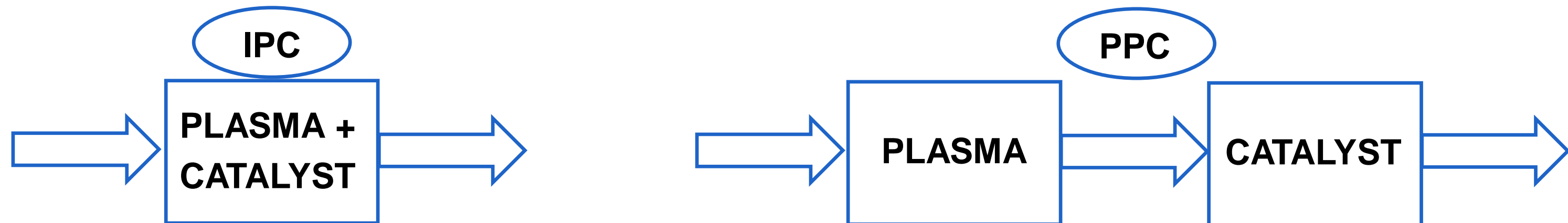
□ Catalyst can be located:

➤ **inside** the discharge region: **IN Plasma-Catalysis**

– example: DBD packed with TiO_2 pellets

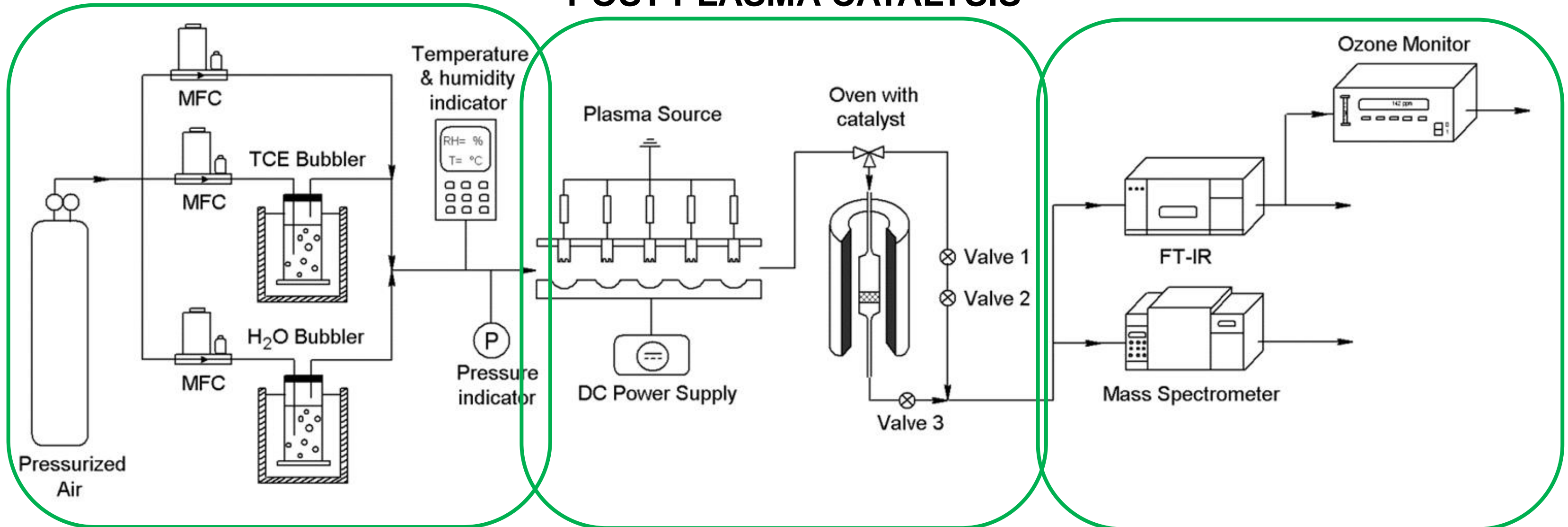
➤ **after** the discharge region: **POST Plasma-Catalysis**

– example: corona discharge with Fe/K-OMS-2 downstream



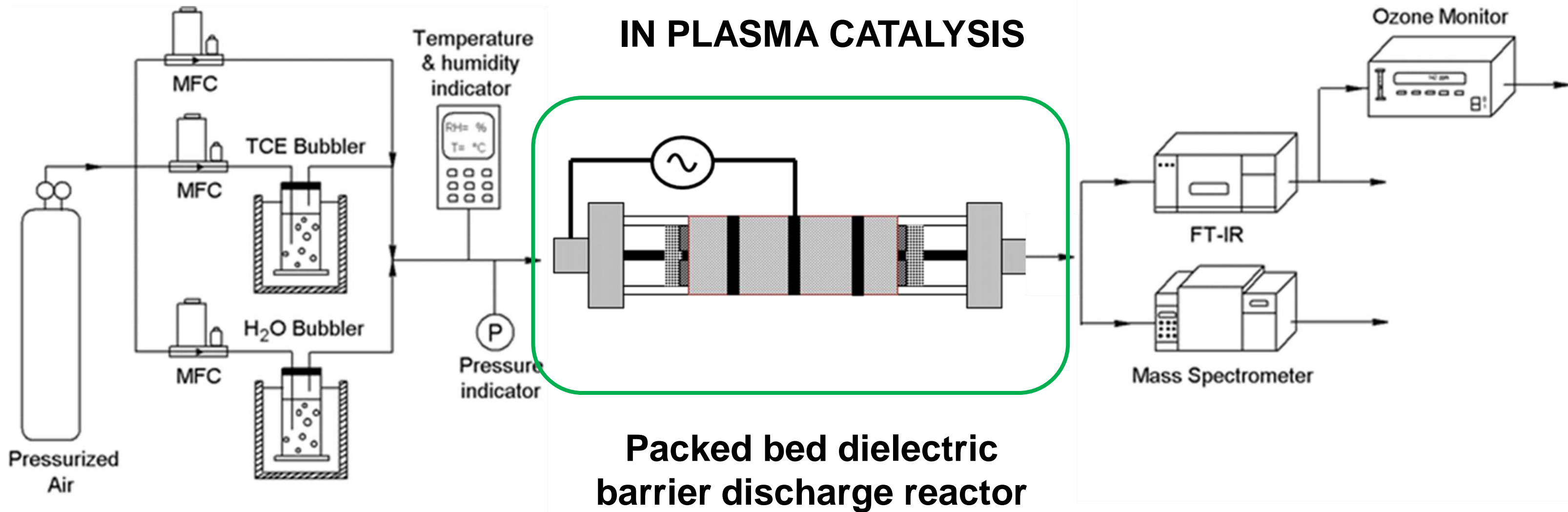
EXPERIMENTAL SET-UP

POST PLASMA CATALYSIS

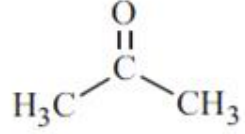
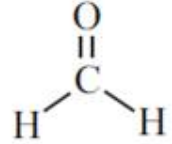
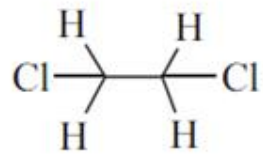
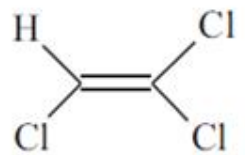
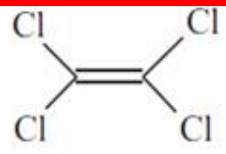


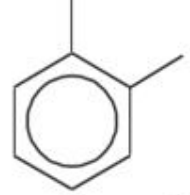
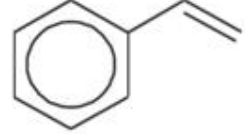


Pin-to-plate dc corona discharge reactor

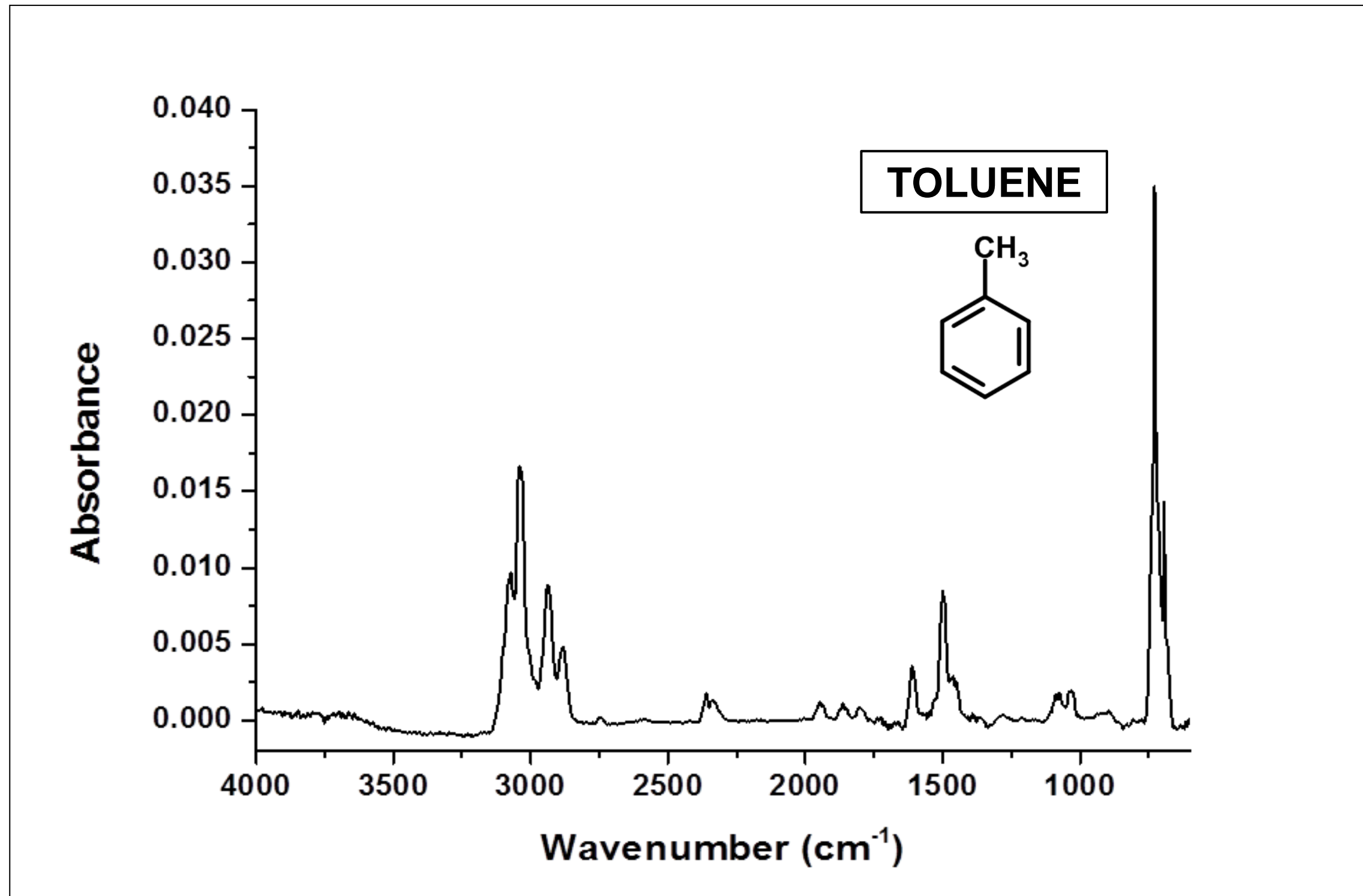
EXPERIMENTAL SET-UP



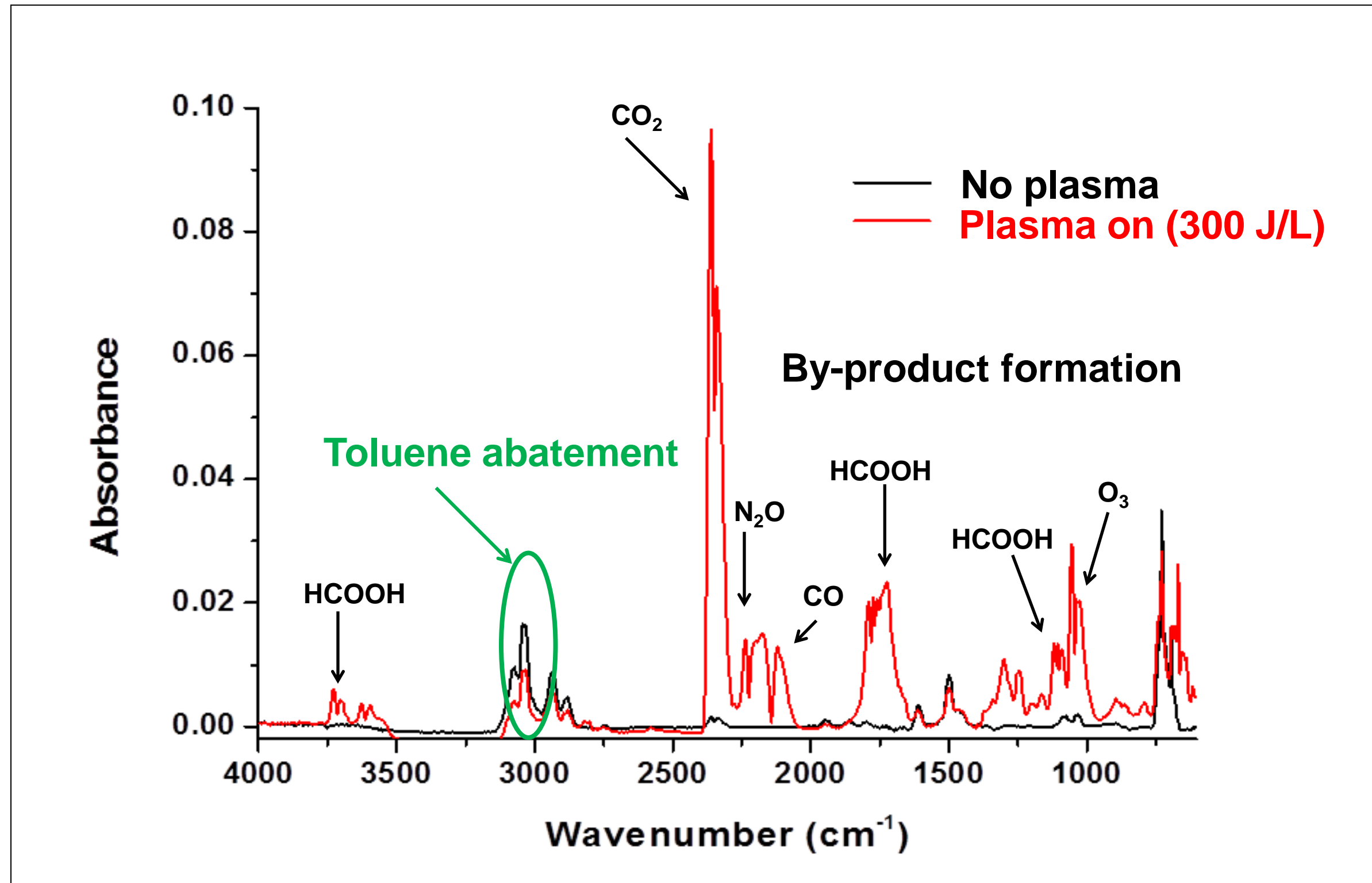
TYPICAL VOCS AND HEALTH EFFECTS

VOC	Formula	Effects
Acetone		Carcinogen
Formaldehyde		Sore throat, dizziness, headache
Dichloroethane		Paralysis of nerve center
Trichloroethylene		Liver and kidney disease, paralysis of nerve center
Tetrachloroethylene		Probable heart and liver disease, skin irritation
Benzene		Carcinogen
Toluene		Headache, dizziness
Xylene		Headache, dizziness
Styrene		Probable carcinogen

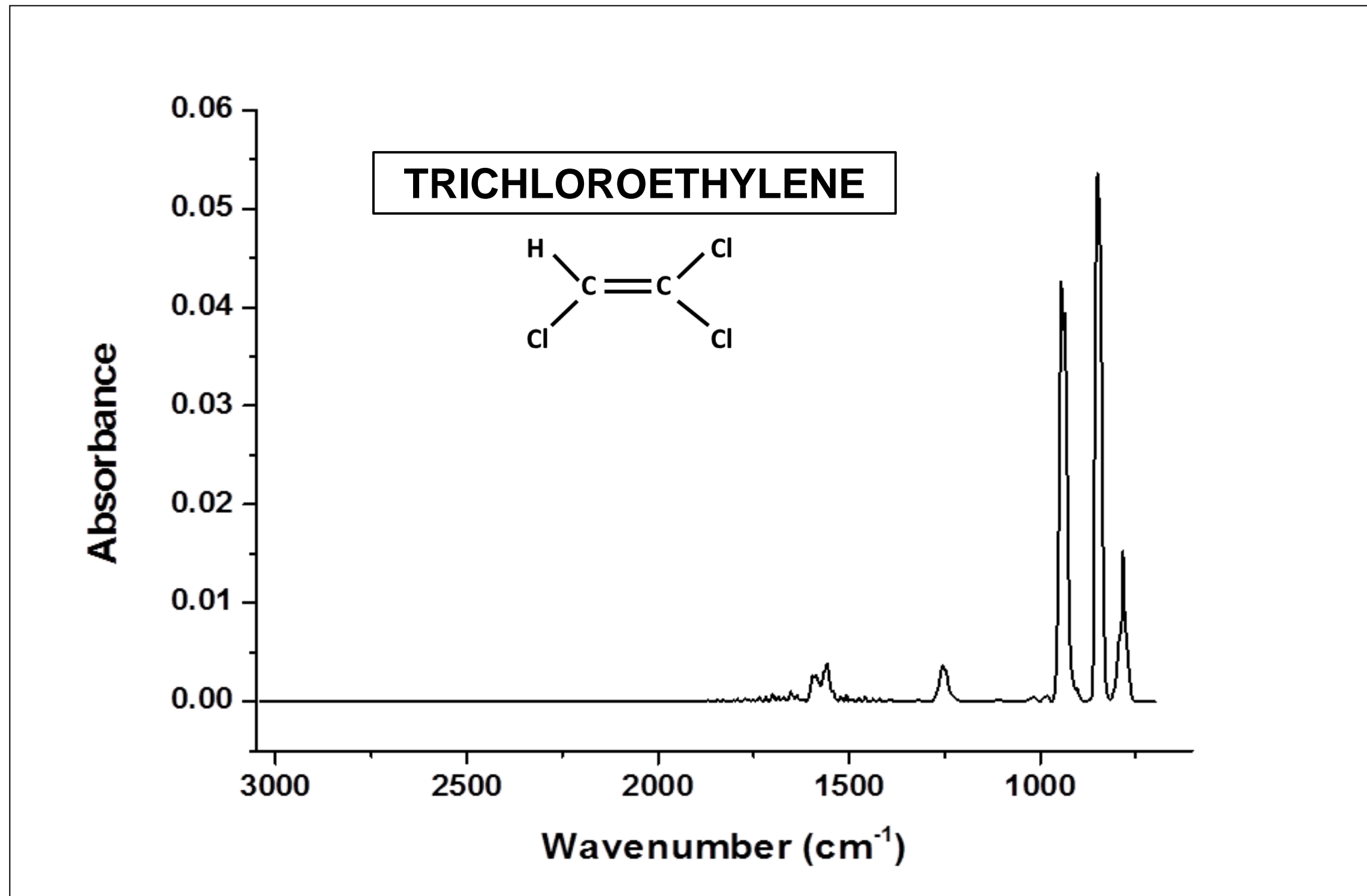
REMOVAL OF TOLUENE WITH NTP



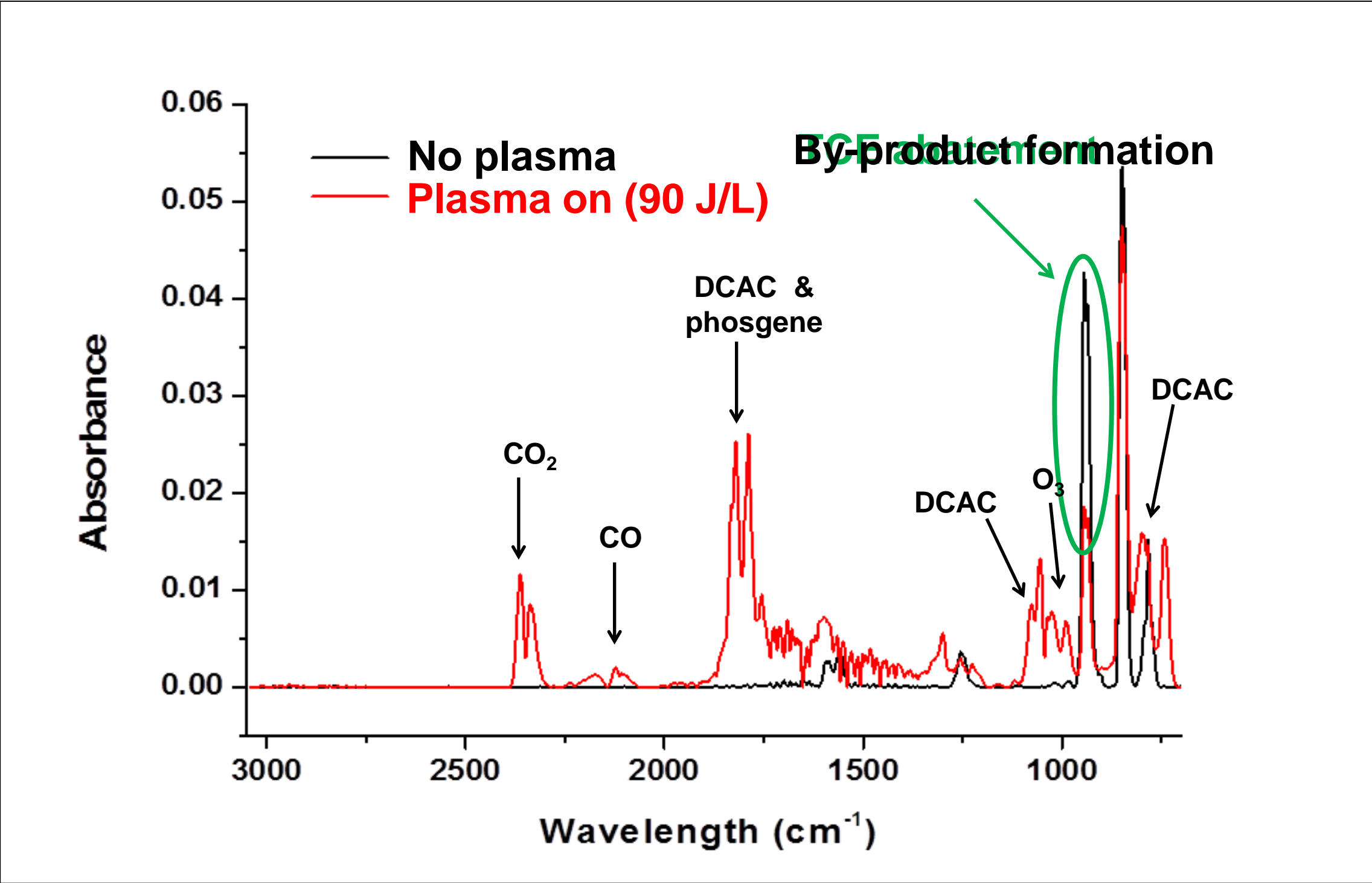
REMOVAL OF TOLUENE WITH NTP



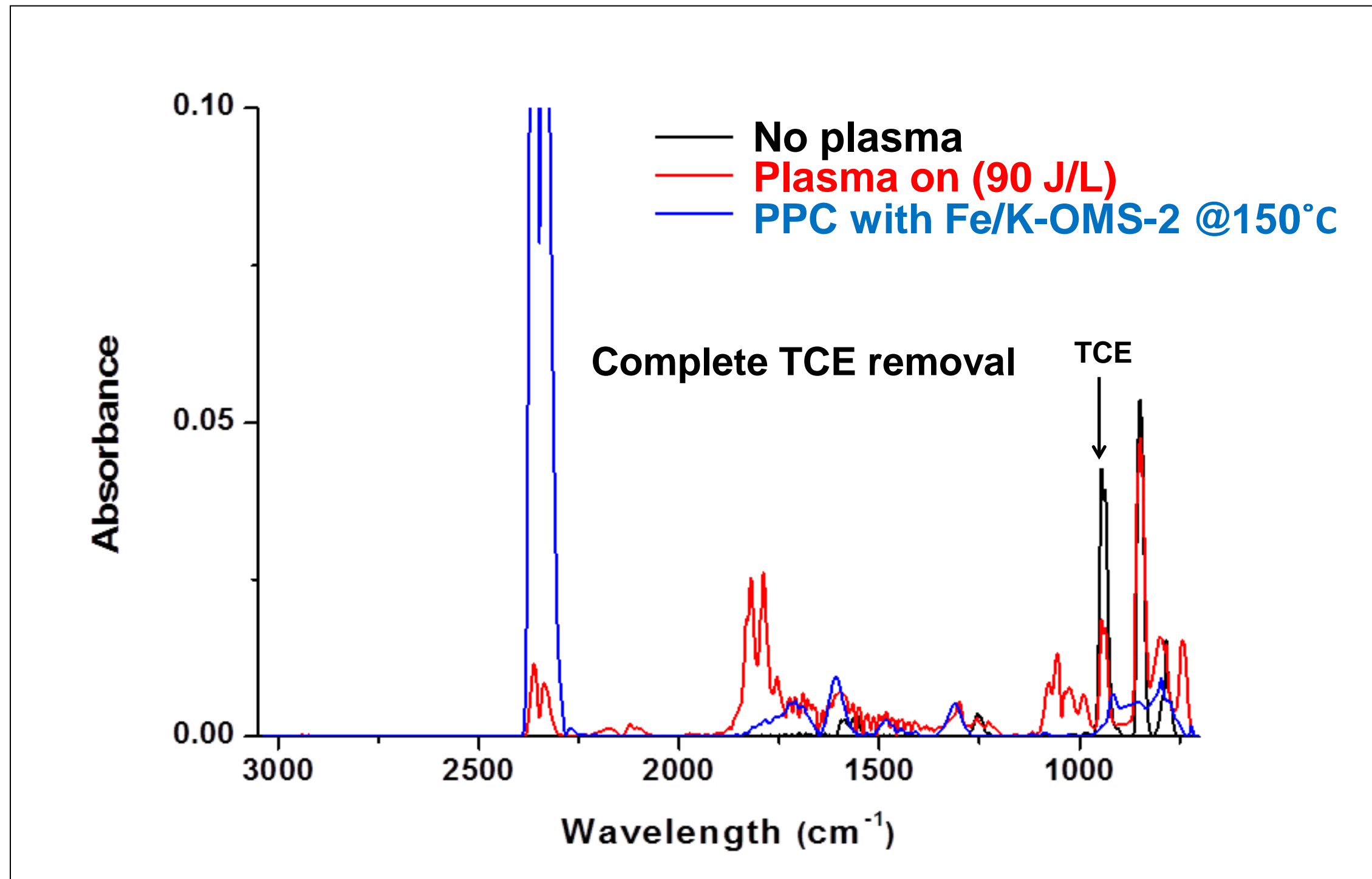
REMOVAL OF TCE WITH NTP



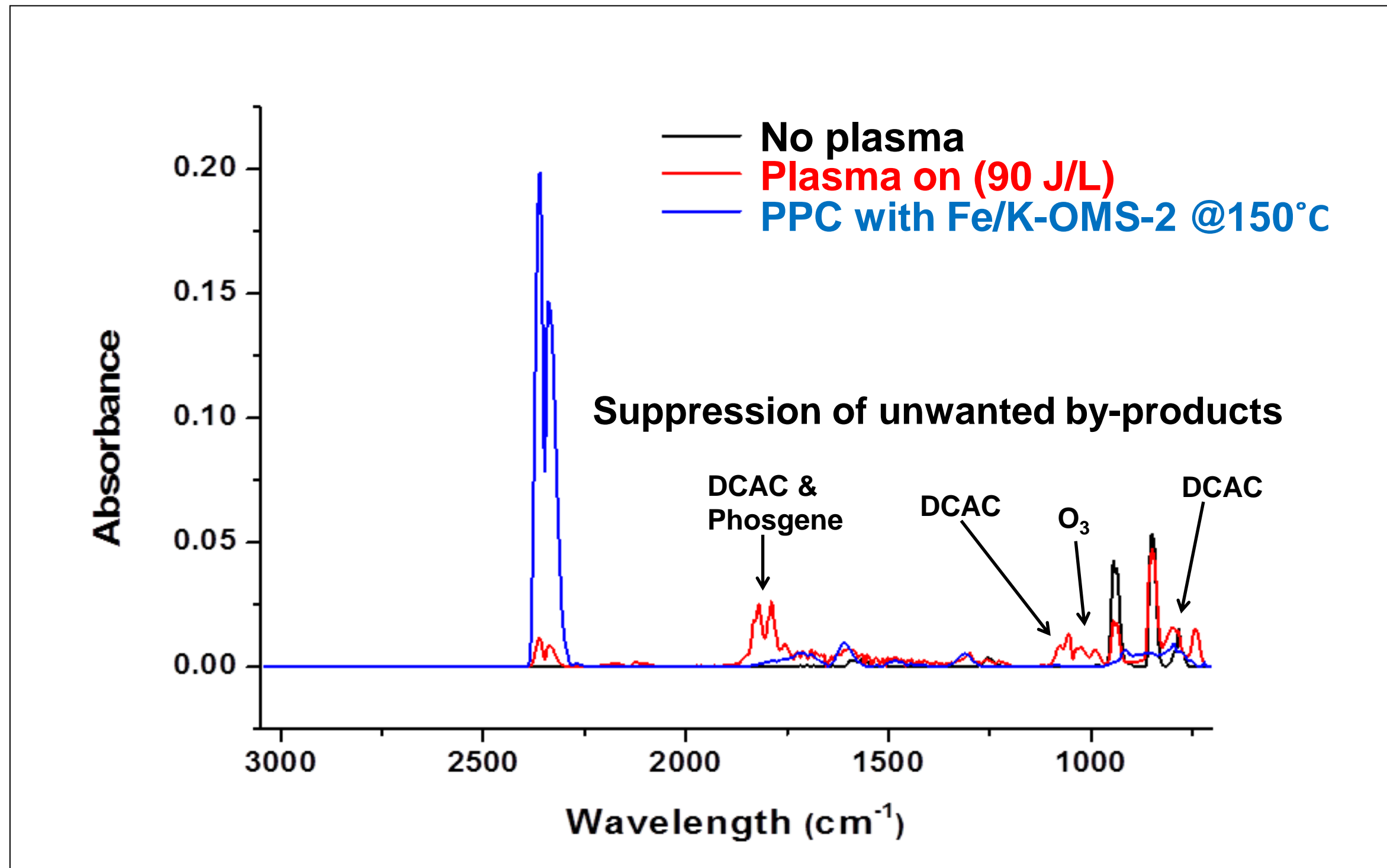
REMOVAL OF TCE WITH NTP



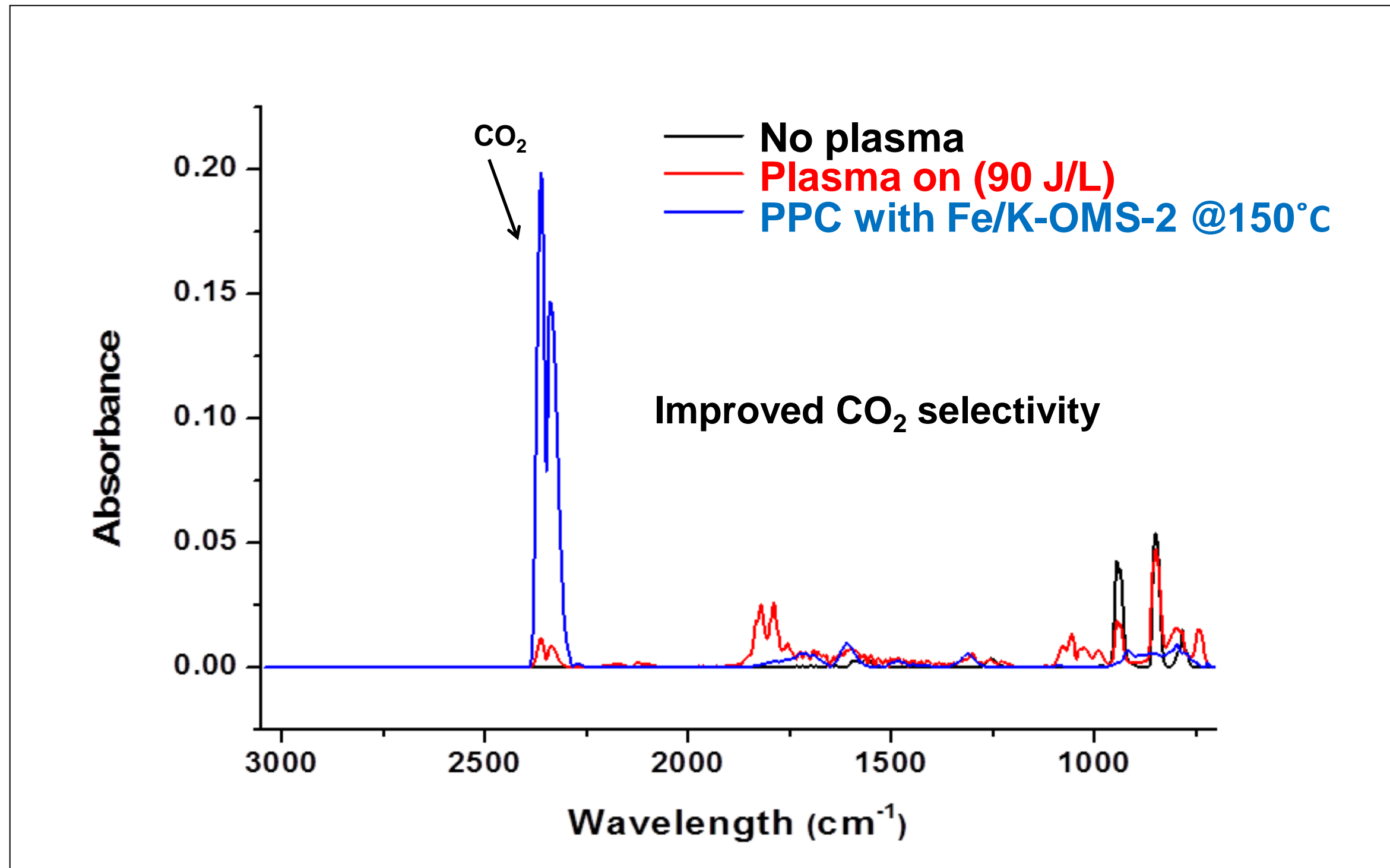
PLASMA CATALYSIS (PPC)



PLASMA CATALYSIS (PPC)



PLASMA CATALYSIS (PPC)



CONCLUSIONS

Non-thermal plasma:

- Can be used for the abatement of VOCs
- Formation of unwanted by-products

Plasma catalysis:

- Complete removal of VOCs
- Improved CO₂ selectivity
- Suppression of unwanted by-products such as O₃, CO, NO_x and other VOCs
- Higher energy efficiency

USEFUL PUBLICATIONS

□ ***Decomposition of trichloroethylene with plasma-catalysis: A review***

Vandenbroucke A M., Morent R., De Geyter N., Leys C.,
Journal of Advanced Oxidation Technologies, Vol. 14, (2011), p. 165-173

□ ***Qualitative by-product identification of plasma-assisted TCE abatement by mass spectrometry and Fourier-transform infrared spectroscopy***

Vandenbroucke A M., Nguyen Dinh M T., Giraudon J M., Morent R., De Geyter N., Lamonier J F., Leys C.,
Plasma Chemistry and Plasma Processing, Vol. 31, (2011), p. 707-718

□ ***Abatement of VOCs with alternate adsorption and plasma-assisted regeneration: A review***

Sultana S., Vandenbroucke A M., Leys C., De Geyter N., Morent R.,
Catalysts 5(2) pp. 718–746, 2015

□ ***Abatement of VOCs using packed bed non-thermal plasma reactors: A review***

Veerapandian S K P., Leys C., De Geyter N., Morent R.,
Catalysts, Vol 7, (2017)

□ ***Synthesis and catalytic performances of K-OMS-2, Fe/K-OMS-2 and Fe-KOMS-2 in post plasma-catalysis for dilute TCE abatement***

Sultana S., Ye Z., Veerapandian S K P., Löfberg A., De Geyter N., Morent R., Giraudon J M., Lamonier J F.,
Catalysis Today, (2017)

CONVENTIONAL TECHNOLOGIES

