MONITORING THE DE-COKING OF COKED CATALYSTS USING DIELECTRIC PROPERTIES OF THE GLOW DISCHARGE

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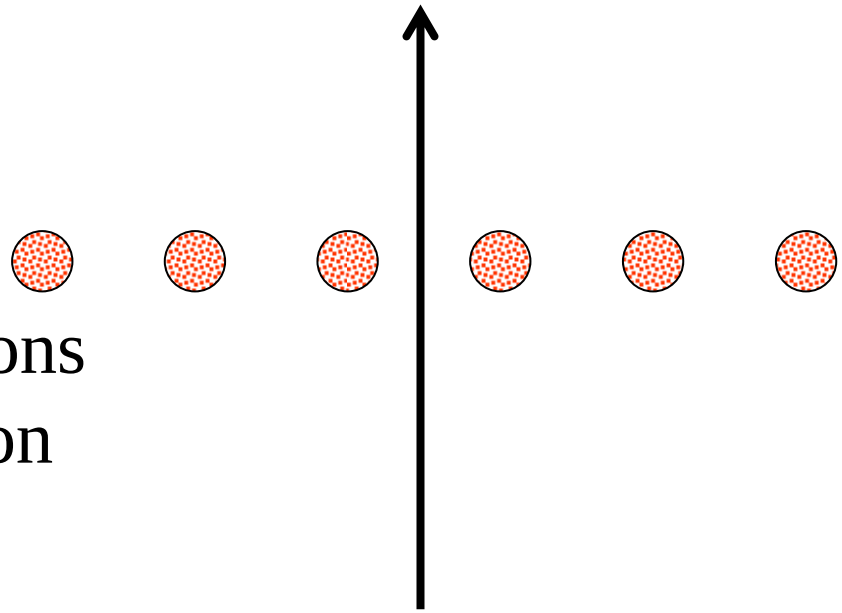
Oil refined
Products

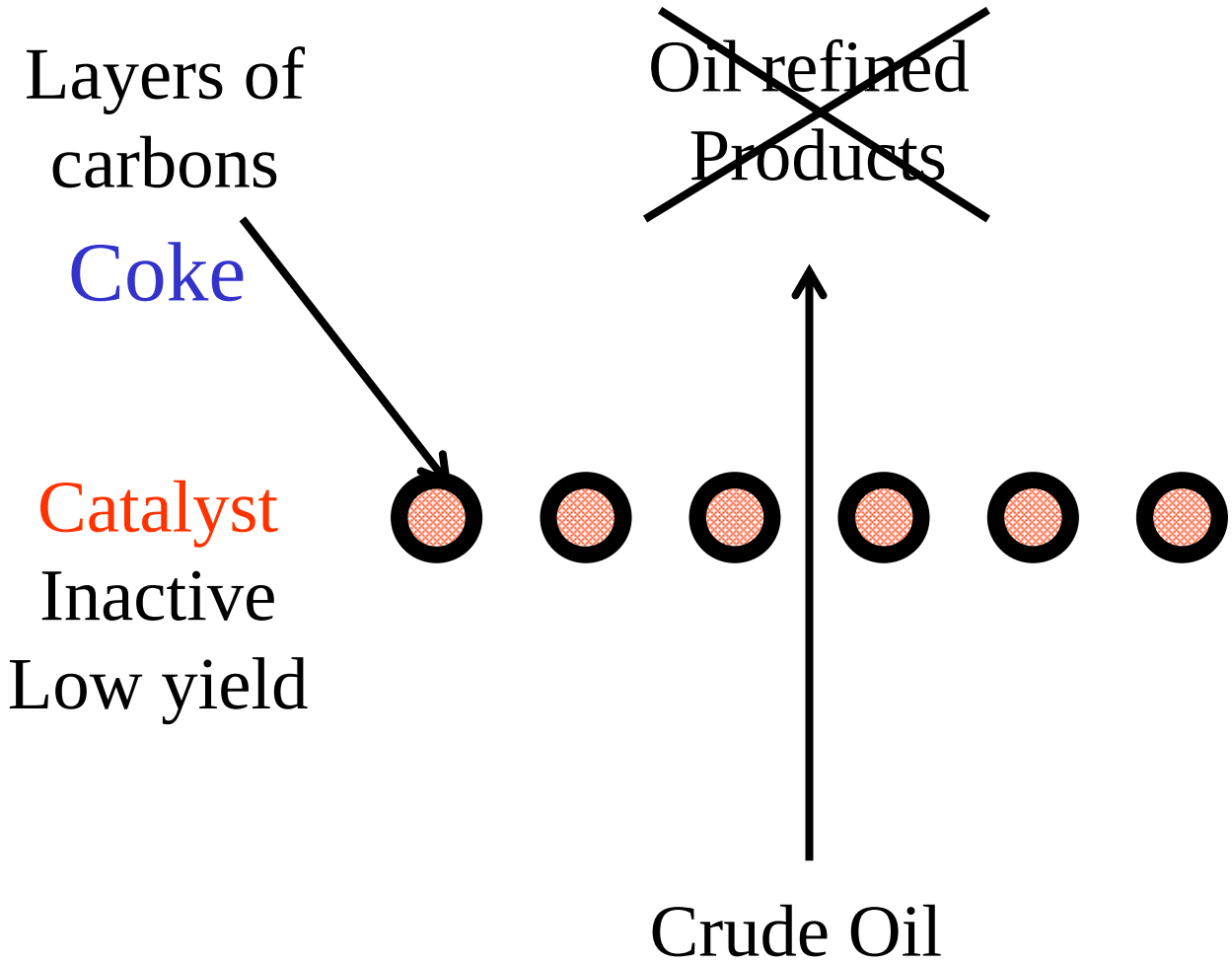


Catalyst

Speeds up reactions

Boosts production

Crude Oil


Layers of carbons
Coke
Oil refined Products
Catalyst
Inactive
Low yield
Crude Oil

Traditional way of reactivating catalysts

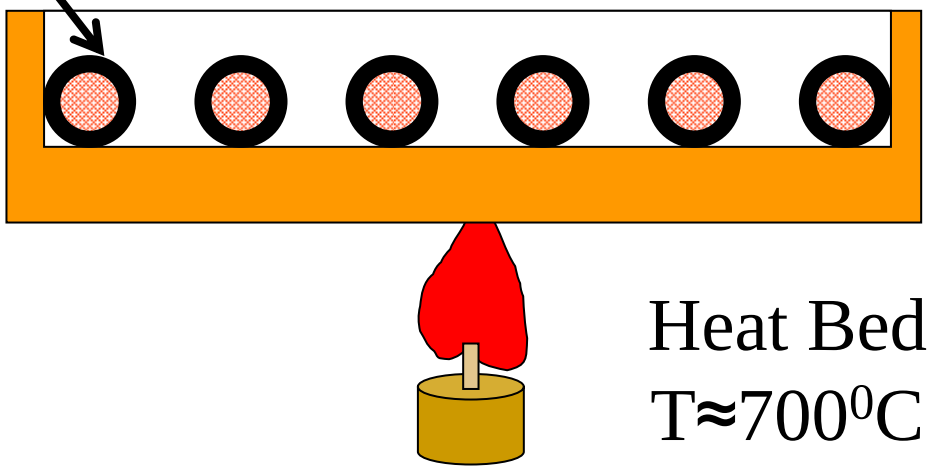
(de-coking)

Layers of carbons

Coke

Air

Inactive Catalyst



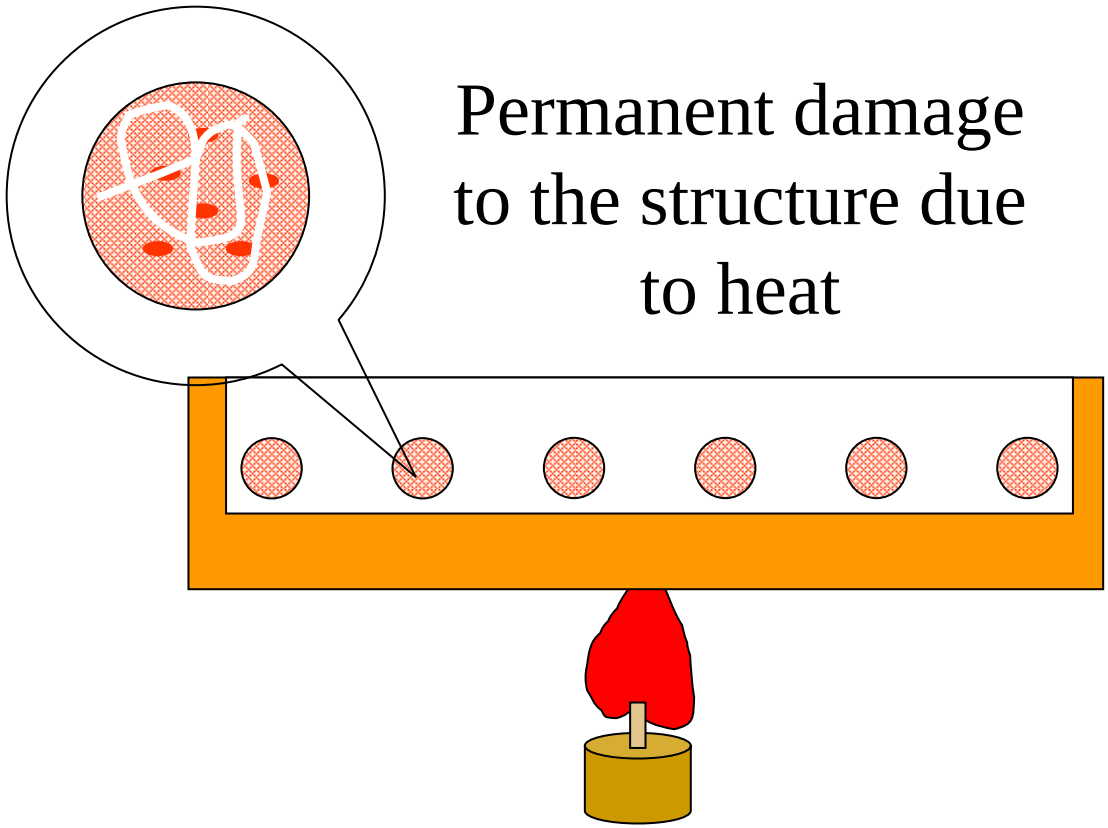
Catalyst regains activity

Heat Bed

T≈700^{0}C

Many hours

Traditional way of reactivating catalysts (de-coking)

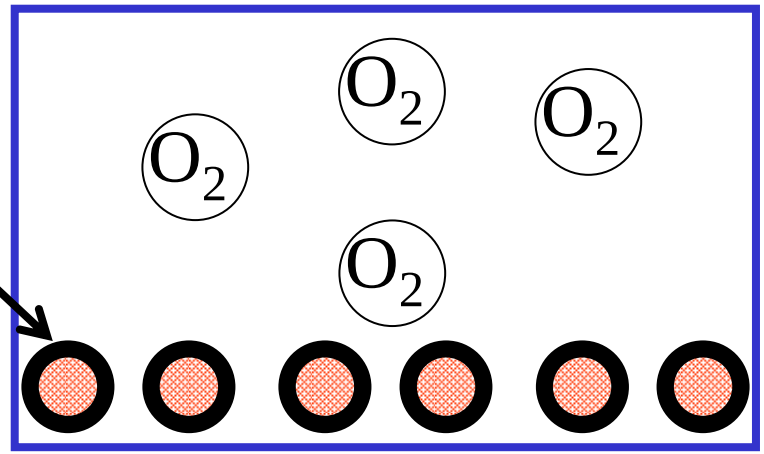


Permanent damage
to the structure due
to heat

Catalysts
do not completely regain activity
Useless after couple of reactivating cycles

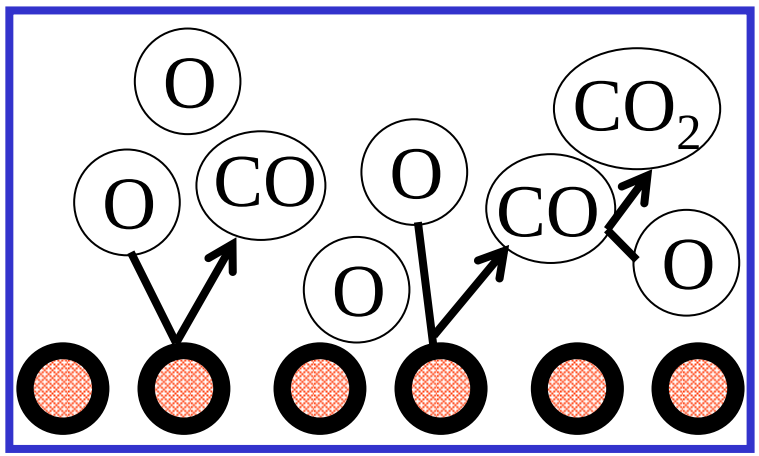
A new way of reactivating catalysts

Layers of carbons



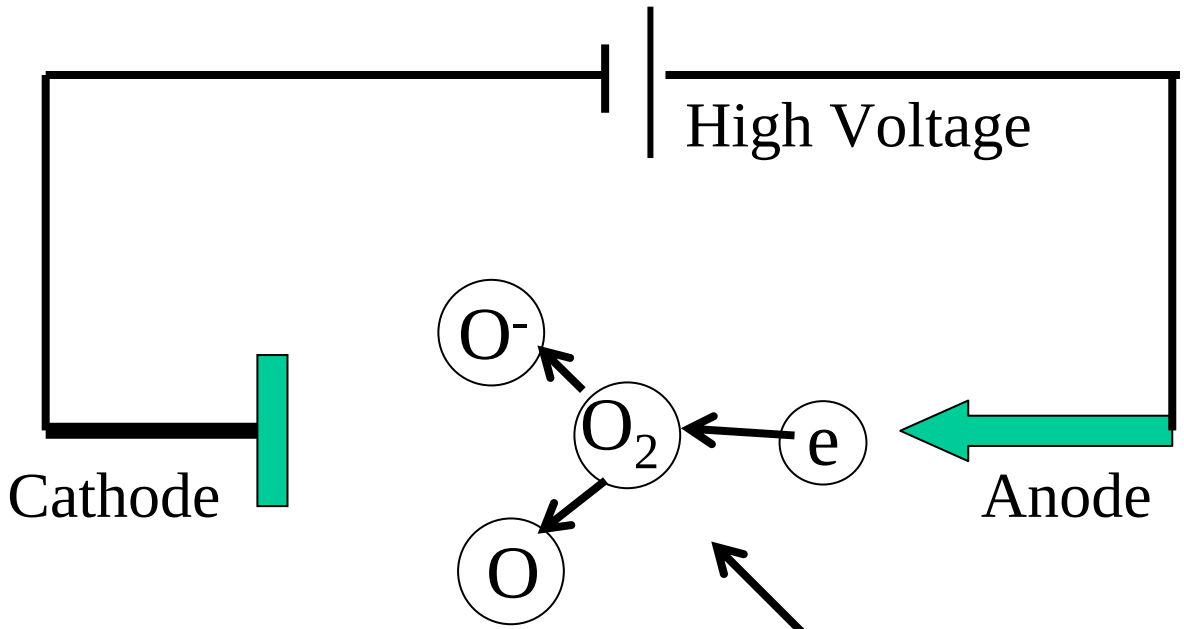
At low temperatures, O_2 molecules do not react well with coke

CO and CO_2 can be easily pumped out of the system



At low temperatures, O atoms are very reactive with coke

How to produce oxygen atoms?



Some other possibilities

$e + O_2 \rightarrow 2O + e$

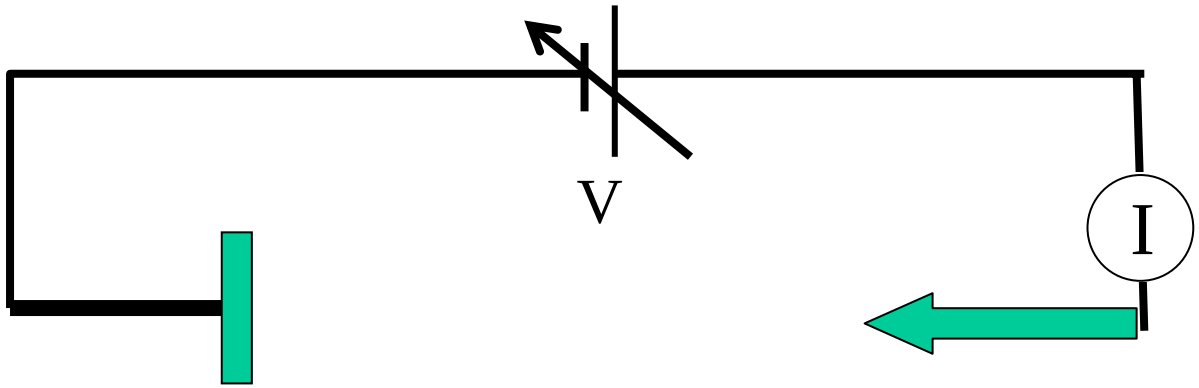
$e + O_2 \rightarrow O_2^-$

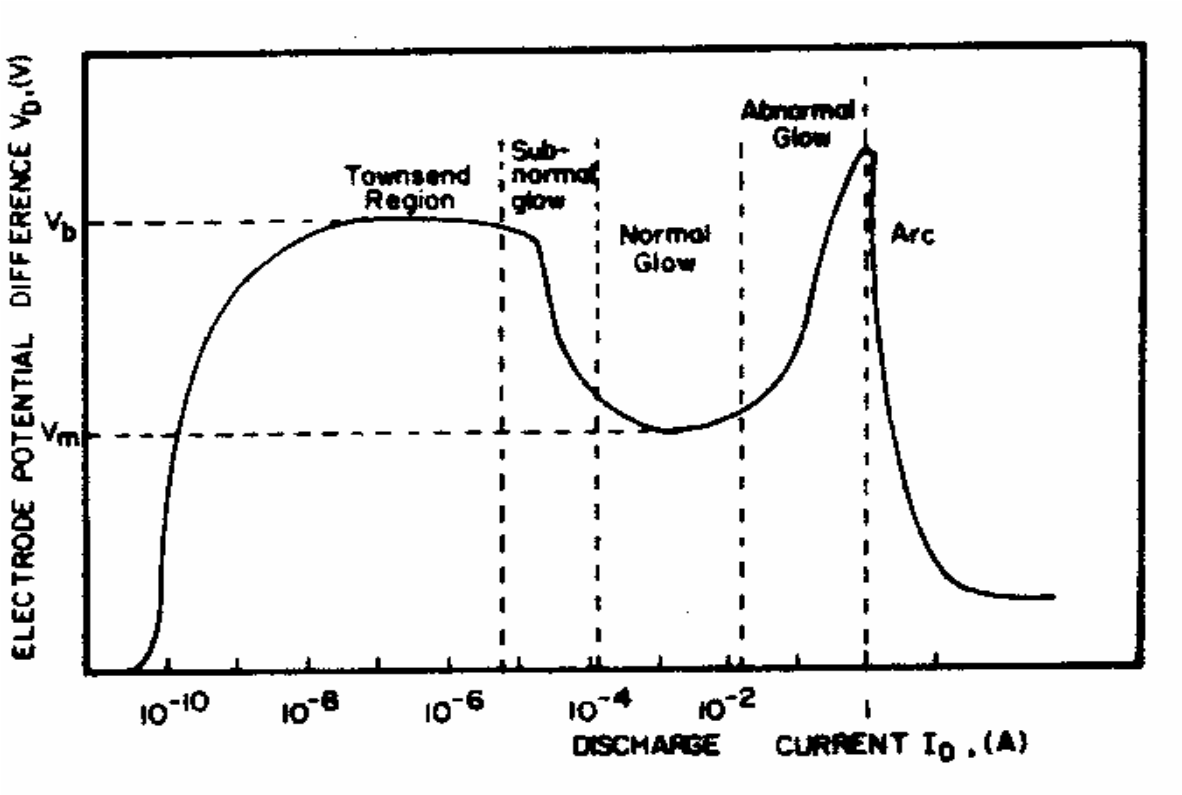
$e + O \rightarrow O^-$

$e + O \rightarrow O^+ + 2\,e$

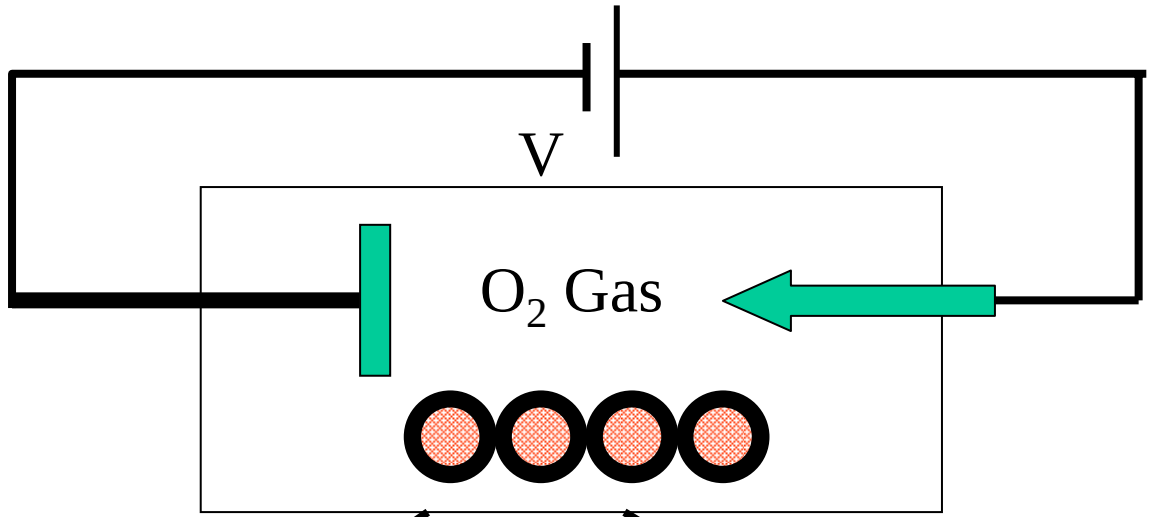
…

Glow Discharge





Assessment of de-coking



Online

Radiation (light)

Spectroscopy

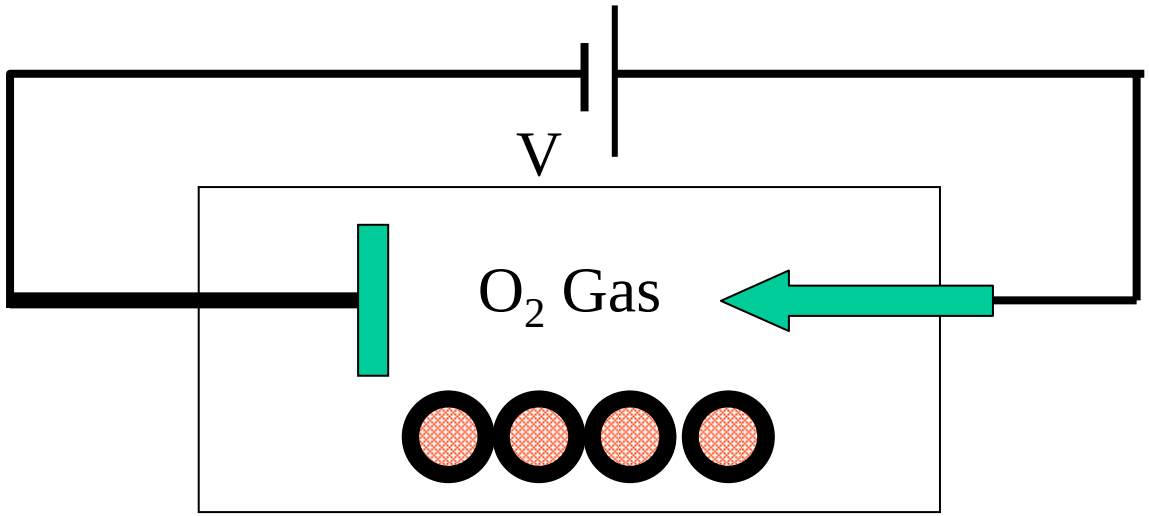
Dielectric property of plasma (electric resistivity)

Offline

Analysis of the surface of the catalyst

Test catalytic activity

Spectroscopy and resistivity



Spectroscopy

- Specific to gas species
- Expensive
- Complicated

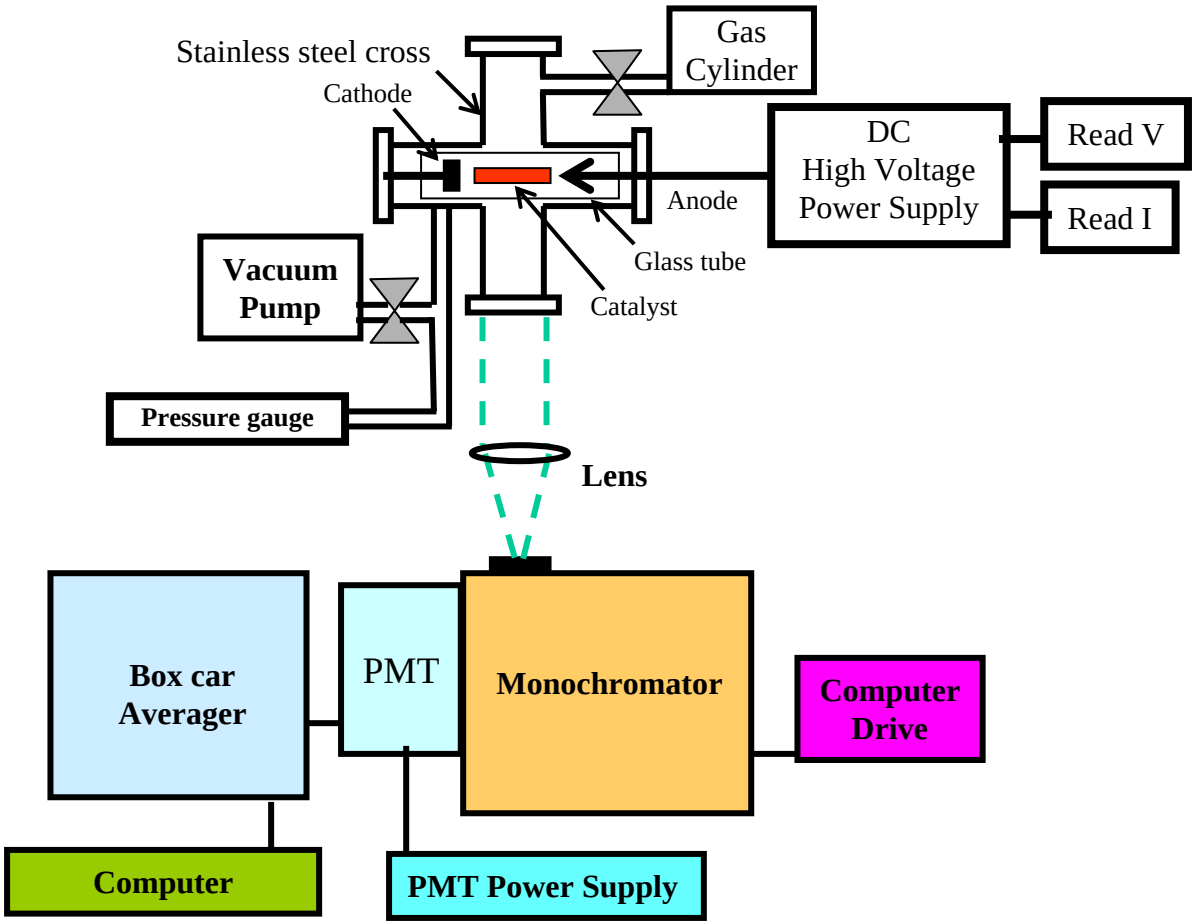
Dielectric property of plasma

- Not specific to gas species
- Cheap
- Simple

correlate ⟷

Experimental setup

Constant-current mode

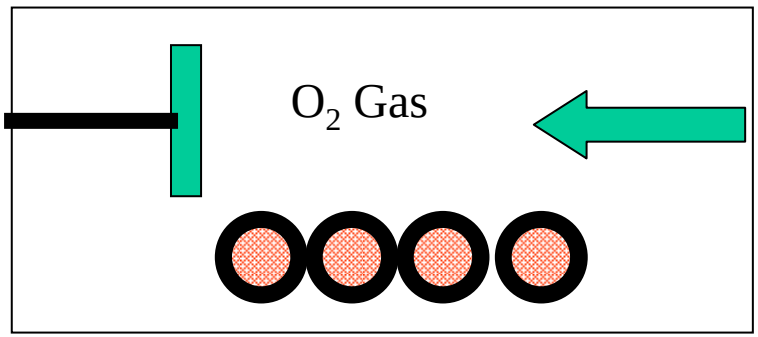


Prediction

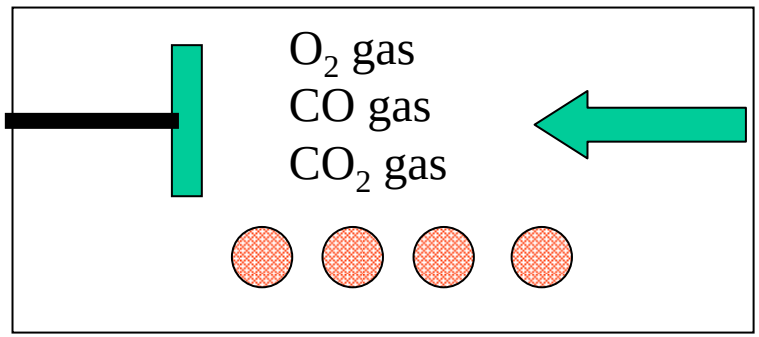
O_2 gas	1.000523
CO_2 gas	1.000985
CO gas	1.00070

Dielectric constant at atmospheric pressure

Before decoking

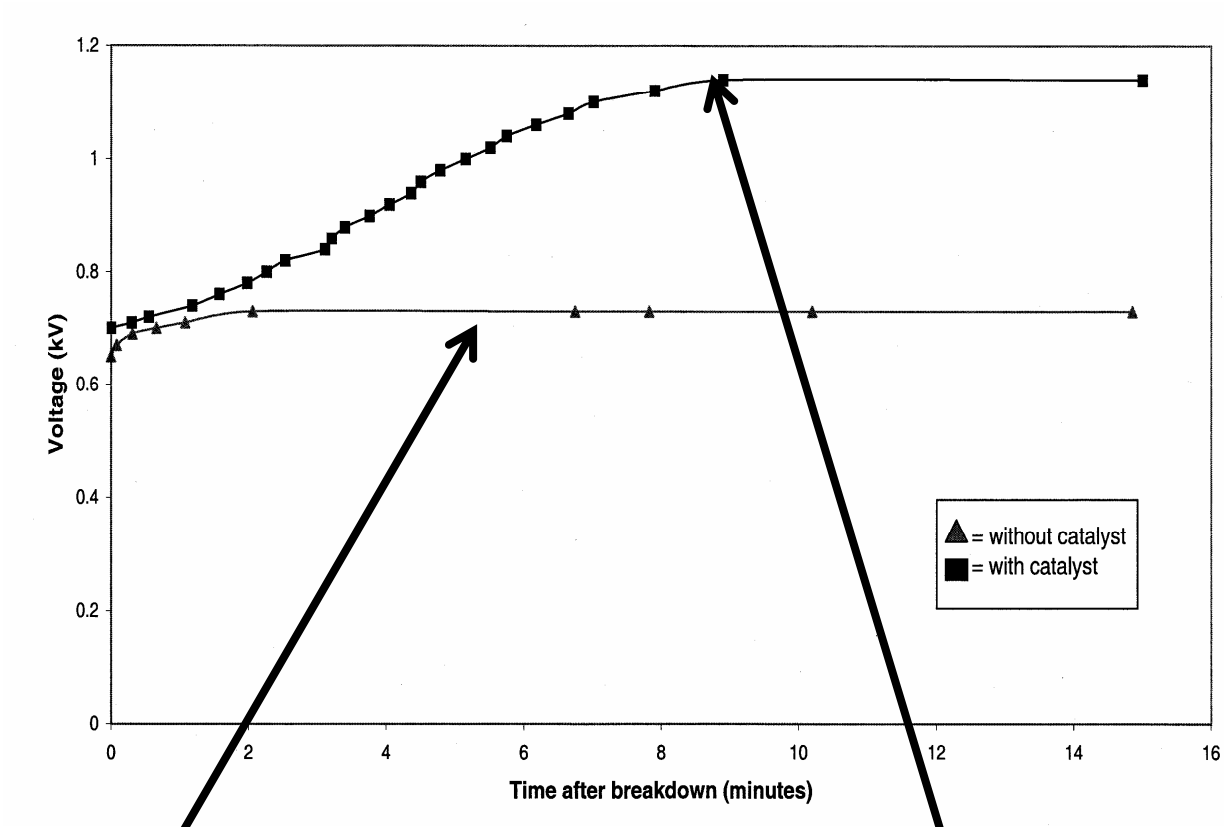


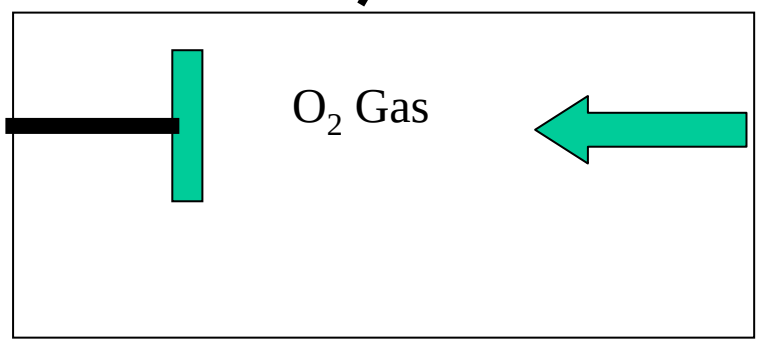
After decoking

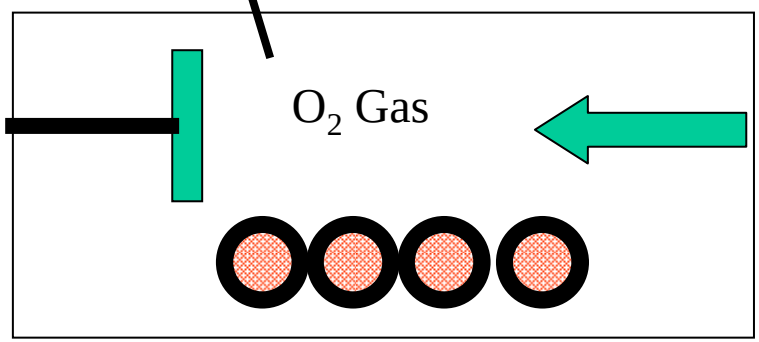


Higher resistivty
Higher dielectric constant
Higher pressure

Results


1.2
1
0.8
0.6
0.4
0.2
0
Voltage (kV)
0
2
4
6
8
10
12
14
16
Time after breakdown (minutes)
= without catalyst
= with catalyst

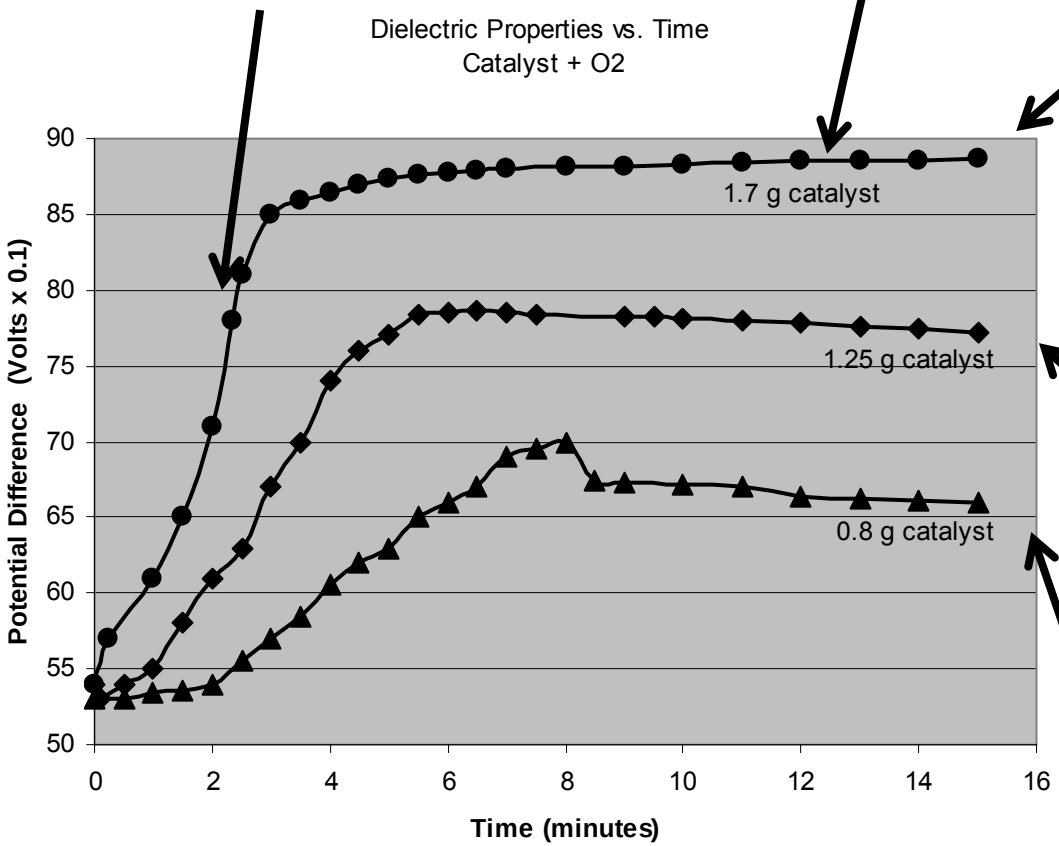

O_2 Gas

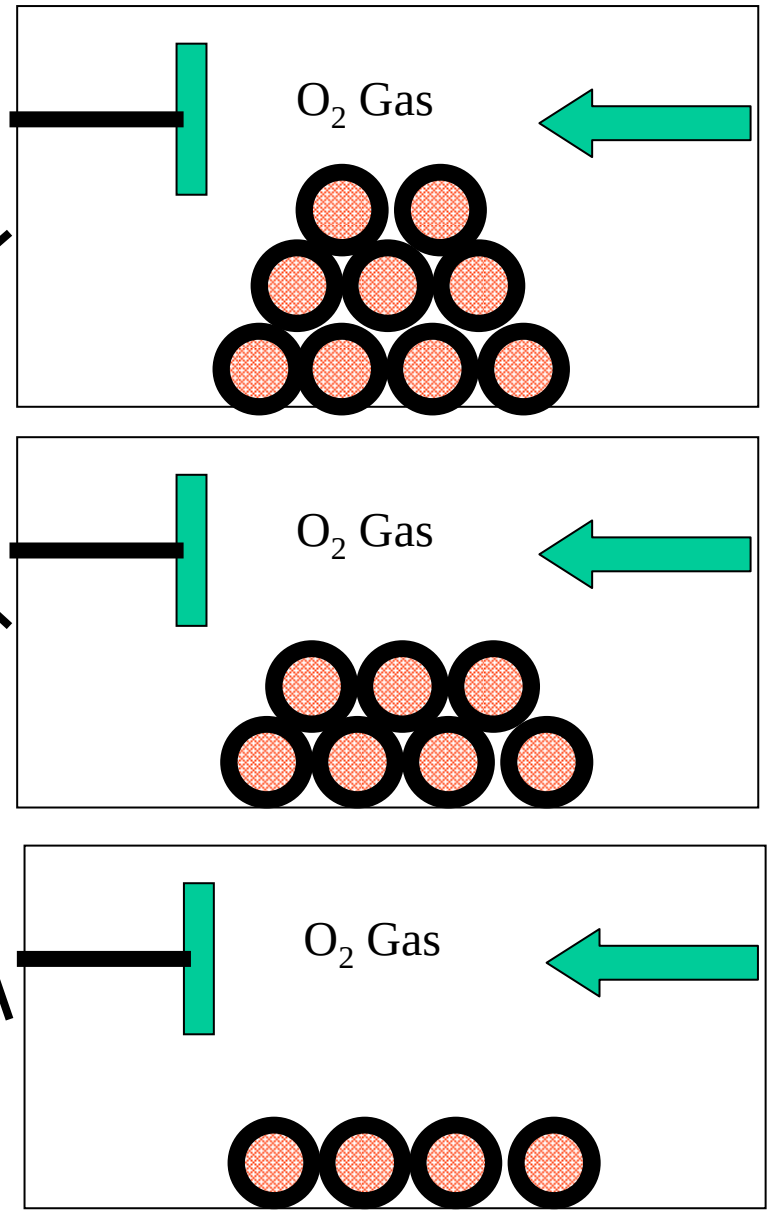

O_2 Gas

Results

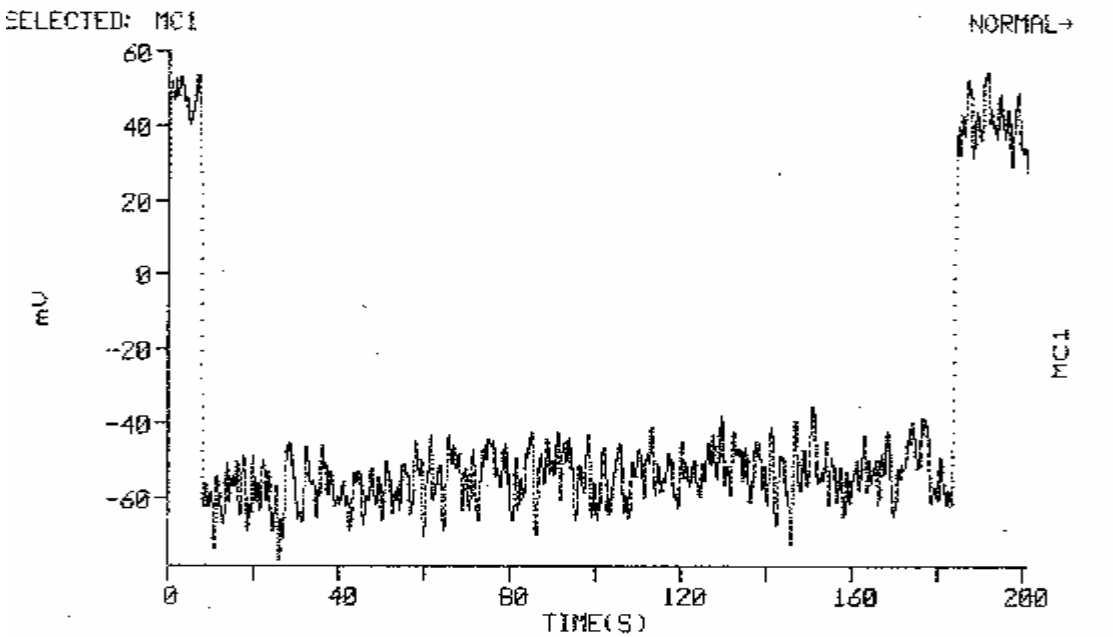
Rate is higher, catalyst is closer to the axis, more O atoms available Faster reaction

More catalyst is regenerated

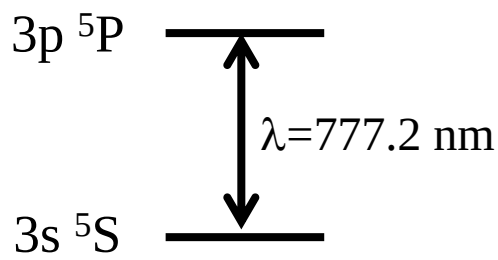




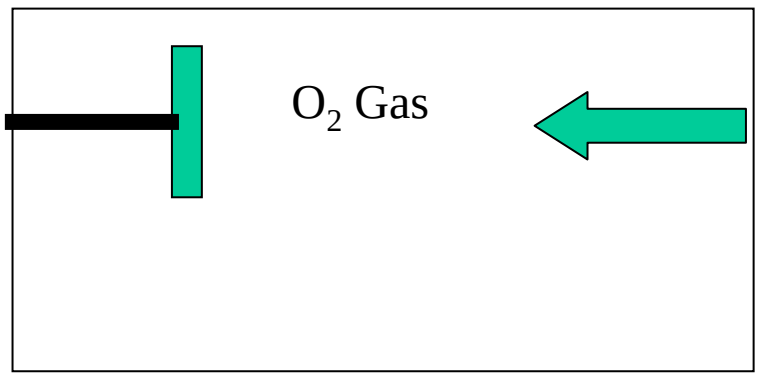
Visible Spectroscopy



O atom

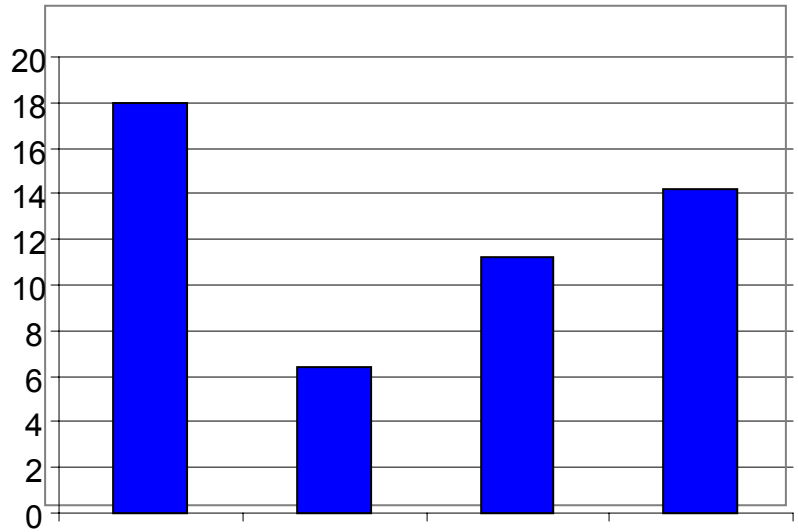


O atoms are not consumed



Visible Spectroscopy

Consumption of Oxygen

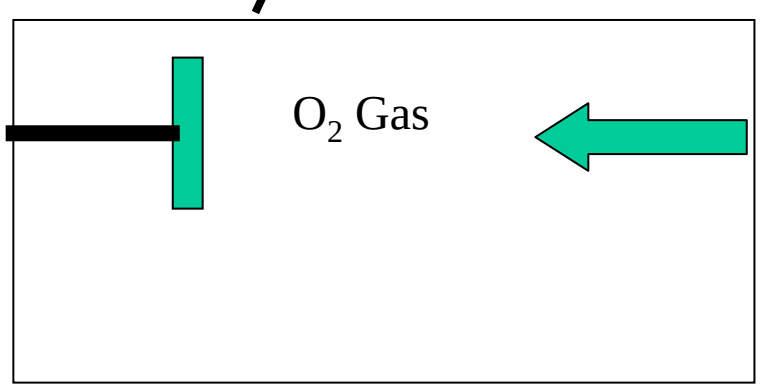


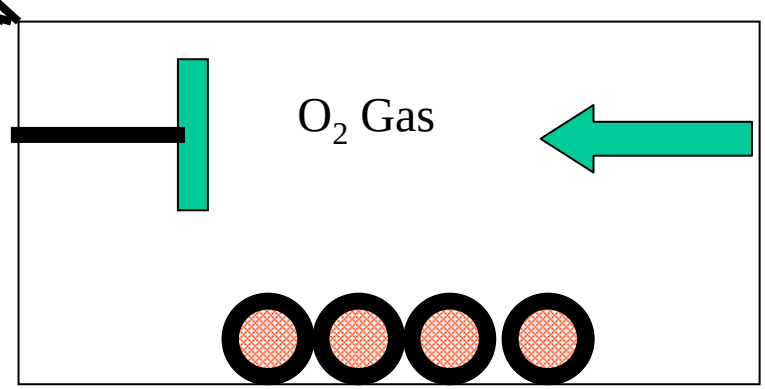
O atom

3p ^{5}P

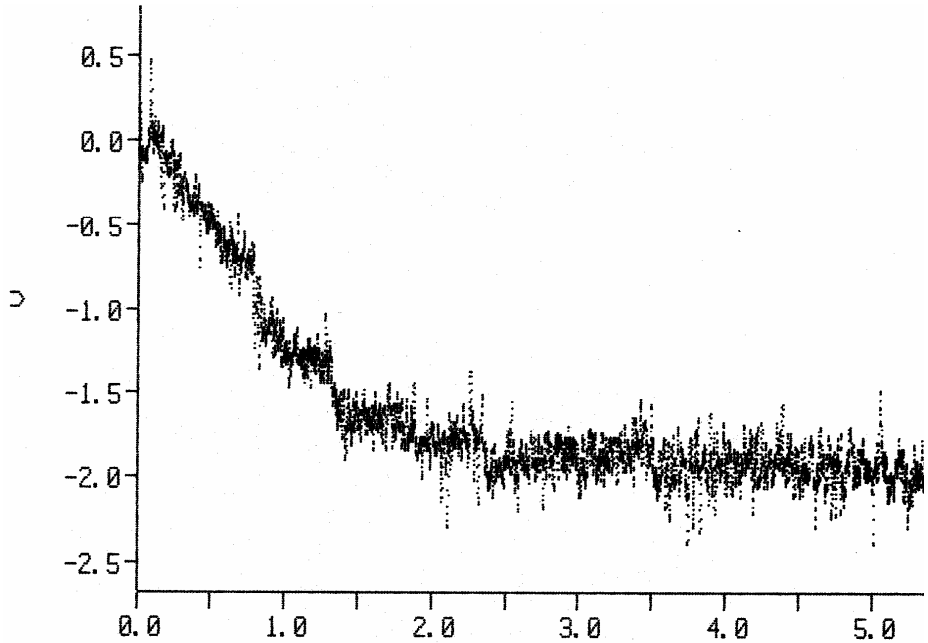
λ=777.2 nm

3s ^{5}S

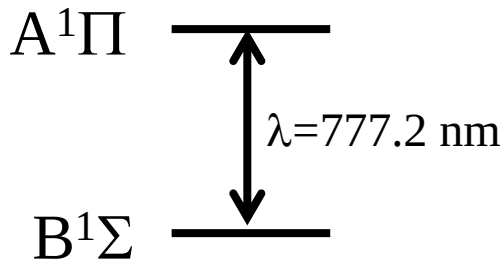




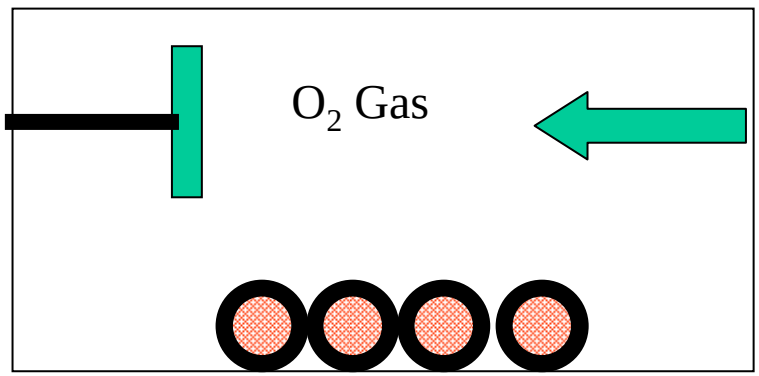
Visible Spectroscopy



CO molecule



CO molecules generated



Conclusion

Dielectric property of plasma can be used to monitor the de-ckoing process of a coked catalyst

Qualitatively, dielectric property of plasma correlates well with the spectroscopic results form O atoms and CO molecules

More experiments are needed to establish the functional relationship between spectroscopic and dielectric property methods

This work is a part of KFUPM-SABIC project number 2000/11. The support of KFUPM, Research Institute and the Physics Department is gratefully acknowledged.

Thank you for you listening