Laboratory of waterTreatment and Valorization of Industrial wastes
Department of Chemistry
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Electrochemical degradation of a textile dye on PbO_2 electrode of a lead-acid battery

Presented by
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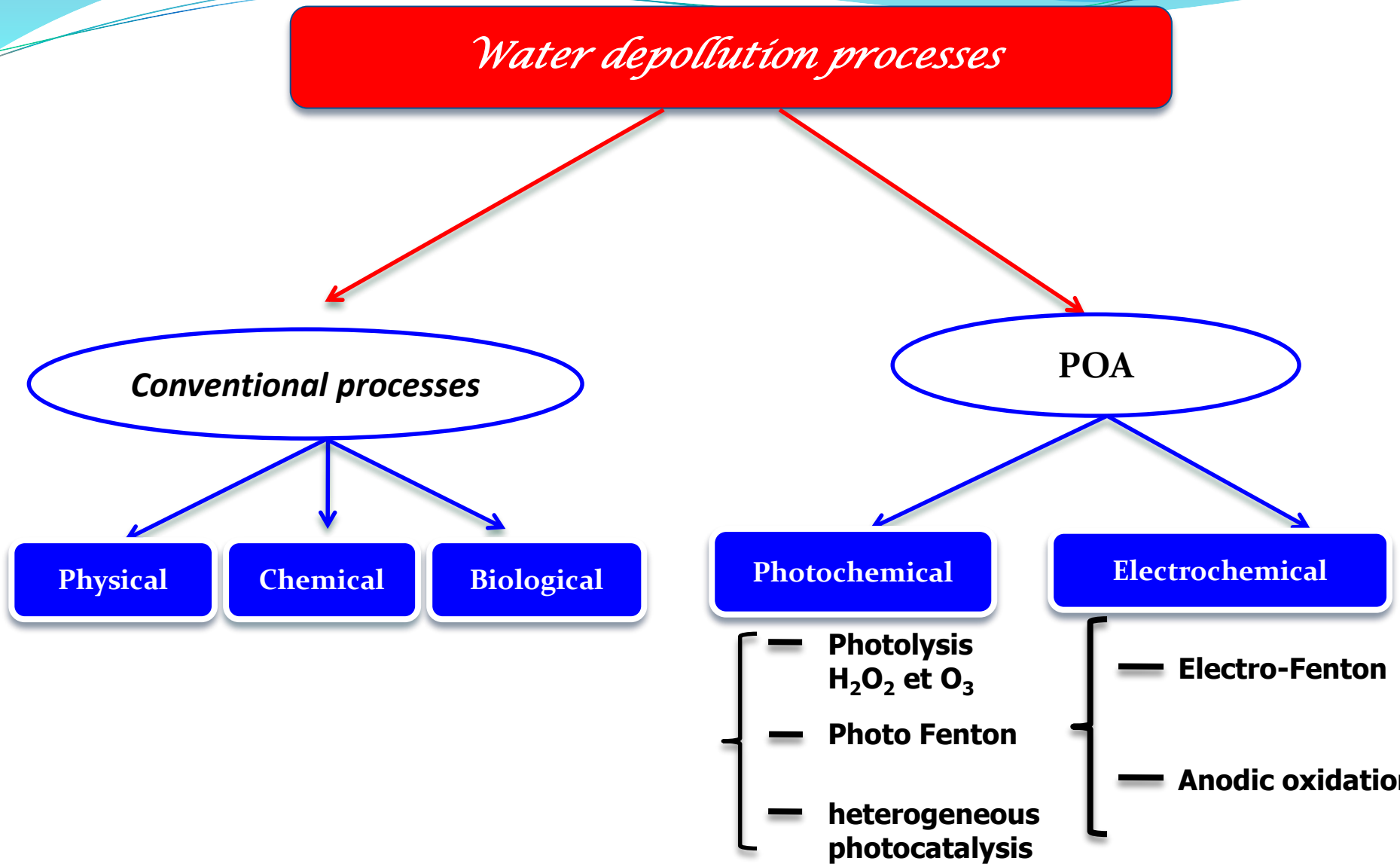
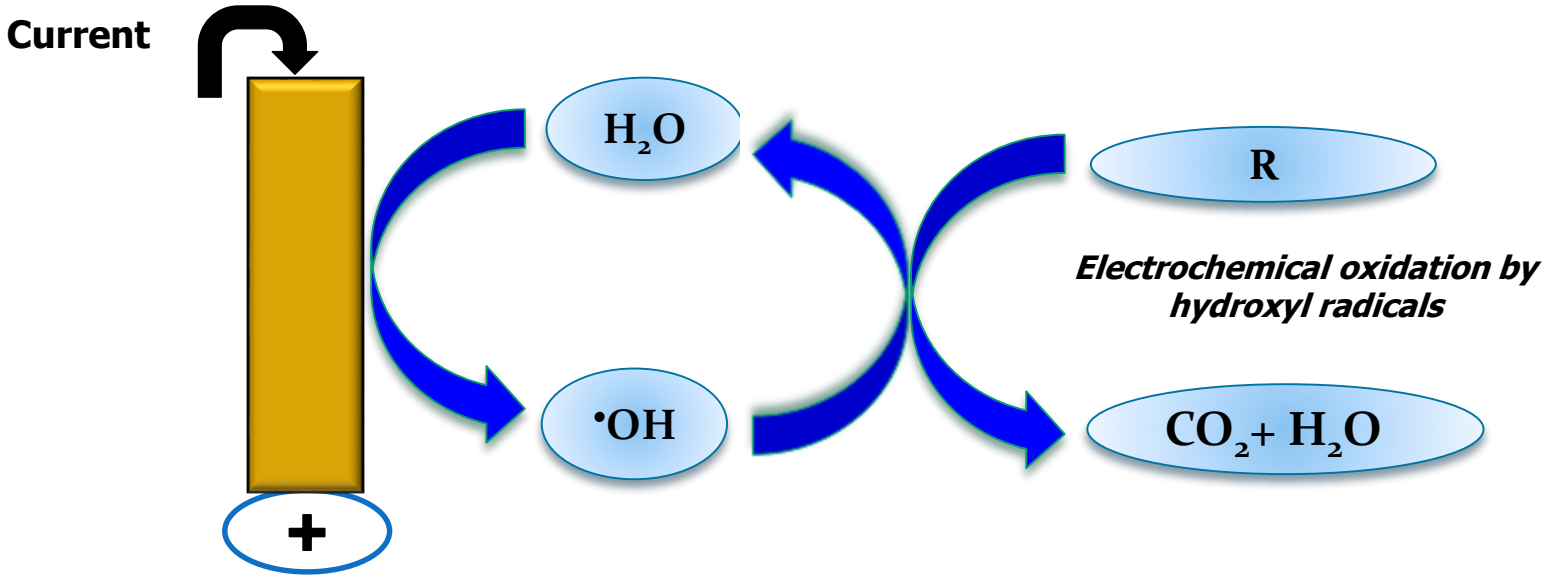
The Presentation Plan

- **Introduction: Water pollution by dyes**
- **Presentation of electrode and Characterization**
- **BM degradation study by electro-oxidation (EO)**
- **Conclusion**

Water pollution by dyes


Water depollution processes
Conventional processes
POA
Physical
Chemical
Biological
Photochemical
Electrochemical
Photolysis
H2O2 et O3
Photo Fenton
heterogeneous
photocatalysis
Electro-Fenton
Anodic oxidation

Principle of anodic oxidation



Electrocatalytic electrodes:

Pt, Pd,…etc

Electrodes with high overpotential oxygen evolution:

$TiIrO_2$, $TiRuO_2$, SnO_2, PbO_2, BDD, etc.

Active electrode and Inactive electrode

Active electrode (chemisorbed oxygen, ex: IrO_2, RuO_2)

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

Strong interaction between °OH and the anode surface

$$MO_x[^{\bullet}OH] \rightarrow Mo_{x+1} + H^+ + e^-$$

Oxidation of the pollutant

$$MO_{x-1} + R \rightarrow RO + MO_x$$

In absence any oxidizable organic

$$MO_{x-1} \rightarrow MO_x + 1/2O_2$$

Inactive electrode (physisorbed oxygen, ex: SnO_2, PbO_2)

Weak interaction between °OH and the anode surface

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

Mineralization of the pollutant

$$MO_x[^{\bullet}OH]Z + [R] \rightarrow MO_x + CO_2 + Z\,H^+ + Ze^-$$

In absence any oxidizable organic

$$MO_x[^{\bullet}OH] \rightarrow MO_x + 1/2O_2 + H^+ + e^-$$

Positive electrode of a lead-acid battery

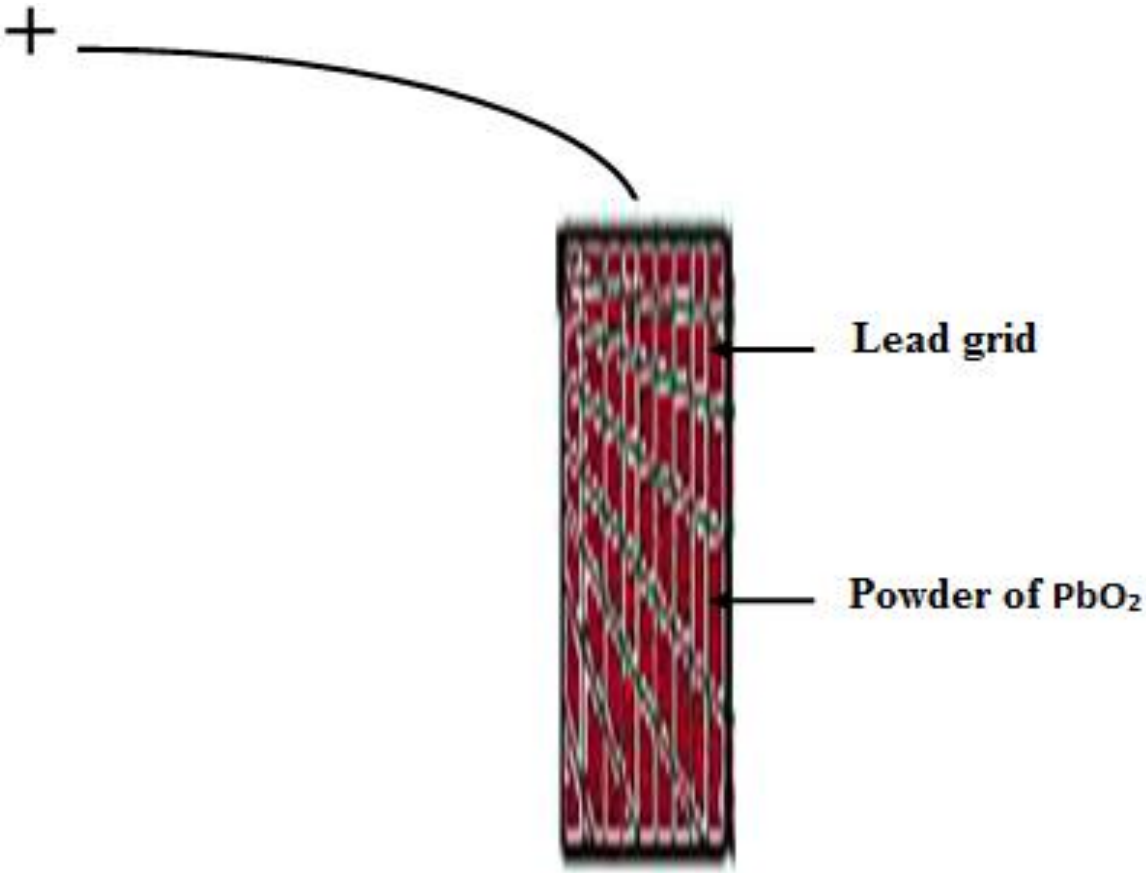
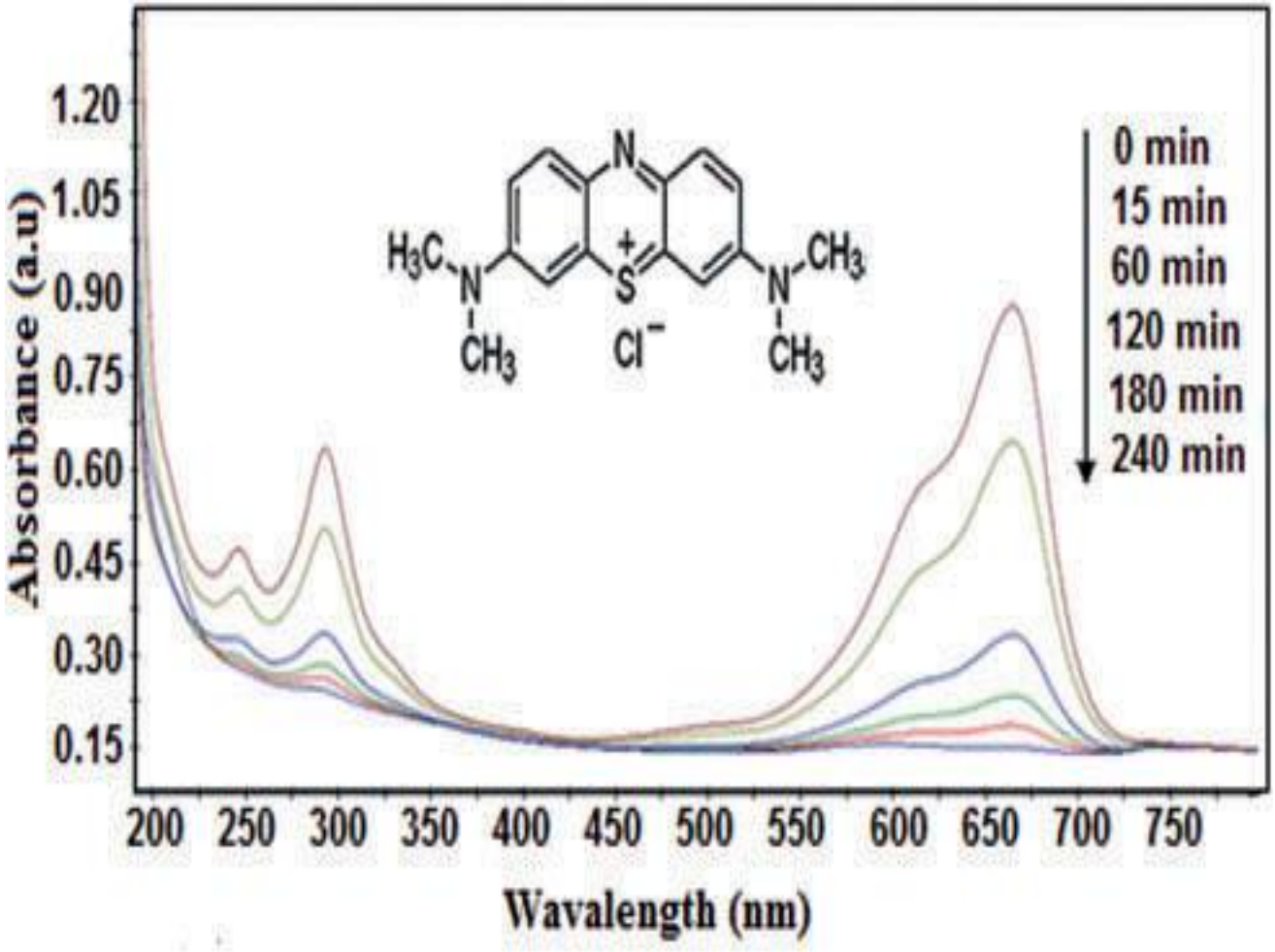
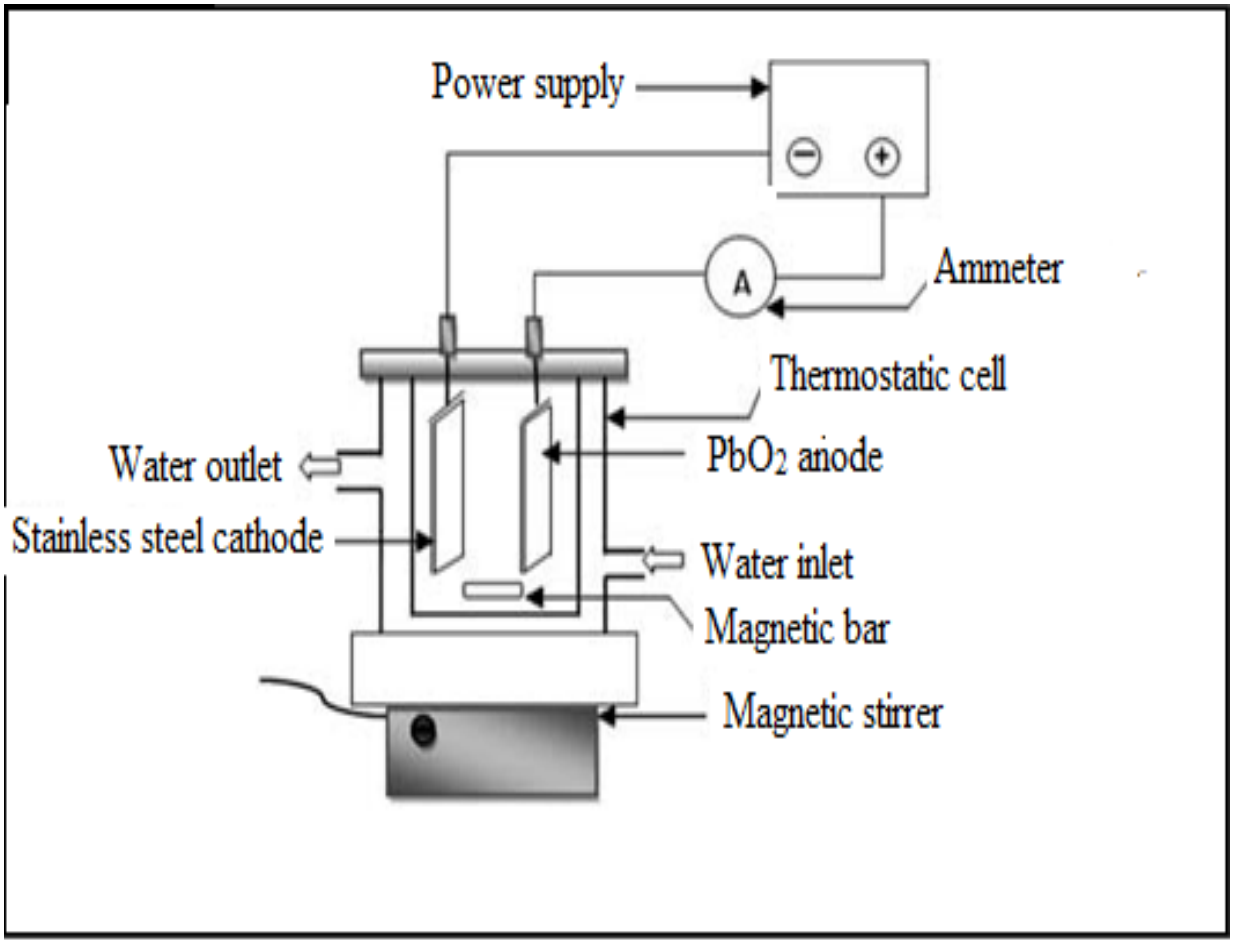


Fig. 3 Lead dioxide electrode

Structure and absorption spectrum of methylene blue



Anodic oxydation



Experimental set-up

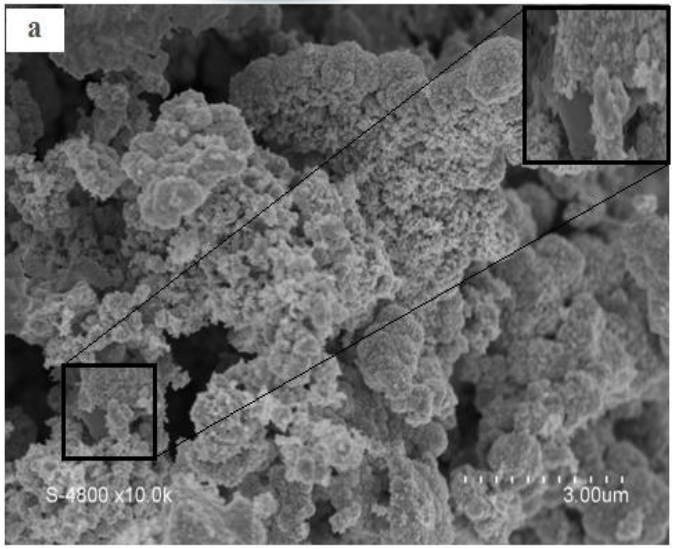
Characterization of Positive electrode lead-acid battey

Chemical analysis of the PbO2 electrode

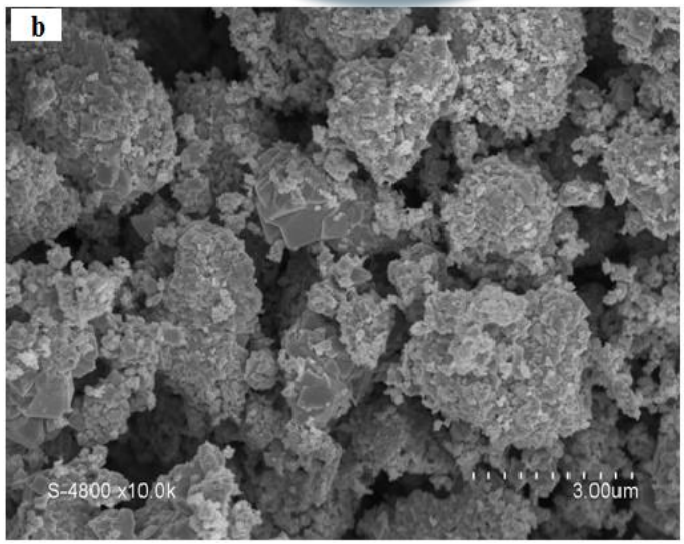
	PbO_2 (%)	$PbSO_4$ (%)
before electrolysis	92.39	2.00
After electrolysis	93.88	1.05

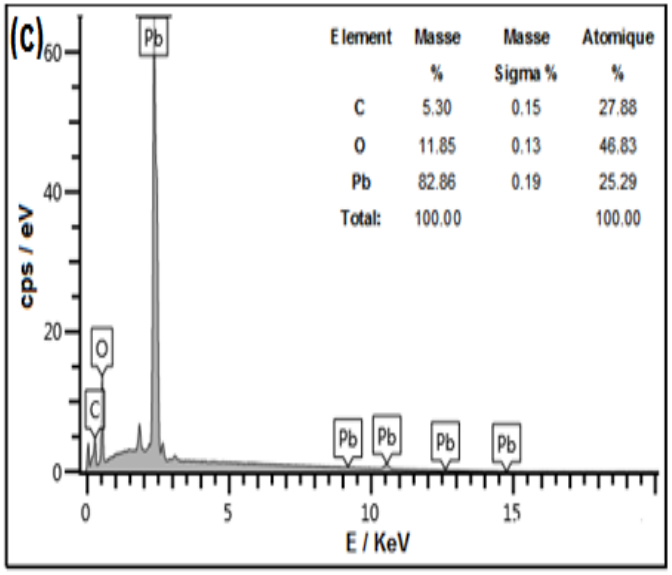
Analysis by SEM and EDS

Before

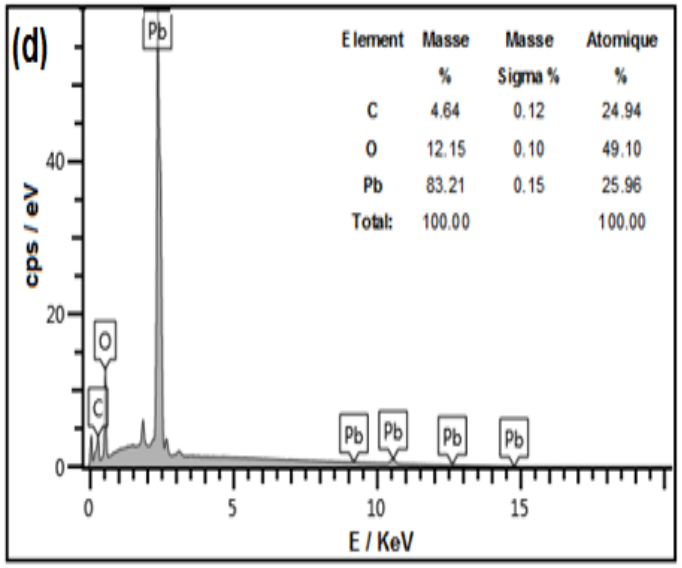


After





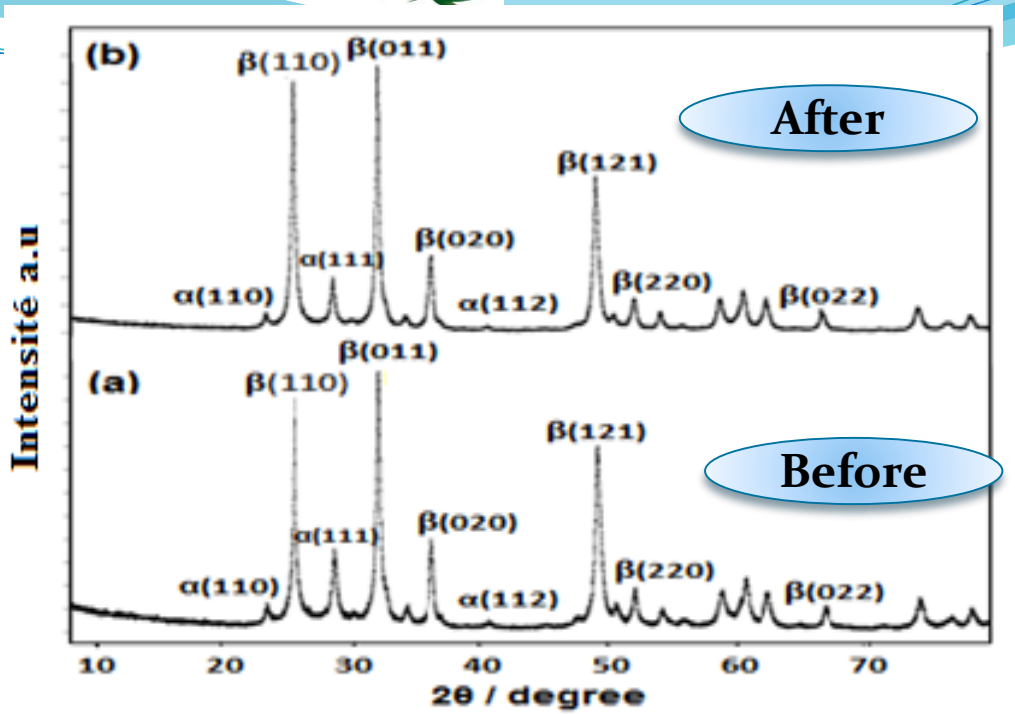
Element	Masse %	Masse Sigma %	Atomique %
C	5.30	0.15	27.88
O	11.85	0.13	46.83
Pb	82.86	0.19	25.29
Total:	100.00		100.00

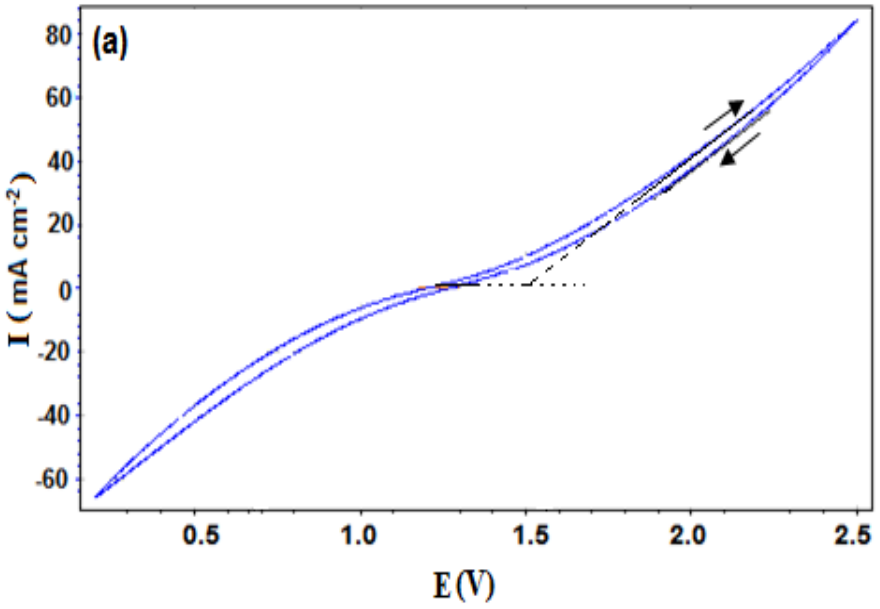


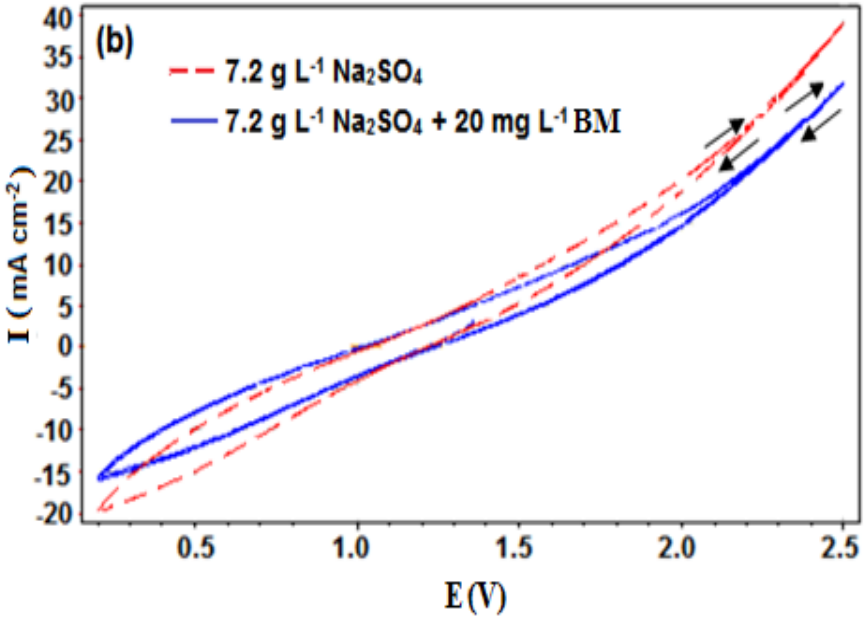
Element	Masse %	Masse Sigma %	Atomique %
C	4.64	0.12	24.94
O	12.15	0.10	49.10
Pb	83.21	0.15	25.96
Total:	100.00		100.00

X-ray Diffractometry Analysis(XRD)

Analysis by cyclic voltammetry(CV)



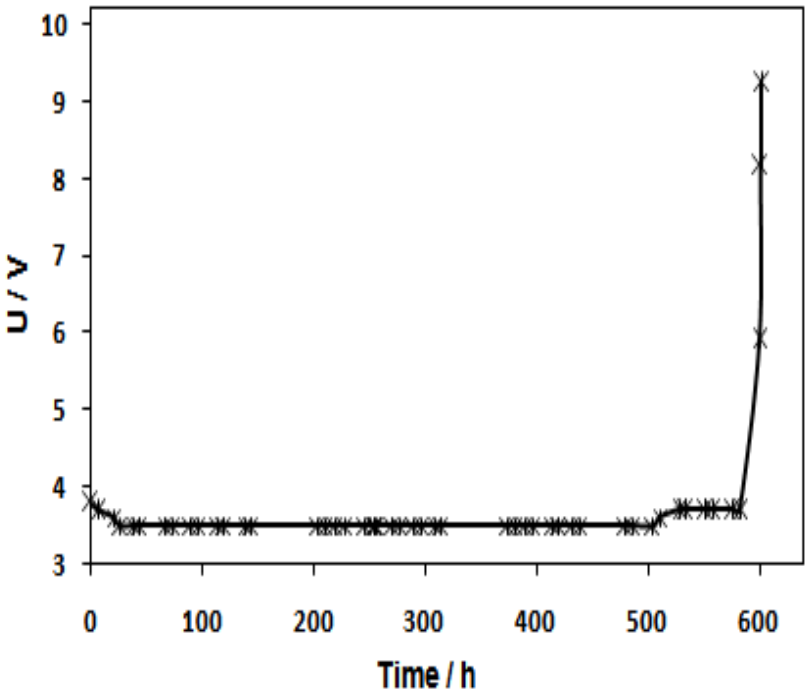




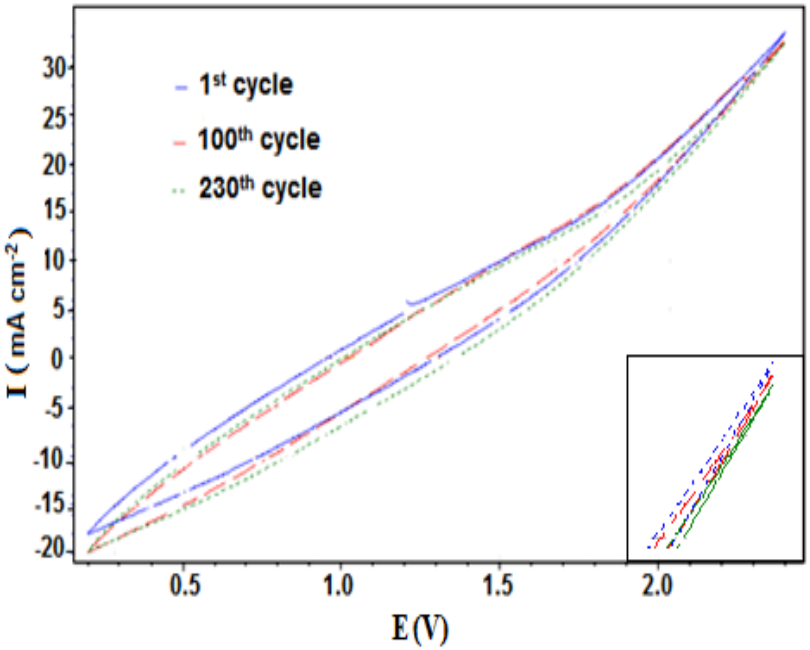
Stability of the electrode

Stability of electrode efficiency

Accelerated electrolysis test



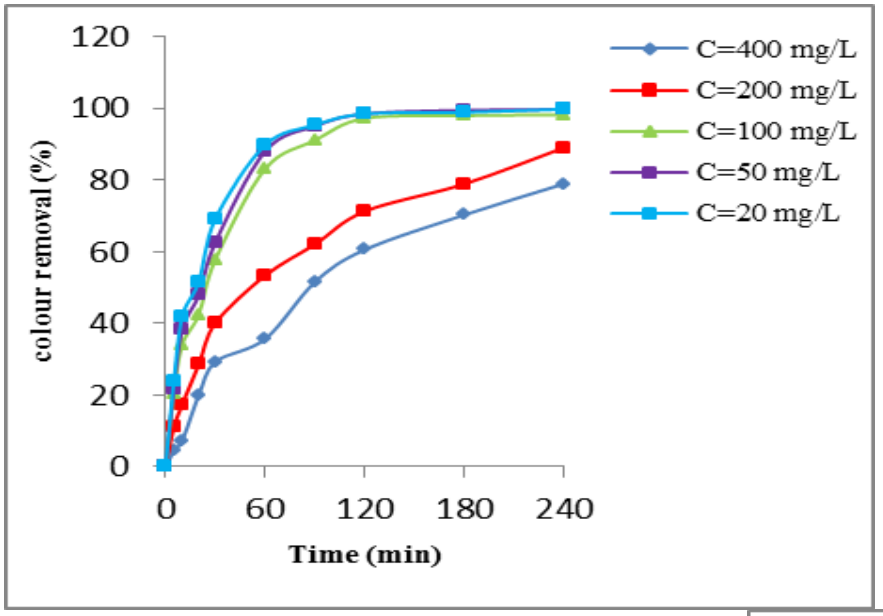
Effect of cycle number



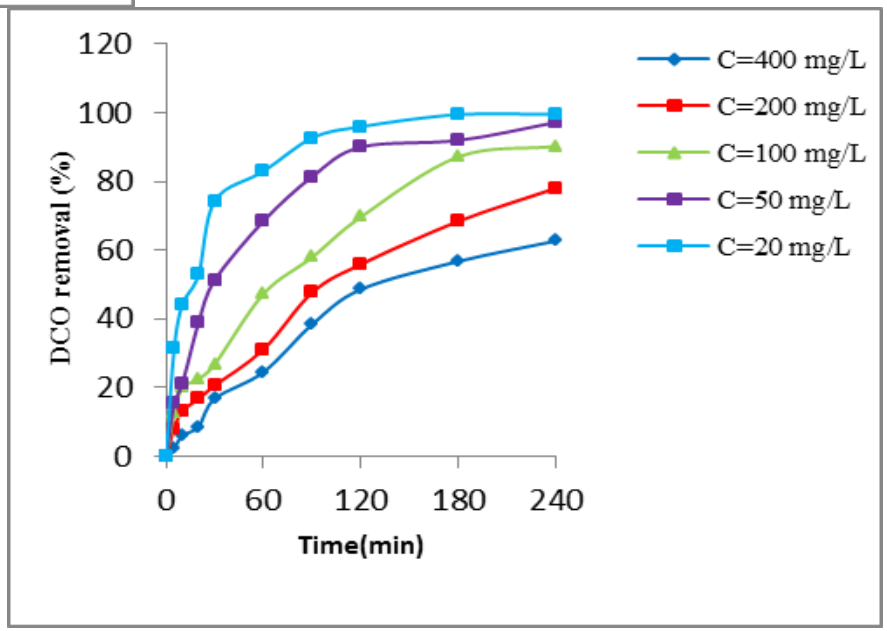
Study of the BM degradation by electro-oxidation :

Effect of some operating parameters

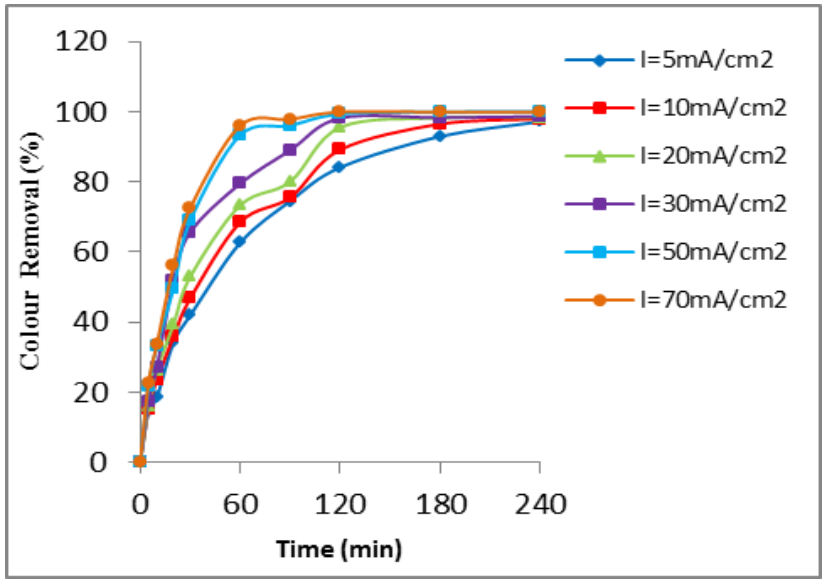
Effect of dye concentration



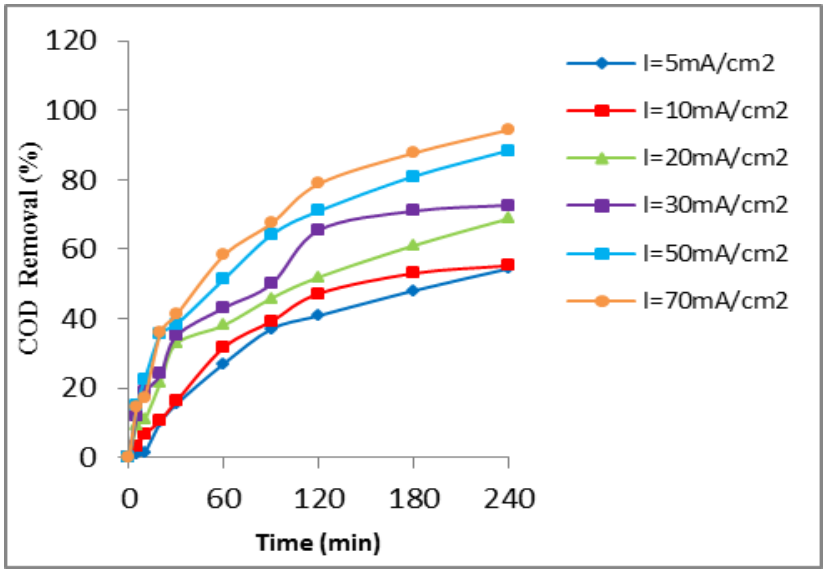
Densité de courant = 50 mA cm^{-2}
Vitesse d'agitation = 400 tr min^{-1}
$[Na_2SO_4]$ = 2 g L^{-1}
pH libre
d = 3,5 cm
T = 30 °C

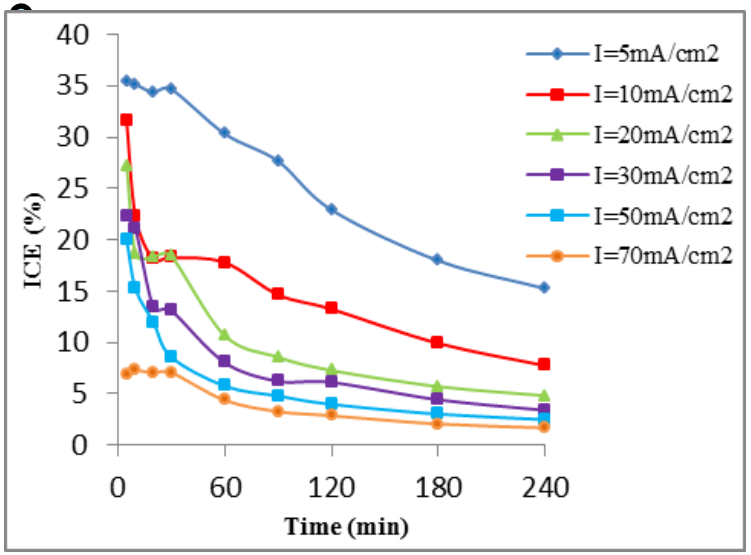


Effect of current density

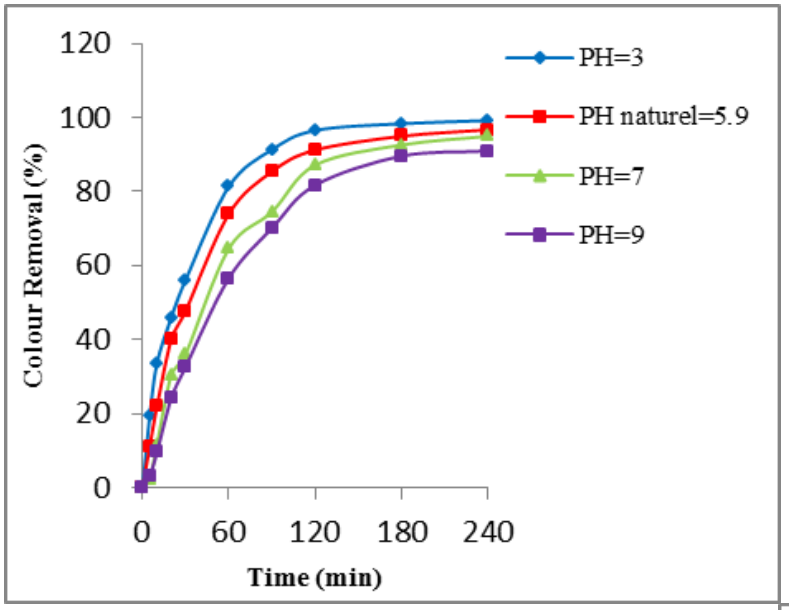


[BM]= 100 mg L^{-1}
vitesse d'agitation = 400 tr min^{-1}
[Na_2SO_4] = 2 g L^{-1}
pH libre
d = 3,5 cm
T = 30 °C

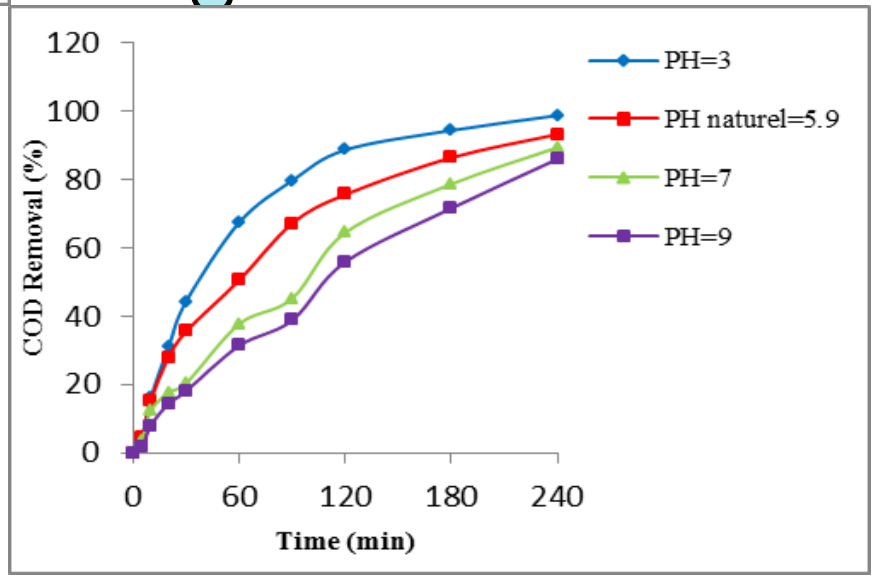




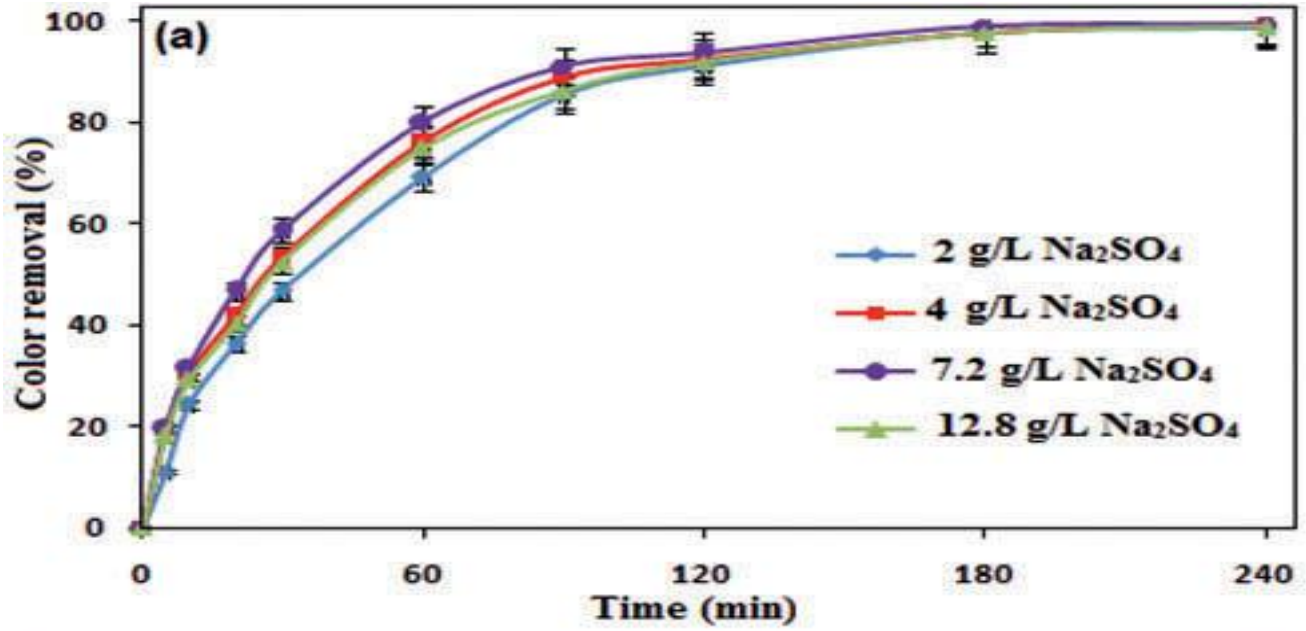
Effect of initial pH

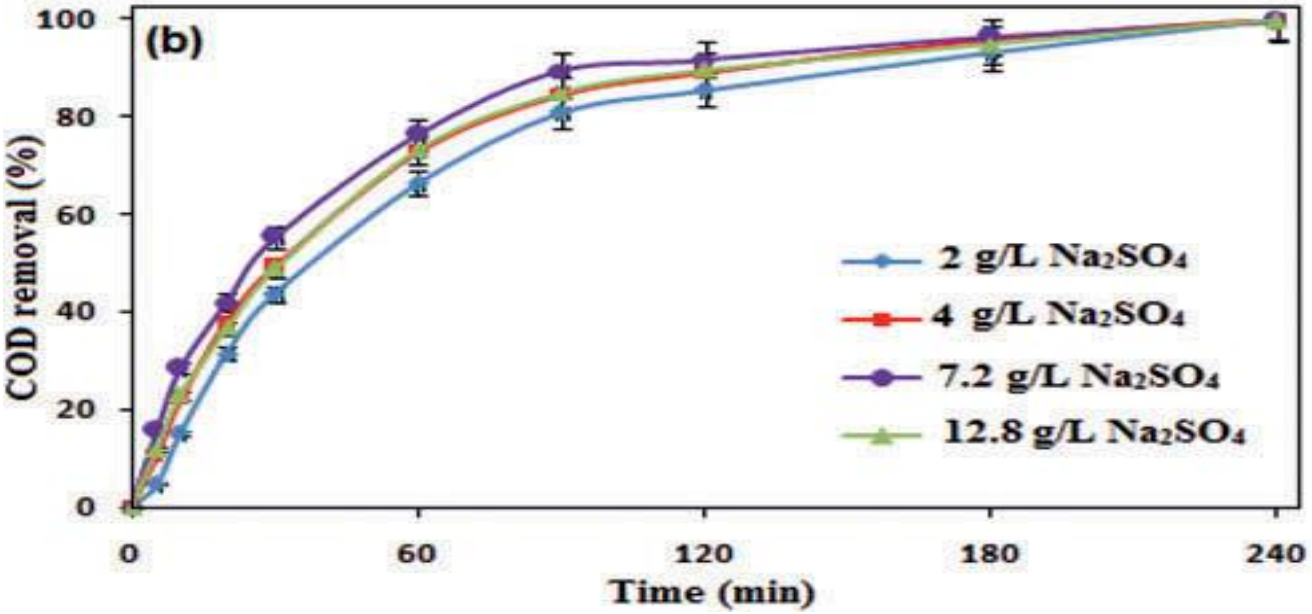


[BM]= 100 mg L^{-1}
Densité de courant = 50 mA cm^{-2}
Vitesse d'agitation = 400 tr min^{-1}
$[Na_2SO_4]$ = 2 g L^{-1}
d = 3,5 cm
T = 30 °C

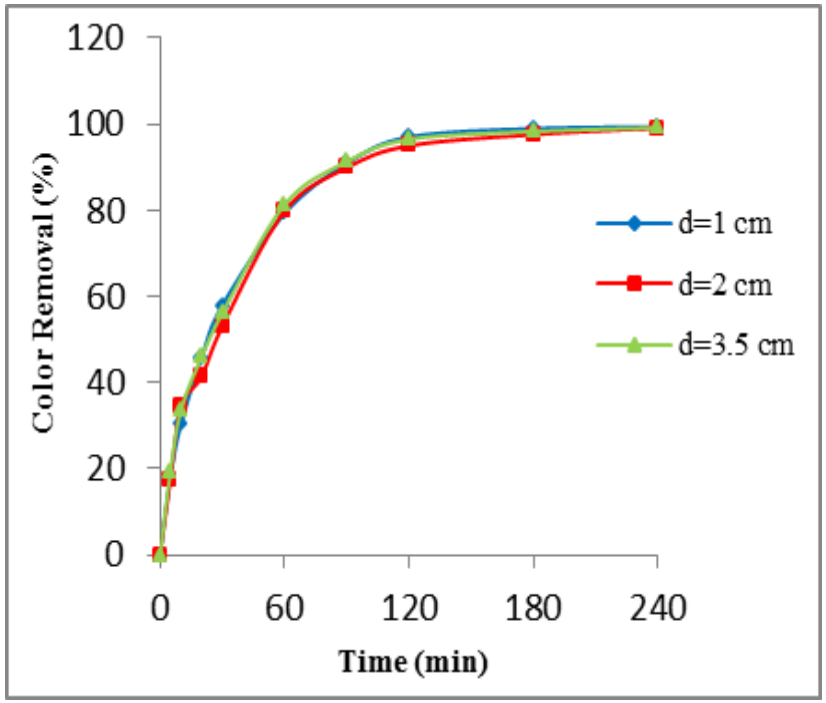


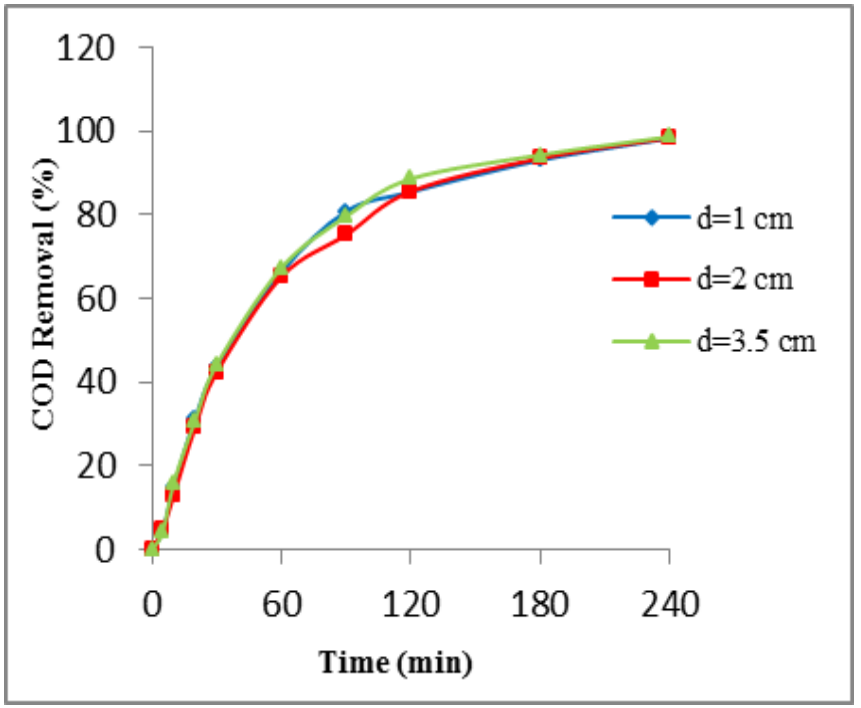
Effect of supporting electrolyte concentration





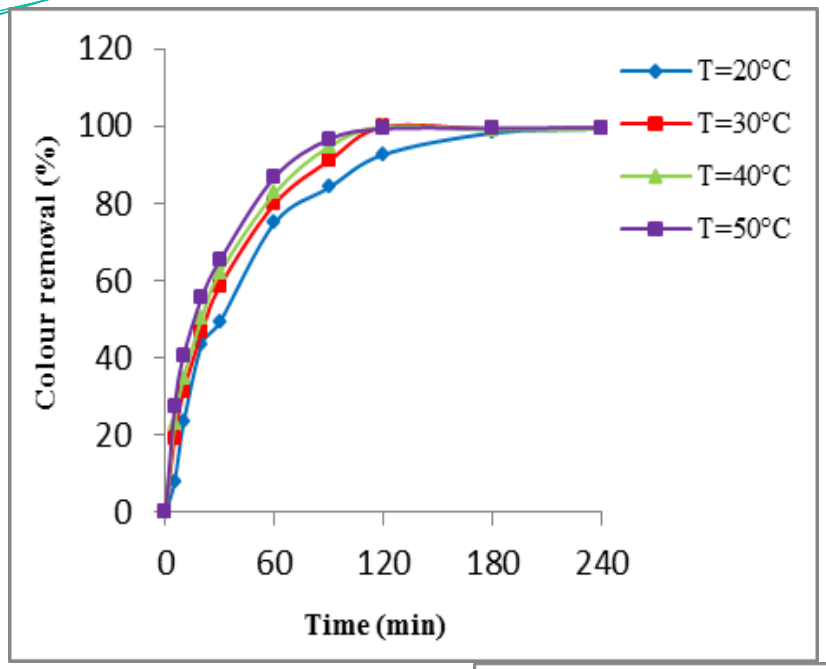
Effect of distance between the electrodes

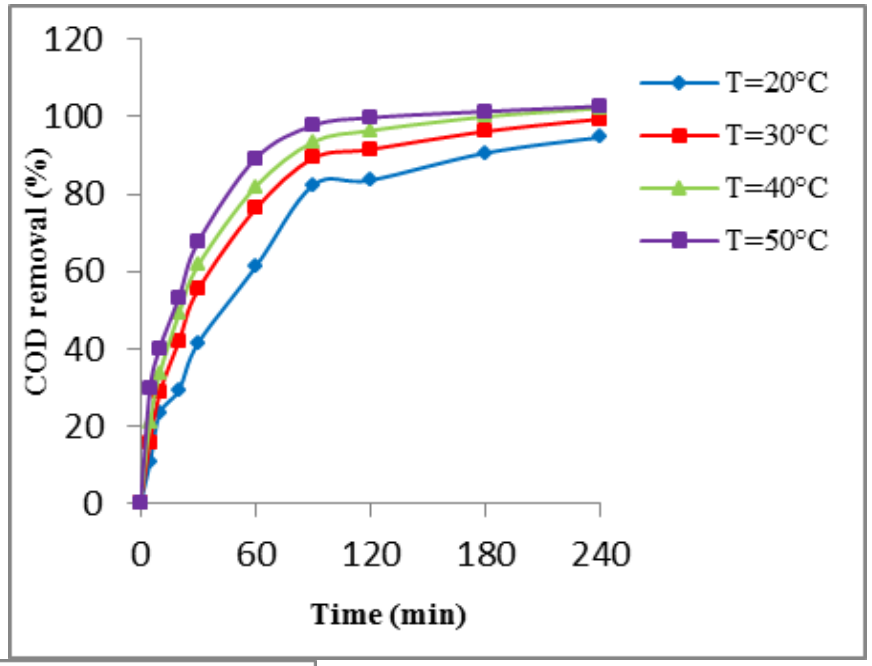


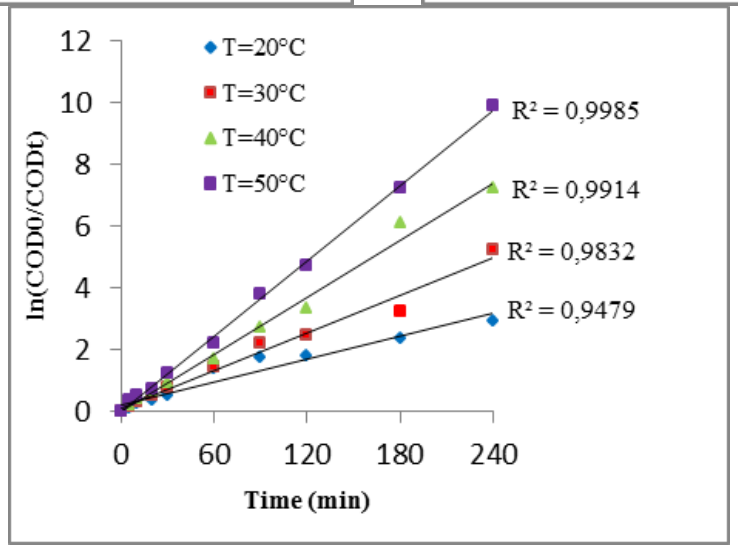


Distance (cm)	I (mA/cm2)	U (Volt)	EC (kw h $(gDCO)^{-1}$)
1.0	50	18.93	2.42
2.0	50	25.33	3.03
3.5	50	30.50	3.64

Effect of temperature







Conclusion

- The anode used in this study has a relatively long life
- Discoloration and mineralization rates increase as initial dye concentration and pH decrease.
- Increasing the current density in the 5-70 mA cm-2 range has a positive effect on the discoloration and mineralization of the solution.
- [supporting electrolyte] ↑ in the range 2-7 g / L results in increased discoloration and mineralization efficiency. At 12 g / L there was a regression
- The energy consumption increases with the distance between the electrodes.
- The effect of temperature on the discoloration and mineralization is relatively low
- The mineralization of the solution follows a pseudo-first order kinetics

This study demonstrated that the PbO2 lead-acid battery positive electrode can be used as an effective anode in the electrochemical degradation of organic pollutants.


Thank you for
your attention