

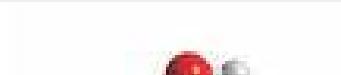


University of São Paulo
Institute of Chemistry of São Carlos
Laboratory of Electrochemistry Interfacial

Application of electrochemical degradation of wastewater composed of mixtures of phenol - formaldehyde

Ana Luiza T. Fornazari; Geoffroy R. P. Malpass; Douglas W. Miwa e Artur J. Motheo

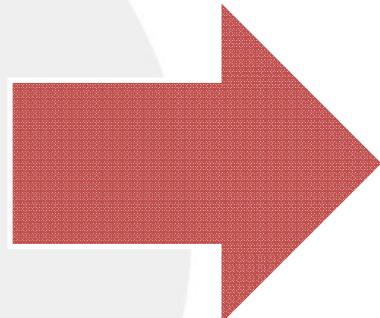
Motivation



Phenol



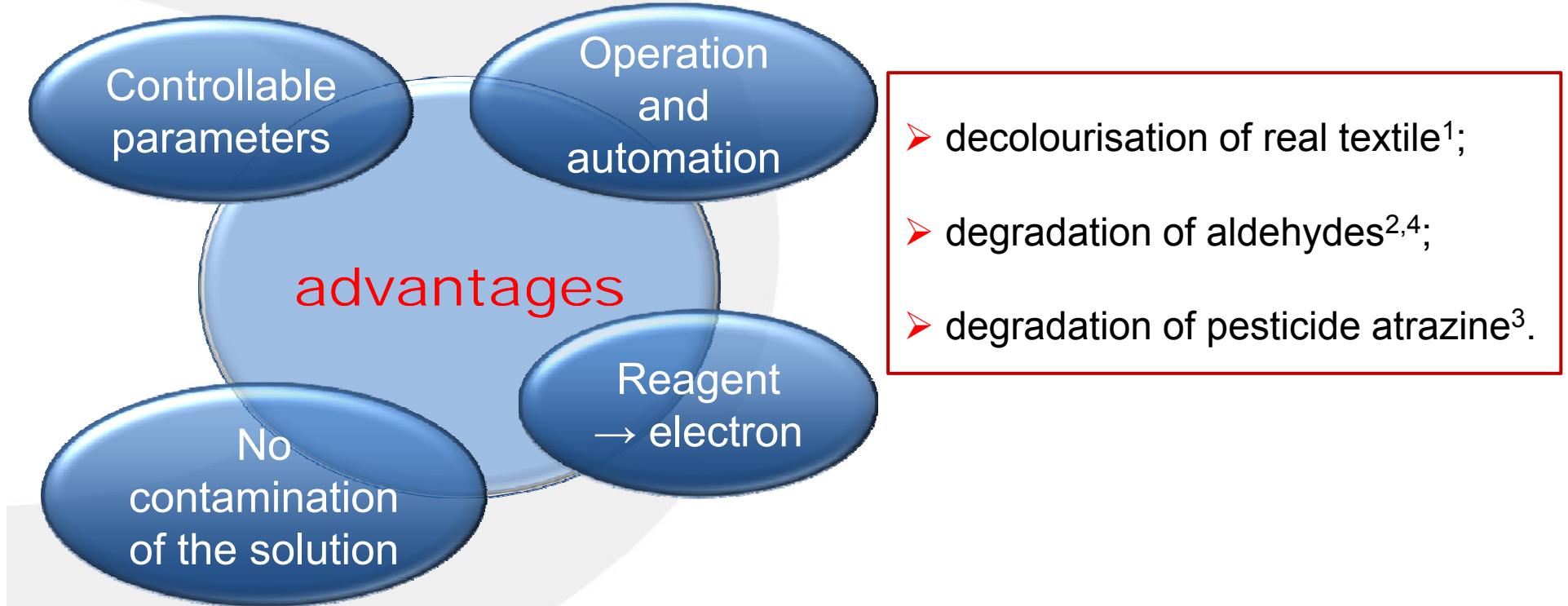
Formaldehyde



- ✓ New methods of treatment

Electrochemical treatment

Electrochemical Treatment



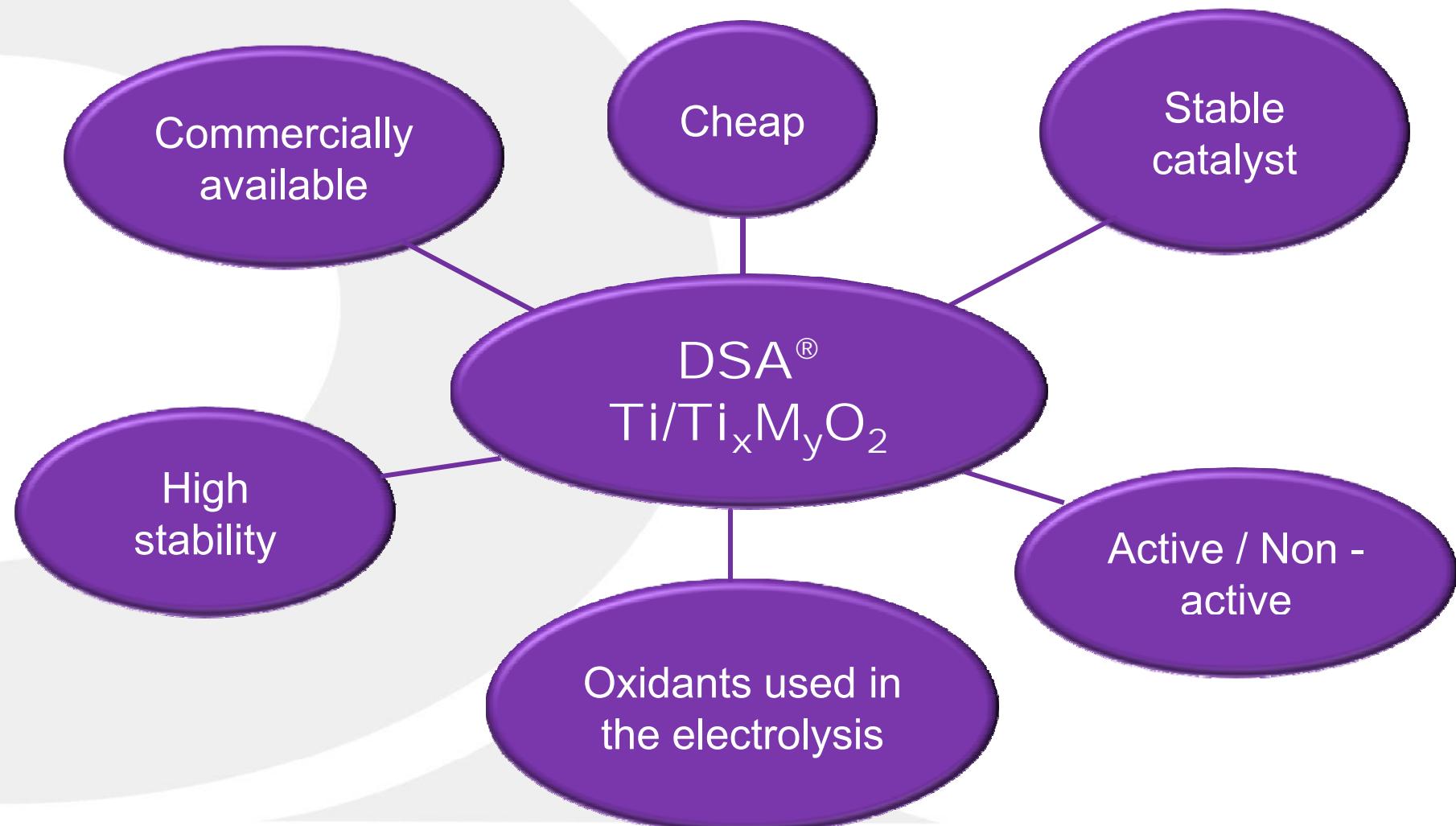
1. Malpass, G.R.P., et. al., 2008. Decolourisation of real textile waste using electrochemical techniques: Effect of electrode composition. *Journal of Hazardous Materials.* 156, 170-177.

2. Malpass, G.R.P., Motheo, A.J., 2003. The galvanostatic oxidation of aldehydes to acids on Ti/Ru0.3Ti0.7O2 electrodes using a filter-press cell. *Journal of the Brazilian Chemical Society.* 14, 65-70.

3. Malpass, G.R.P., et. al., 2006 a. Oxidation of the pesticide atrazine at DSA (R) electrodes. *Journal of Hazardous Materials.* 137, 565-572

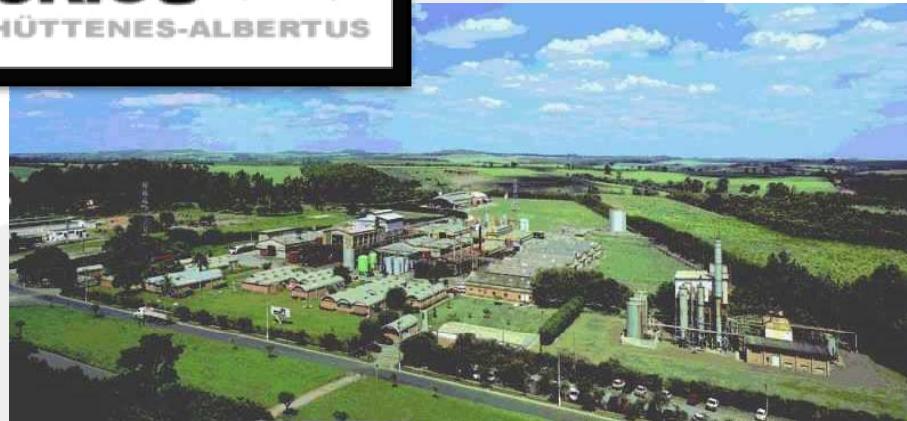
4. Motheo, A.J., et. al., 2000. The oxidation of formaldehyde on high overvoltage DSA type electrodes. *Journal of the Brazilian Chemical Society.* 11, 16-21 3

Dimensionally Stable Anode



Wastewater Composed of Mixtures of Phenol - Formaldehyde

- ✓ Manufacture of phenolic resins.



Polycondensation products of phenols and aldehydes (mainly formaldehyde)

Schenectady Crios S.A., Rio Claro – SP.

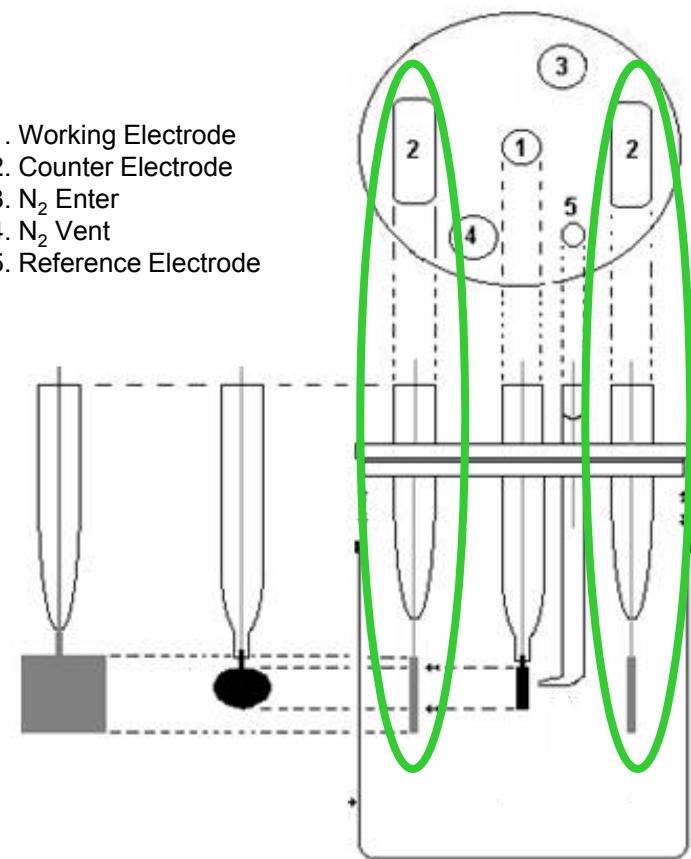
Cell and Equipment

✓ Electrochemical system.



Titanium plate

1. Working Electrode
2. Counter Electrode
3. N₂ Enter
4. N₂ Vent
5. Reference Electrode



Cell and Equipment

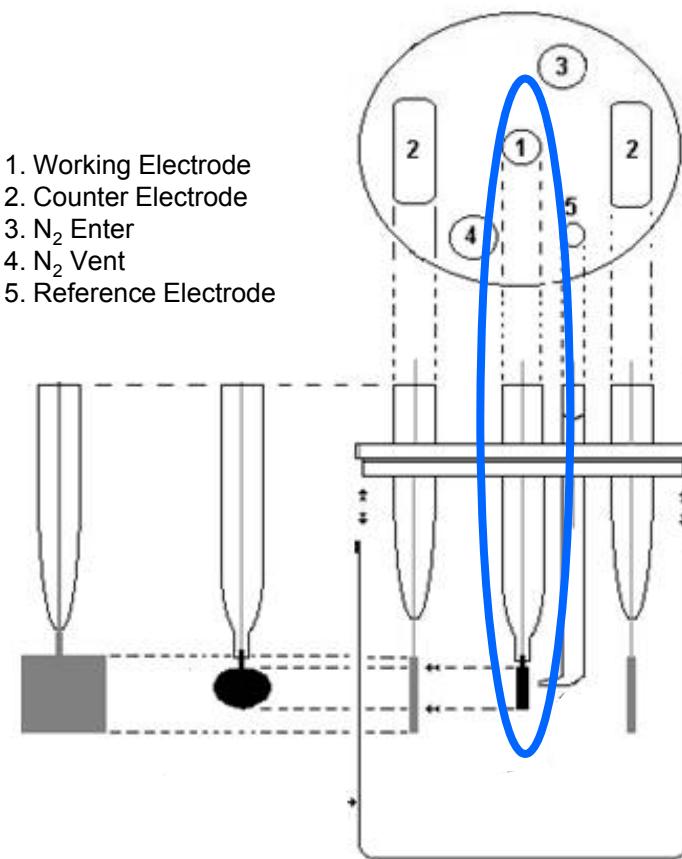
✓ Electrochemical system.



DSA®

Ti/ Ru_{0,3}Ti_{0,7}O₂

1. Working Electrode
2. Counter Electrode
3. N₂ Enter
4. N₂ Vent
5. Reference Electrode



Cell and Equipment

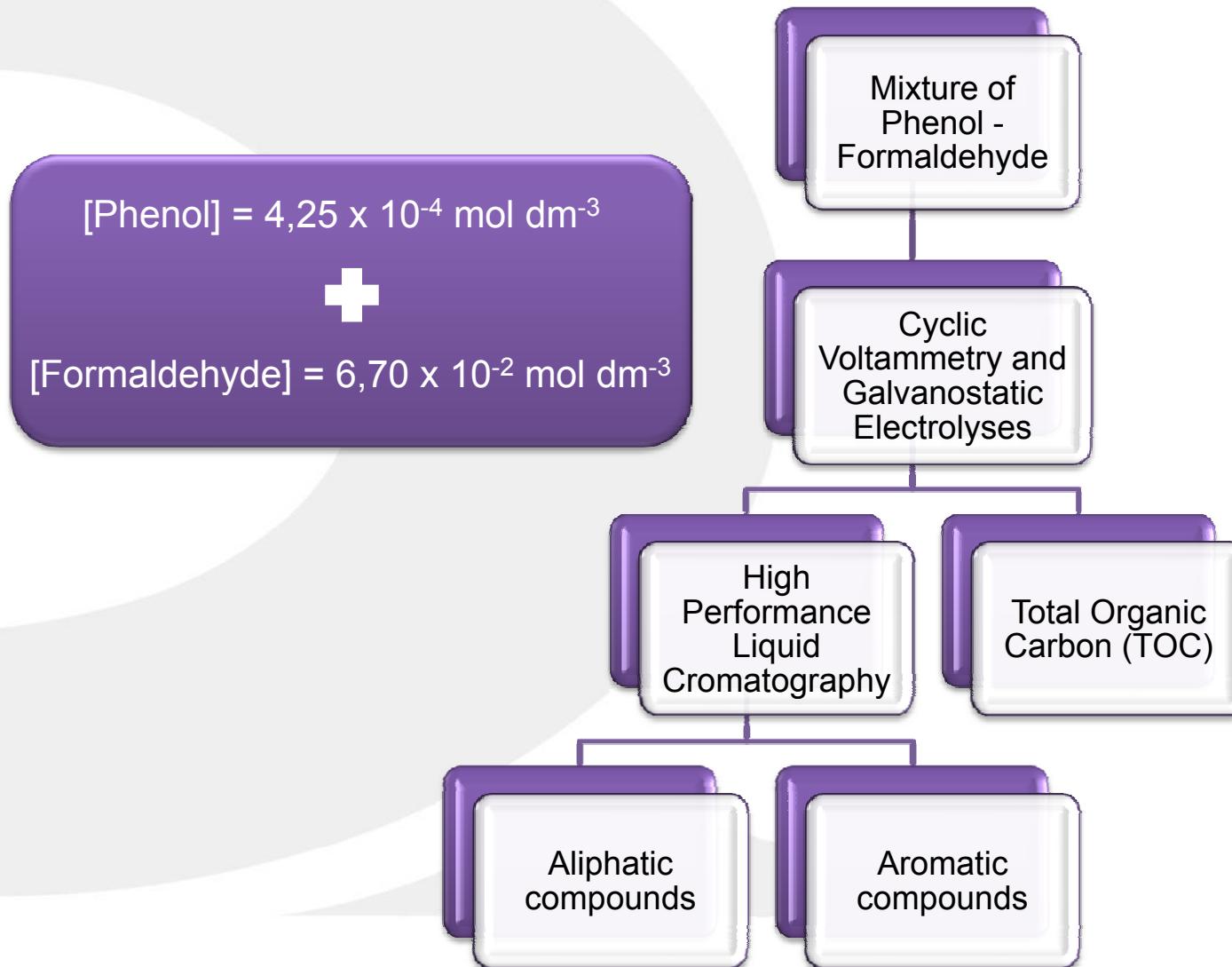
- ✓ Electrochemical cell used in the oxidation/degradation



Potentiostat / galvanostat –
Autolab, model SPGSTAT30



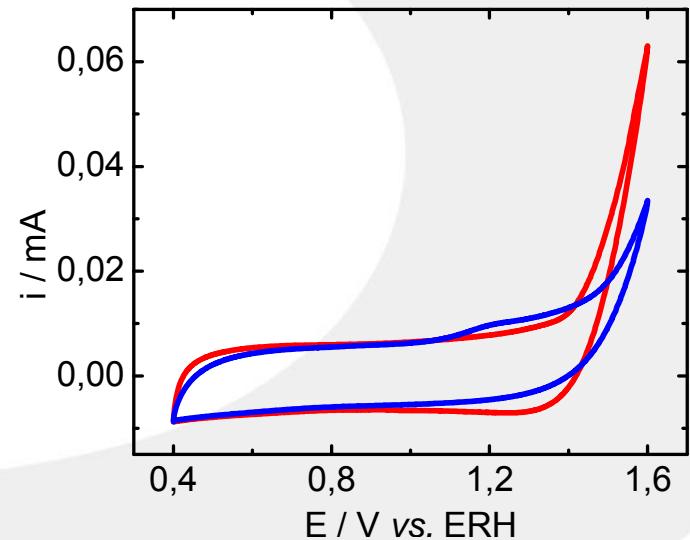
Experimental



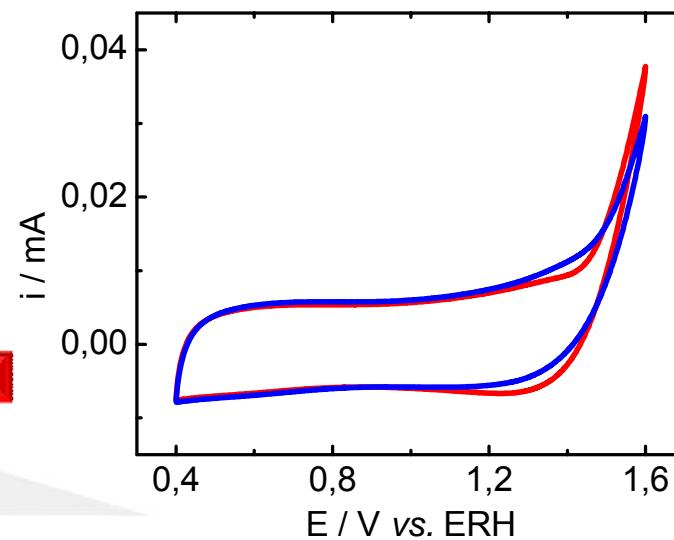
Characterization of DSA®

(—) without the presence of organic;

(—) in the presence of organic.



Phenol



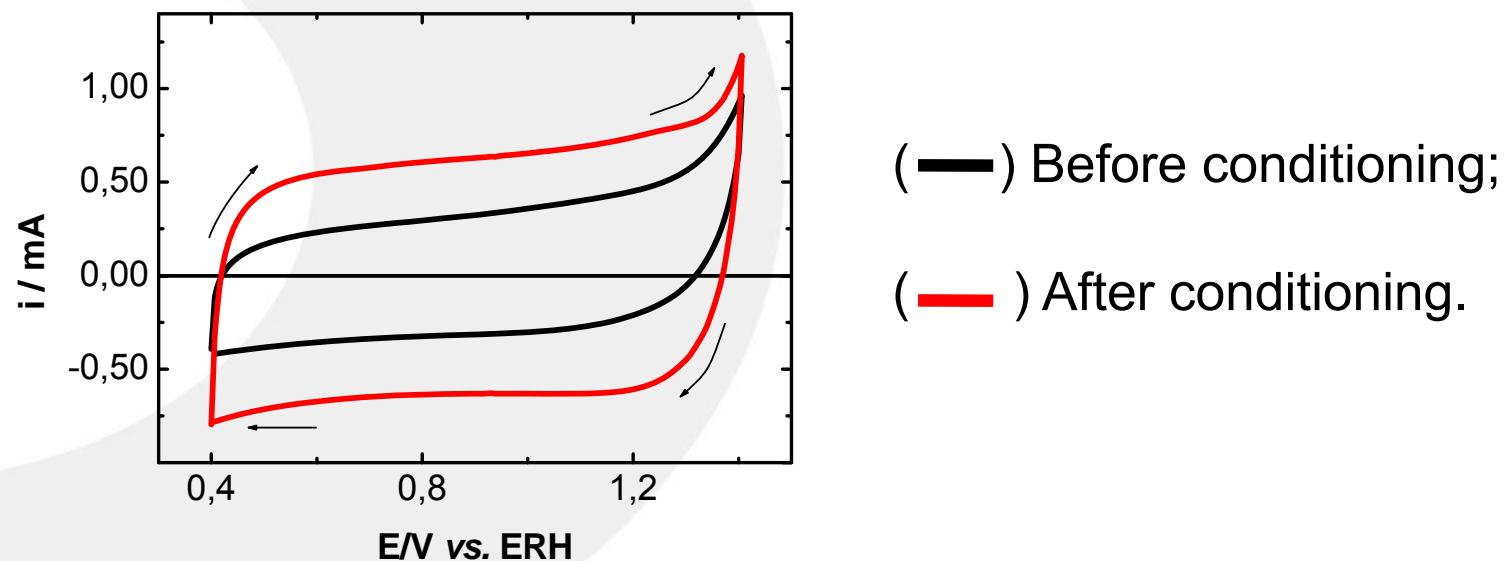
Formaldehyde

$v = 50 \text{ mV s}^{-1}$

Characterization of DSA[®]



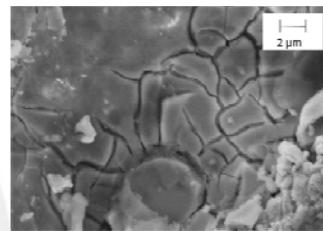
Mixture of phenol and formaldehyde.



$$v = 50 \text{ mV s}^{-1}$$

Characterization of DSA[®]

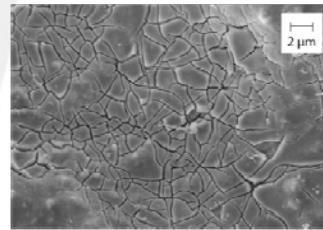
New electrode



EDX

Ru - 25%
Ti - 75%

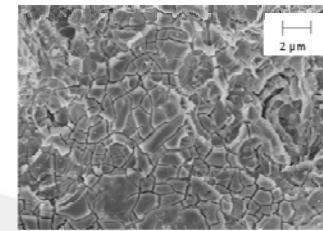
Electrode after conditioning



EDX

Ru - 33%
Ti - 67%

Electrode after electrolyses
(t = 34 h; j_(med) = 40 mA cm⁻²)

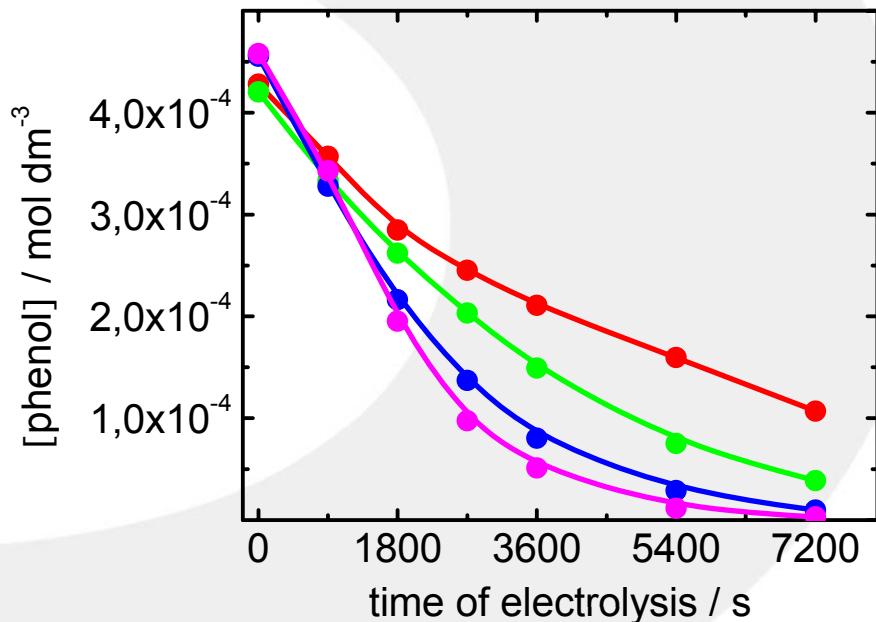


EDX

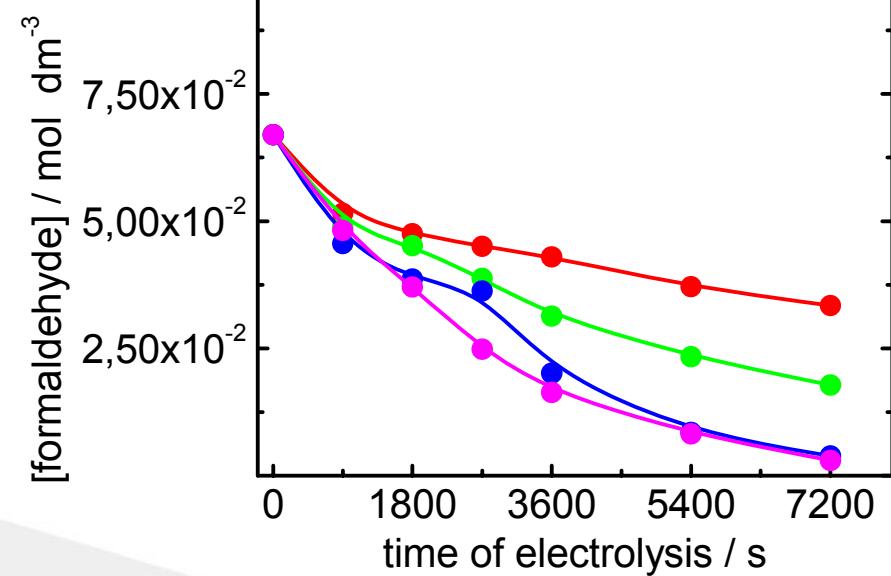
Ru - 24%
Ti - 76%

Effect of Current Density

10 (—), 20 (—), 40 (—) and 50 (—) mA cm⁻²



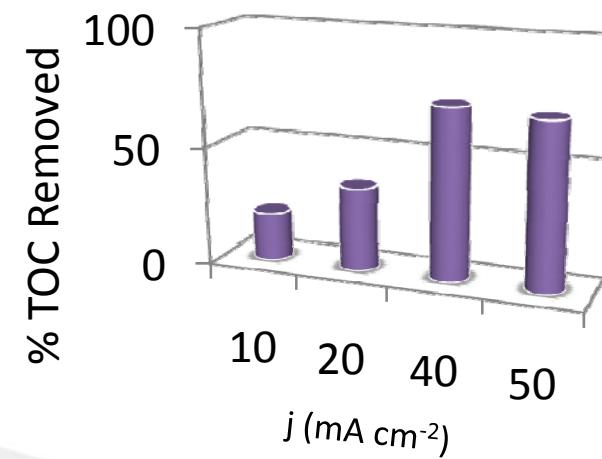
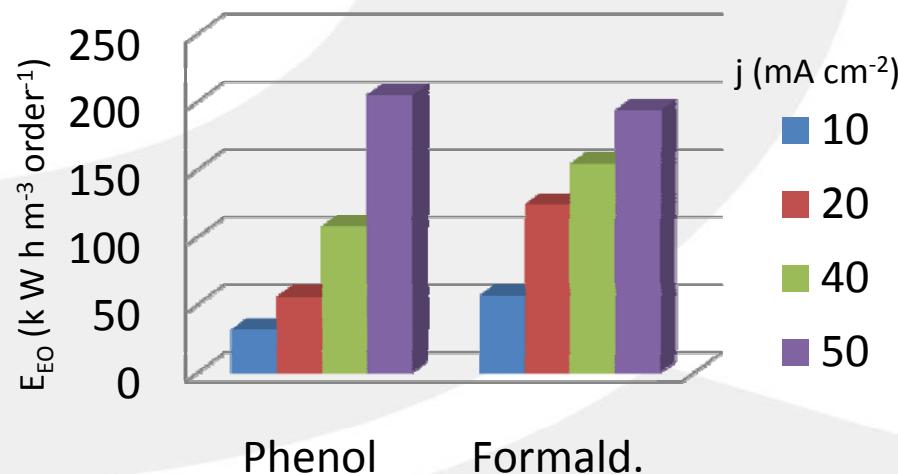
Phenol



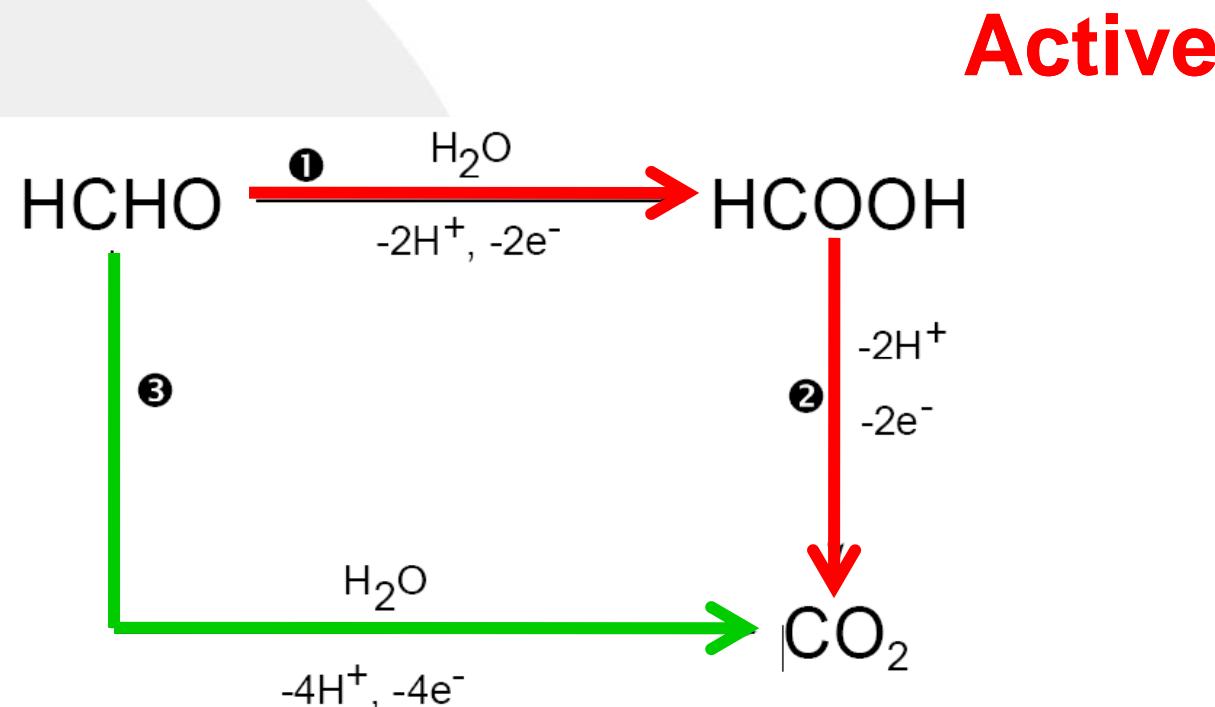
Formaldehyde

Effect of Current Density

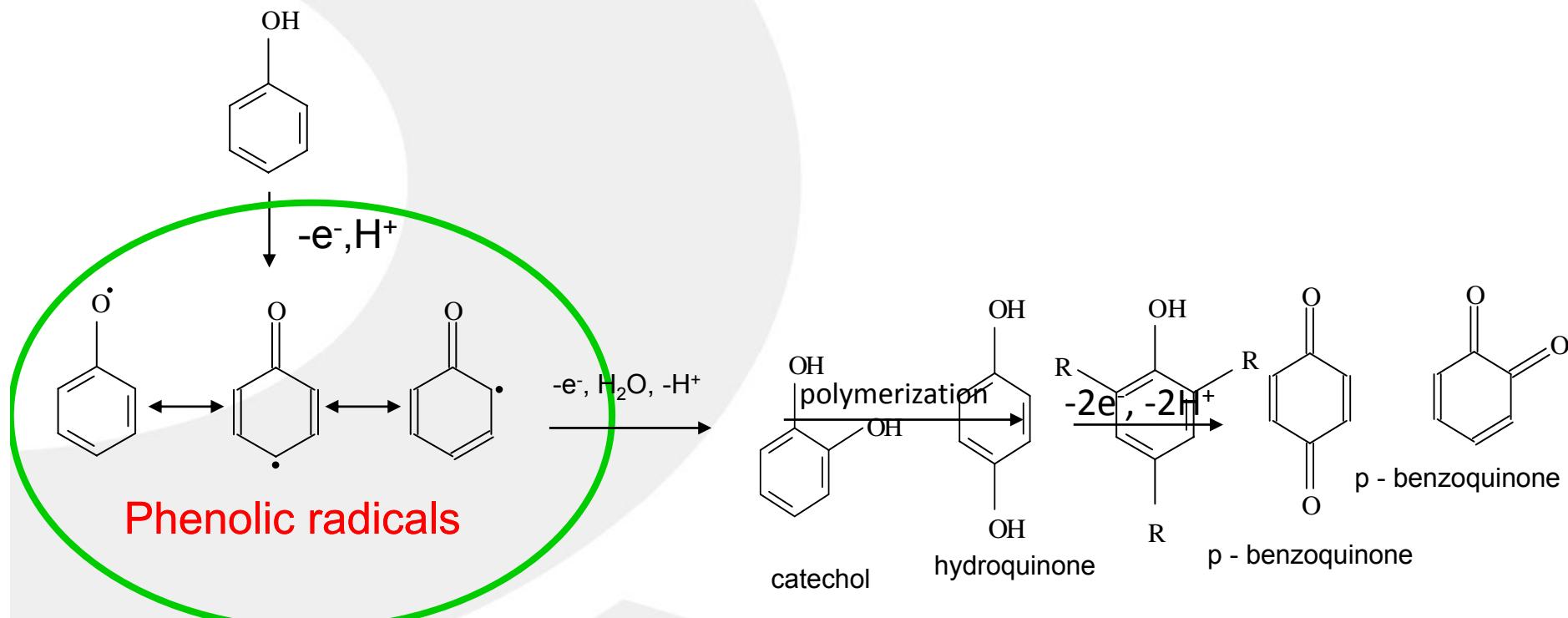
j (mA cm $^{-2}$)	E_{cell} (V)	k phenol (s $^{-1}$)	k formald. (s $^{-1}$)
10	4,62	$1,67 \times 10^{-4}$	$8,90 \times 10^{-5}$
20	7,01	$3,13 \times 10^{-4}$	$8,56 \times 10^{-5}$
40	10,85	$5,50 \times 10^{-4}$	$1,84 \times 10^{-4}$
50	15,56	$6,89 \times 10^{-4}$	$1,65 \times 10^{-4}$



Mechanism of Electrochemical Oxidation of Formaldehyde

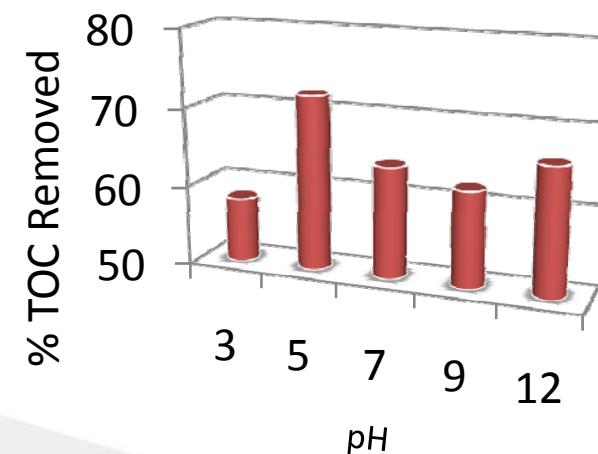
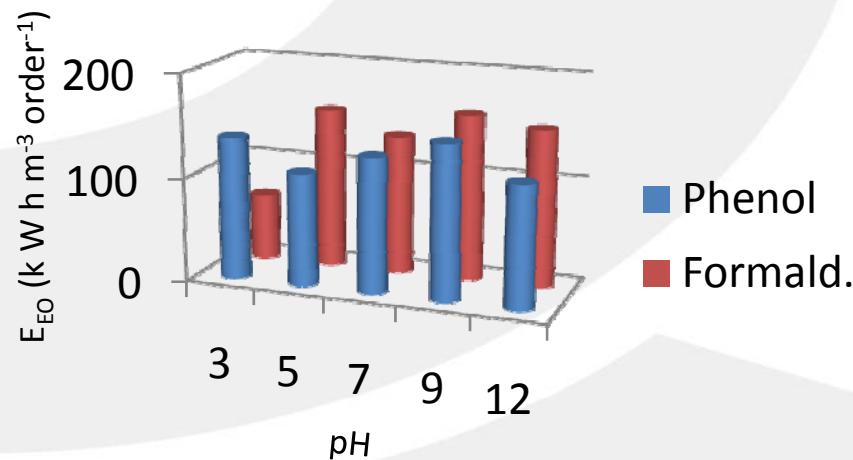


Mechanism of Electrochemical Oxidation of Phenol



Effect of pH (40 mA cm^{-2})

pH	E_{cell} (V)	k phenol (s^{-1})	k formald. (s^{-1})
3	11,15	$4,85 \times 10^{-4}$	$9,30 \times 10^{-5}$
5	10,85	$5,50 \times 10^{-4}$	$1,84 \times 10^{-4}$
7	10,37	$2,72 \times 10^{-4}$	$8,27 \times 10^{-5}$
9	11,40	$3,78 \times 10^{-4}$	$2,63 \times 10^{-4}$
12	12,75	$3,26 \times 10^{-4}$	$9,30 \times 10^{-5}$



Conclusions

- ✓ The present study demonstrates that the electrochemical process can be used to degrade wastewater containing phenol and formaldehyde .

 - Best current density: 40 mA cm^{-2} ;
 - Best pH: 5;
- 
- 72% TOC Removed

Future studies

- Increase scale (volume) of treatment process.



Acknowledgements



INTERNATIONAL WORKSHOP
ADVANCES IN CLEANER PRODUCTION



Conselho Nacional de Desenvolvimento
Científico e Tecnológico



Acknowledgements



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