

Green synthesis polypyrrol-supported metal catalysts: application to nitrate removal in water

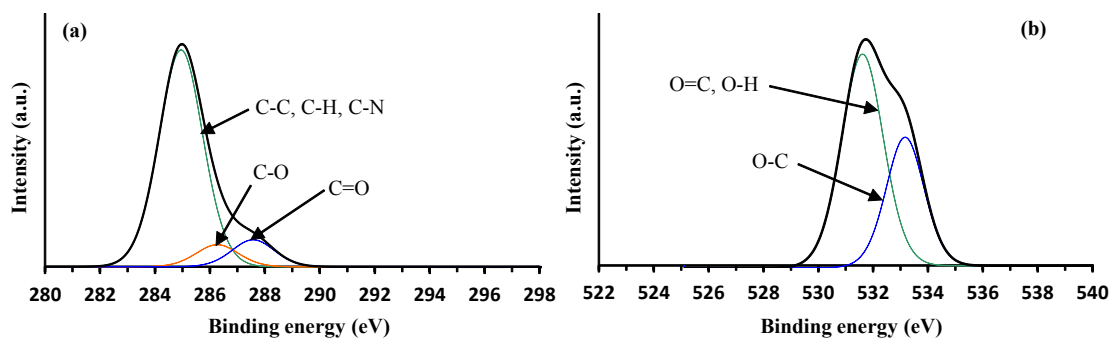
M. Jesús García-Fernández, R. Buitrago-Sierra, M. Mercedes Pastor-Blas,
O.S.G.P. Soares, M.F.R. Pereira and A. Sepúlveda-Escribano

Supplementary information

Supplementary information Table 1. XPS surface chemical composition (at.%) of the different samples^[a].

<i>Binding energy (eV)</i>	284.5	531.5	398.1	198.5	71.2	487.6	710.9
<i>Element</i>	C 1s	O 1s	N 1s	Cl 2p	Pt 4f	Sn 3d	Fe 2p
PPy-2%Pt-(Pt:Sn)(1:1)	74.21	13.97	4.47	3.76	1.07	2.52	0
PPy-2%Pt-(Pt:Sn)(1:1)-P	65.15	19.12	6.05	4.32	2.07	3.29	0
PPy-2%Pt-(Pt:Sn)(1:1)-P-R	69.24	20.68	6.26	0.49	0.68	2.65	0
PPy-2%Pt-(Pt:Sn)(3:1)	71.67	4.44	12.13	11.32	0.23	0.21	0
PPy-2%Pt-(Pt:Sn)(3:1)-P	68.65	15.40	6.71	3.27	4.21	1.76	0
PPy-2%Pt-(Pt:Sn)(3:1)-P-R	72.42	16.16	7.88	0.61	1.37	1.56	0
PPy-2%Pt	84.15	5.68	4.98	3.53	1.66	-	0
PPy-2%Pt-P	70.36	14.88	8.02	2.96	3.73	-	0.05
PPy-2%Pt-P-R	78.26	12.35	7.75	0.64	1.00	-	0
PPy	77.95	6.52	13.16	2.37	-	-	0
PPy-R	77.52	10.26	11.48	0.37	-	-	0
PPy-Plasma	71.77	14.16	12.37	1.70	-	-	0
PPy-Plasma-R	73.65	13.71	12.18	0.47	-	-	0

[a] P = plasma; R = recovered catalyst after 300 min of nitrate reduction with hydrogen.



Supplementary information Fig. 1. XPS (a) C 1s and (b) O 1s spectra of as-synthesized polypyrrole.

Supplementary information Table 2. Atomic percentages of the different surface species estimated from the areas of the contributions to the XPS spectra corresponding to the C 1s level^[a].

<i>Element</i>	<i>C 1s</i>				
<i>Sample</i>	<i>Binding energy (eV)</i>	<i>Species</i>	<i>Composition (at. %)</i>		
			<i>No Plasma</i>	<i>Plasma</i>	<i>Plasma-R</i>
PPy-2%Pt-(Pt:Sn)(1:1)	284.9	C - C, C - H, C - N	63.94	50.61	56.92
	286.6	C - O	6.90	8.04	5.42
	288.4	C = O	3.37	6.50	6.90
PPy-2%Pt-(Pt:Sn)(3:1)	285.1	C - C, C - H, C - N	63.73	51.48	61.37
	287.2	C - O	5.76	10.11	6.32
	289.1	C = O	2.18	7.06	4.73
PPy-2%Pt	285.1	C - C, C - H, C - N	73.01	52.87	65.64
	286.7	C - O	6.96	10.18	9.05
	288.3	C = O	4.18	7.31	3.57
PPy	285.0	C - C, C - H, C - N	63.85	57.71	59.70
	286.3	C - O	6.34	5.26	7.31
	287.6	C = O	7.76	8.80	6.64

[a] R = recovered catalyst after 300 min of nitrate reduction with hydrogen.

Supplementary information Table 3. Atomic percentages of the different surface species estimated from the areas of the contributions to the XPS spectra corresponding to the O 1s level^[a].

<i>Element</i>	<i>O 1s</i>				
<i>Sample</i>	<i>Binding energy (eV)</i>	<i>Species</i>	<i>Composition (at. %)</i>		
			<i>No Plasma</i>	<i>Plasma</i>	<i>Plasma-R</i>
PPy-2%Pt-(Pt:Sn)(1:1)	531.7	O = C, O - H	8.37	10.69	13.30
	533.1	O - C	5.60	8.43	7.38
PPy-2%Pt-(Pt:Sn)(3:1)	531.8	O = C, O - H	2.43	9.04	9.40
	533.1	O - C	2.01	6.36	6.76
PPy-2%Pt	532.0	O = C, O - H	3.44	8.90	8.62
	533.6	O - C	2.24	5.98	3.73
PPy	531.6	O = C, O - H	4.20	9.94	9.90
	533.2	O - C	2.32	4.22	3.81

[a] R = recovered catalyst after 300 min of nitrate reduction with hydrogen.

Supplementary information Table 4. Atomic percentages of the different surface species estimated from the areas of the contributions to the XPS spectra corresponding to the N 1s level^[a].

<i>Element</i>	<i>N 1s</i>				
<i>Sample</i>	<i>Binding energy (eV)</i>	<i>Species</i>	<i>Composition (at. %)</i>		
			<i>No Plasma</i>	<i>Plasma</i>	<i>Plasma-R</i>
PPy-2%Pt-(Pt:Sn)(1:1)	400.1	-NH-	3.84	4.51	1.95
	401.8	N ⁺	0.63	1.54	4.31
PPy-2%Pt-(Pt:Sn)(3:1)	400.2	-NH-	5.03	5.68	1.86
	401.9	N ⁺	7.10	1.03	6.02
PPy-2%Pt	399.3	=N-	1.35	1.75	2.25
	400.4	-NH-	3.63	6.27	5.50
PPy	399.7	=N-	4.65	0	3.11
	400.3	-NH-	8.51	11.24	9.07
	401.5	N ⁺	0	1.13	0

[a] R = recovered catalysts after 300 min of nitrate reduction with hydrogen.

Supplementary information Table 5. Atomic percentages of the different surface species estimated from the areas of the contributions to the XPS spectra corresponding to the Pt 4f level^[a].

<i>Element</i>	<i>Pt 4f</i>	
<i>Sample</i>	<i>Species</i>	<i>Composition (at. %)</i>
PPy-2%Pt-(Pt:Sn)(1:1)	Pt ²⁺	0.09
	Pt ⁴⁺	0.98
PPy-2%Pt-(Pt:Sn)(1:1)-Plasma	Pt ⁰	0.85
	Pt ²⁺	1.22
PPy-2%Pt-(Pt:Sn)(1:1)-Plasma-R	Pt ⁰	0.22
	Pt ²⁺	0.46
PPy-2%Pt-(Pt:Sn)(3:1)	Pt ²⁺	0.13
	Pt ⁴⁺	0.10
PPy-2%Pt-(Pt:Sn)(3:1)-Plasma	Pt ⁰	3.11
	Pt ²⁺	1.11
PPy-2%Pt-(Pt:Sn)(3:1)-Plasma-R	Pt ⁰	0.82
	Pt ²⁺	0.55
PPy-2%Pt	Pt ²⁺	1.50
	Pt ⁴⁺	0.15
PPy-2%Pt-Plasma	Pt ⁰	2.28
	Pt ²⁺	1.45
PPy-2%Pt-Plasma-R	Pt ²⁺	0.43
	Pt ⁴⁺	0.57

[a] R = recovered catalysts after 300 min of nitrate reduction with hydrogen.