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The binding of phosphonic acids at aluminium oxide surfaces and correlation with passivation of aluminium flake

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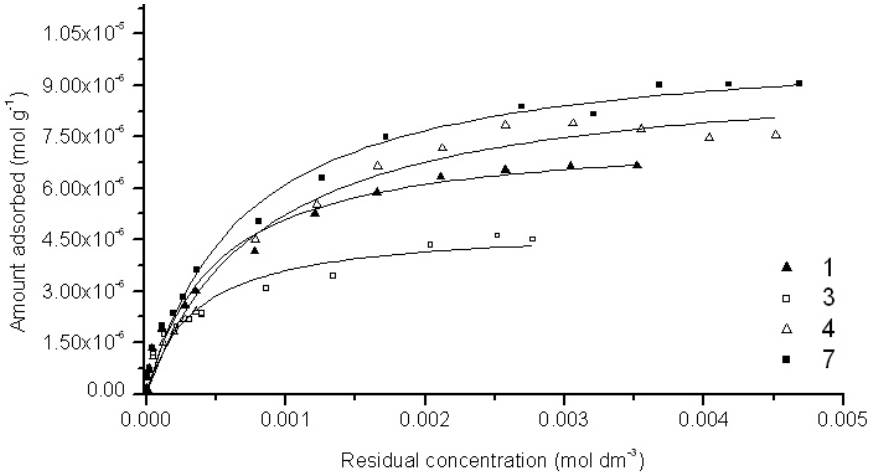
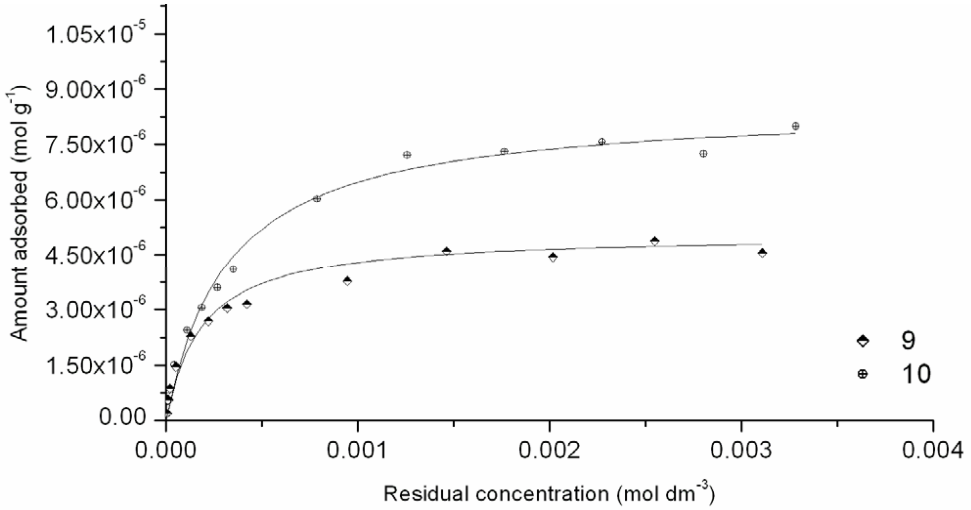
*Data for Figure 3 – isotherms of **1**, **3**, **4** and **7** (pH 8.5, 25 °C)*



Compound **1**		Compound **3**		Compound **4**		Compound **7**	
Residual concentration (mol dm^{-3})	**Amount adsorbed (mol g^{-1})**	**Residual concentration (mol dm^{-3})**	**Amount adsorbed (mol g^{-1})**	**Residual concentration (mol dm^{-3})**	**Amount adsorbed (mol g^{-1})**	**Residual concentration (mol dm^{-3})**	**Amount adsorbed (mol g^{-1})**
3.03E-06	1.61E-07	3.03E-06	1.78E-07	4.32E-06	1.43E-07	3.03E-06	1.74E-07
9.16E-06	4.76E-07	1.14E-05	4.78E-07	1.05E-05	4.92E-07	9.36E-06	5.19E-07
1.86E-05	7.12E-07	2.32E-05	6.98E-07	1.99E-05	7.47E-07	1.90E-05	7.78E-07
4.09E-05	1.34E-06	5.06E-05	1.18E-06	4.66E-05	1.08E-06	4.19E-05	1.33E-06
1.12E-04	1.91E-06	1.26E-04	1.75E-06	1.21E-04	1.49E-06	1.11E-04	1.99E-06
2.74E-04	2.60E-06	2.16E-04	1.97E-06	1.98E-04	1.81E-06	1.91E-04	2.36E-06
3.52E-04	3.01E-06	3.07E-04	2.17E-06	2.74E-04	2.17E-06	2.67E-04	2.82E-06
7.77E-04	4.16E-06	4.00E-04	2.30E-06	3.55E-04	2.42E-06	3.58E-04	3.62E-06
1.21E-03	5.27E-06	3.97E-04	2.35E-06	7.83E-04	4.51E-06	8.06E-04	5.04E-06
1.66E-03	5.88E-06	8.60E-04	3.08E-06	1.22E-03	5.52E-06	1.26E-03	6.30E-06
2.11E-03	6.34E-06	1.34E-03	3.44E-06	1.66E-03	6.64E-06	1.72E-03	7.49E-06
2.58E-03	6.54E-06	2.04E-03	4.36E-06	2.12E-03	7.17E-06	2.69E-03	8.38E-06
3.05E-03	6.64E-06	2.52E-03	4.61E-06	2.58E-03	7.83E-06	3.21E-03	8.16E-06
3.52E-03	6.66E-06	2.77E-03	4.51E-06	3.06E-03	7.89E-06	3.68E-03	9.01E-06
-	-	-	-	3.55E-03	7.72E-06	4.18E-03	9.03E-06

-	-	-	-	4.04E-03	7.49E-06	4.68E-03	9.05E-06
-	-	-	-	4.52E-03	7.54E-06	-	-

*Data for Figure 4 – isotherms of **9** and **10** (pH 8.5, 25 °C)*



Compound **9**		Compound **10**	
Residual concentration (mol dm^{-3})	**Amount adsorbed (mol g^{-1})**	**Residual concentration (mol dm^{-3})**	**Amount adsorbed (mol g^{-1})**
3.19E-06	1.92E-07	3.45E-06	1.70E-07
9.84E-06	5.66E-07	1.00E-05	5.23E-07
1.98E-05	8.72E-07	1.86E-05	8.13E-07
5.08E-05	1.46E-06	4.25E-05	1.50E-06
1.28E-04	2.28E-06	1.08E-04	2.44E-06
2.20E-04	2.69E-06	1.86E-04	3.05E-06
3.17E-04	3.04E-06	2.67E-04	3.60E-06
4.21E-04	3.14E-06	3.51E-04	4.10E-06
9.44E-04	3.78E-06	7.88E-04	6.02E-06
1.46E-03	4.60E-06	1.26E-03	7.21E-06
2.02E-03	4.44E-06	1.77E-03	7.31E-06
2.55E-03	4.88E-06	2.27E-03	7.56E-06

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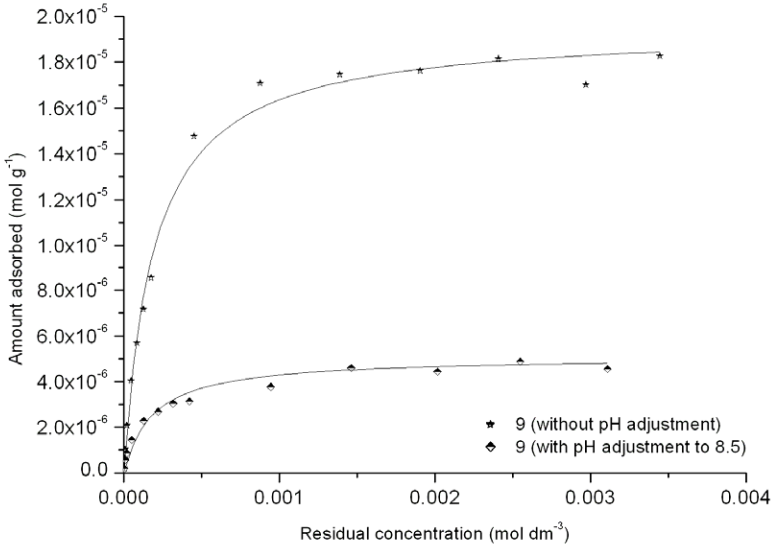
3.11E-03	4.56E-06	2.80E-03	7.25E-06
-	-	3.28E-03	7.99E-06

*Data for Figure 5 – isotherms of **9** (with and without pH adjustment), pH 8.5 and pH 3.0, 25 °C*



Compound **9**		Compound **9** (without pH adjustment)	
Residual concentration (mol dm^{-3})	**Amount adsorbed (mol g^{-1})**	**Residual concentration (mol dm^{-3})**	**Amount adsorbed (mol g^{-1})**
3.19E-06	1.92E-07	2.16E-06	2.06E-07
9.84E-06	5.66E-07	6.13E-06	6.27E-07
1.98E-05	8.72E-07	1.01E-05	1.04E-06
5.08E-05	1.46E-06	2.04E-05	2.08E-06
1.28E-04	2.28E-06	4.63E-05	4.04E-06
2.20E-04	2.69E-06	8.43E-05	5.69E-06
3.17E-04	3.04E-06	1.26E-04	7.17E-06
4.21E-04	3.14E-06	1.75E-04	8.56E-06
9.44E-04	3.78E-06	4.51E-04	1.48E-05
1.46E-03	4.60E-06	8.76E-04	1.71E-05
2.02E-03	4.44E-06	1.39E-03	1.75E-05
2.55E-03	4.88E-06	1.90E-03	1.76E-05
3.11E-03	4.56E-06	2.41E-03	1.82E-05
-	-	2.97E-03	1.70E-05
-	-	3.45E-03	1.83E-05

Calculations and discussion associated with Figure 5 and Table 4

If ligands are close packed on the surface, the theoretical area of each molecule can be estimated by assuming initially that the nuclei of the oxygen atoms of the head group (PO_3^{2-} or PO_3H^-) lie on the circumference of a circle radius, r. Allowance will then need to be made for the van der Waals radii of the deprotonated oxygen atoms or likely contact radius for oxygen atoms forming H-bonds (Figure A).

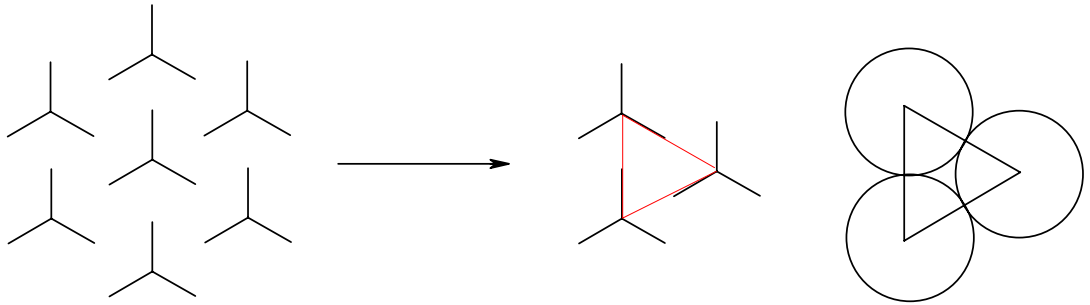


Figure A Schematic representation of the arrangement of hexagonal close packed PO_3^{2-} or PO_3H^- units. In practice the radius of the packed disc will depend on the van der Waals radii of anionic and protonated O-atoms.

The radius of this disc (r in ***a***, Figure B) can be calculated using trigonometry. The length of a P-O bond can be taken to be 1.57 Å.[1, 2] Using the *sine* rule, the O·····O distance (see ***b*** in Figure B) is 2(1.57 sin109.5°/2) = 2.56 Å.

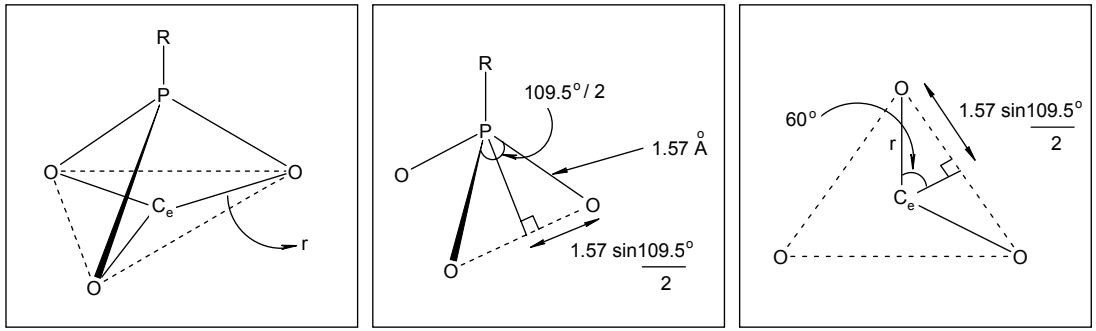


Figure B Using trigonometry to calculate the radius of a *disc* (C_e is the centroid).

The radius defined by the nuclei of the oxygen atoms (***c*** in Figure B) is (2.56/2)/sin60° = 1.48 Å. The diameter of the PO_3^{2-} disc is defined as twice the distance from the centroid (C_e) to the nucleus of an O atom, *plus* the van der Waals radius of oxygen, 1.40 Å,[3] see Figure C, i.e. $2(r + r_{vdw}) = 2(1.48 + 1.40) = 5.76$ Å.

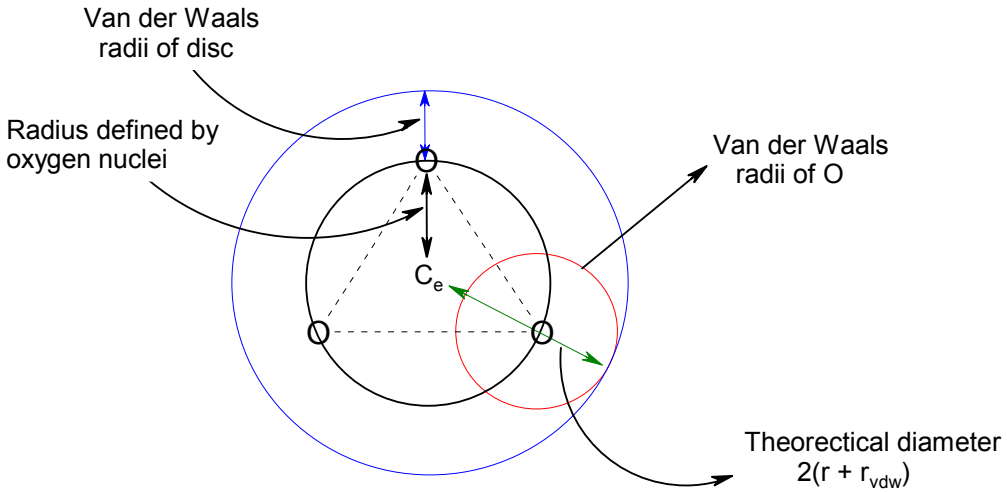


Figure C Schematic representation of the radius of a PO_3^{2-} disc.

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For primitive packing of PO_3^{2-} as in Figure D, the area of the surface required per molecule is equal to the diameter of the disc squared, because each square shown contains four quarters of a molecule. Hence the area required per molecule is $5.76^2 = 33.2$ Å^2.

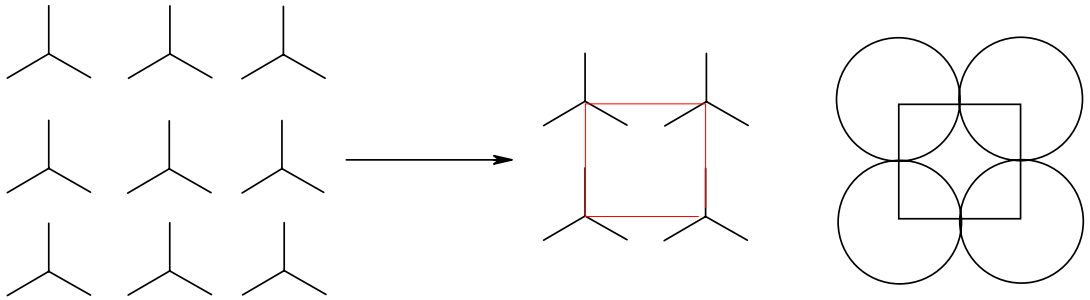

Figure D Schematic illustration of the arrangement of primitive close packing.

For hexagonal close-packing (Figure A), the surface area required per molecule is equal to twice the area of the equilateral triangle shown [(½ x base) x height], because each triangle contains 3 x 1/6 of a molecule. Hence the surface area required per molecule is $2[(½ \times 5.76) \times (5.76 \sin 60°)] = 28.7$ Å^2.

These theoretical areas can be compared with those determined experimentally by adsorption isotherms. The specific surface area for the ATH was determined by BET methods[4] to be 6.0 m^2 g^{-1}. If the isotherm for **9** (without pH adjustment prior to analysis, *ca.* pH 3.0) is fitted by the Langmuir equation, the uptake is 20.0 (± 0.4) x 10^{-6} mol g^{-1}.

As one gram of ATH has a surface area of 6.0 m^2 the saturation surface coverage = 20.0 (± 0.4) x 10^{-6} / 6.0 = 3.33 (± 0.07) x 10^{-6} g m^2. Multiplication by Avogadro's number gives 3.33 (± 0.07) x (6.02 x 10^{17}) = 20.1 (± 0.4) x 10^{17} molecules m^{-2} or 20.1 (± 0.4) x 10^{17} / 10^{20} = 20.1 (± 0.4) x 10^{-3} molecules Å^{-2}. Thus the area occupied by a single molecule = 1 / 20.1 (± 0.4) x 10^{-3} = 48 (± 5) Å^2.

For the isotherm determined with solutions made up to pH 8.5, the observed surface coverage is significantly smaller, 5.1 (± 0.3) x 10^{-6} mol g^{-1} (Table 3), and consequently the apparent area per adsorbed molecule is larger, 195 (± 9) Å^2.

For 'primitive packing', the surface occupancy is defined by the area of the square shown in Figure D, the sides of which are 2 x radius of the touching discs. Consequently, the diameter of the discs is √48 (± 5) = 6.9 (± 0.4) Å for uptake at pH 3.0 and 14.0 (± 0.4) Å at pH 8.5. For hexagonal close packing of the disc-shaped head groups (see Figure A), on average a molecule requires twice the area of the triangle shown.

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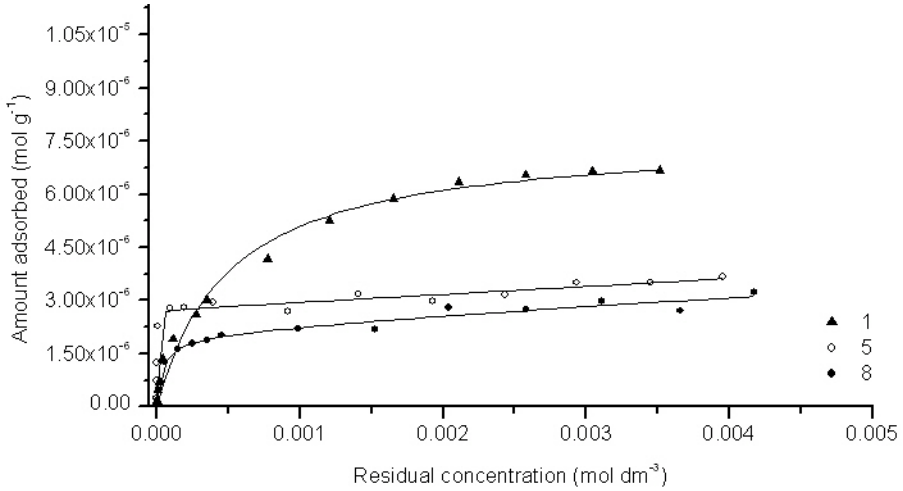
Thus, for saturation at pH 3.0 the area of the triangle = 48 (± 5) / 2 = 24 (± 2.5) Å^2. As the area of the triangle = ½ x base x height = ½ x 2r x 2r sin60° = 1.73 r^2, r = √[24 (± 2.5)/1.73] = 2.83 (± 0.2) and the diameter = 7.4 (± 0.4) Å. For the uptake at pH 8.5 the diameter of the disc representing the head group is 15.0 (± 0.4) Å.

*Data for Figure 6 – isotherms of **1**, **5** and **8** (pH 8.5, 25 °C)*



Compound **1**		Compound **5**		Compound **8**	
Residual concentration	**Amount adsorbed**	**Residual concentration**	**Amount adsorbed**	**Residual concentration**	**Amount adsorbed**

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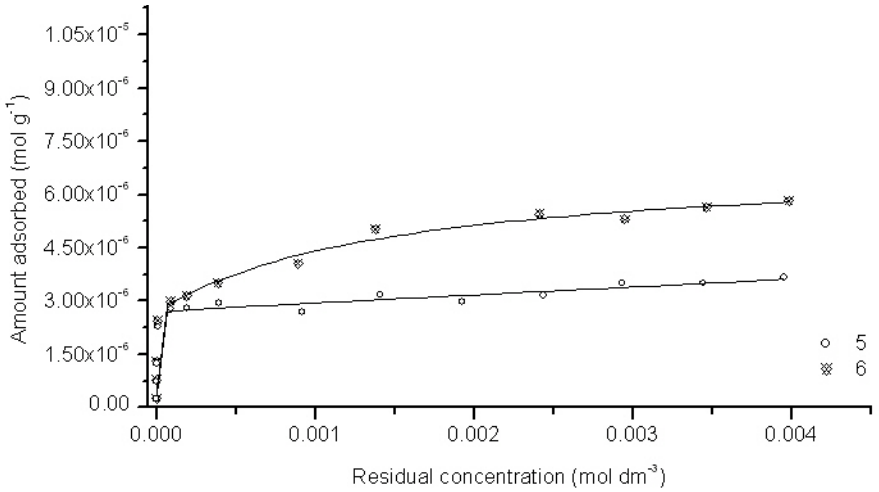
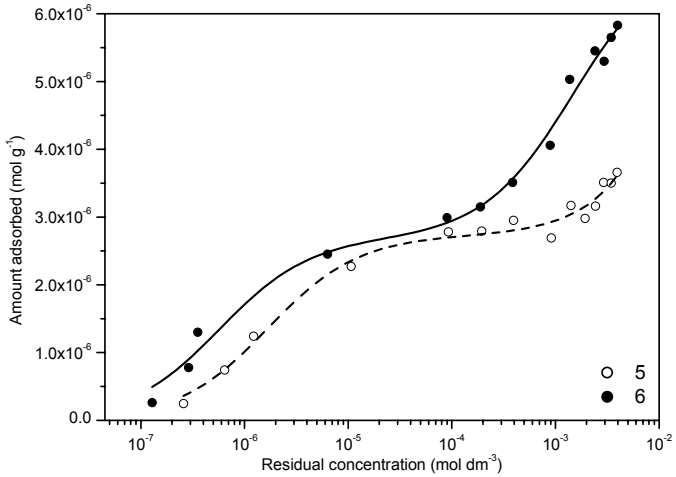
(mol dm^{-3})	(mol g^{-1})	(mol dm^{-3})	(mol g^{-1})	(mol dm^{-3})	(mol g^{-1})
3.03E-06	1.61E-07	2.58E-07	2.46E-07	4.10E-06	1.63E-07
9.16E-06	4.76E-07	6.45E-07	7.42E-07	1.27E-05	4.85E-07
1.86E-05	7.12E-07	1.23E-06	1.24E-06	2.55E-05	6.98E-07
4.09E-05	1.34E-06	1.07E-05	2.27E-06	5.67E-05	1.25E-06
1.12E-04	1.91E-06	9.31E-05	2.78E-06	1.50E-04	1.63E-06
2.74E-04	2.60E-06	1.94E-04	2.79E-06	2.51E-04	1.80E-06
3.52E-04	3.01E-06	3.94E-04	2.95E-06	3.54E-04	1.88E-06
7.77E-04	4.16E-06	9.17E-04	2.69E-06	4.56E-04	2.02E-06
1.21E-03	5.27E-06	1.41E-03	3.17E-06	9.87E-04	2.19E-06
1.66E-03	5.88E-06	1.93E-03	2.98E-06	1.52E-03	2.17E-06
2.11E-03	6.34E-06	2.44E-03	3.16E-06	2.04E-03	2.80E-06
2.58E-03	6.54E-06	2.93E-03	3.51E-06	2.58E-03	2.74E-06
3.05E-03	6.64E-06	3.45E-03	3.50E-06	3.11E-03	2.97E-06
3.52E-03	6.66E-06	3.95E-03	3.66E-06	3.66E-03	2.70E-06
-	-	-	-	4.18E-03	3.24E-06

*Data for Figure 7 – isotherms of **5** and **6** (right graph plotted on a logarithmic scale), pH 8.5, 25 °C*





Compound **5**	Compound **6**

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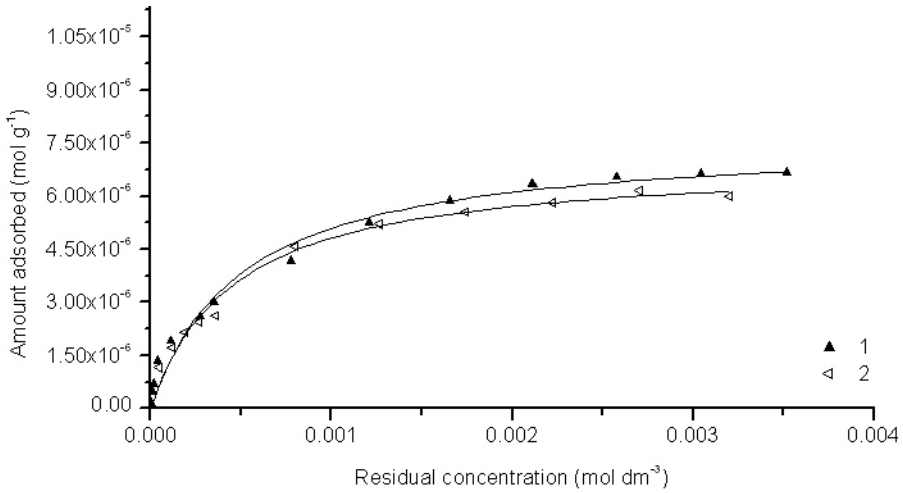
Residual concentration (mol dm^{-3})	**Amount adsorbed (mol g^{-1})**	**Residual concentration (mol dm^{-3})**	**Amount adsorbed (mol g^{-1})**
2.58E-07	2.46E-07	1.29E-07	2.60E-07
6.45E-07	7.42E-07	2.90E-07	7.77E-07
1.23E-06	1.24E-06	3.55E-07	1.30E-06
1.07E-05	2.27E-06	6.36E-06	2.45E-06
9.31E-05	2.78E-06	9.01E-05	2.99E-06
1.94E-04	2.79E-06	1.89E-04	3.15E-06
3.94E-04	2.95E-06	3.86E-04	3.51E-06
9.17E-04	2.69E-06	8.91E-04	4.06E-06
1.41E-03	3.17E-06	1.38E-03	5.03E-06
1.93E-03	2.98E-06	2.41E-03	5.45E-06
2.44E-03	3.16E-06	2.95E-03	5.30E-06
2.93E-03	3.51E-06	3.46E-03	5.65E-06
3.45E-03	3.50E-06	3.98E-03	5.83E-06
3.95E-03	3.66E-06	-	-

*Data for isotherms of compounds **1** and **2** (pH 8.5, 25 °C)*



Compound **1**	Compound **2**

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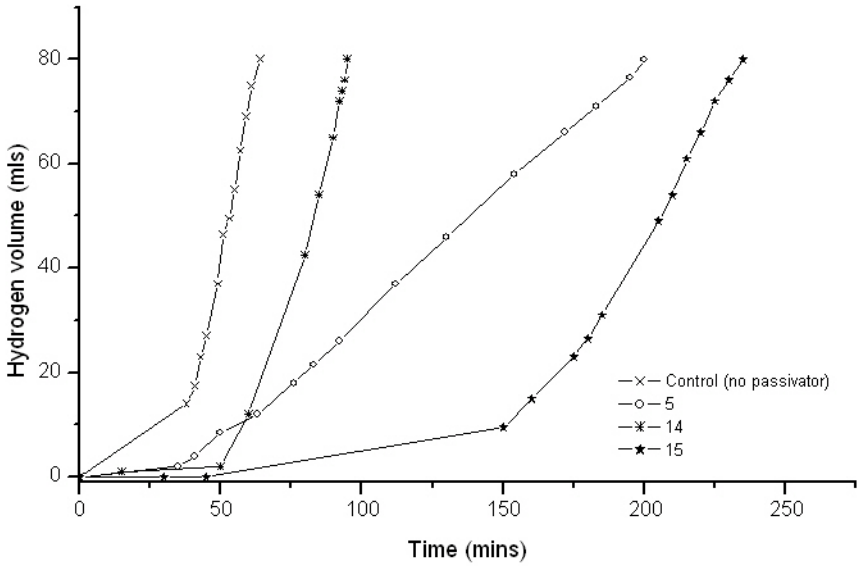
Residual concentration (mol dm^{-3})	Amount adsorbed (mol g^{-1})	Residual concentration (mol dm^{-3})	Amount adsorbed (mol g^{-1})
3.03E-06	1.61E-07	4.57E-05	1.16E-06
9.16E-06	4.76E-07	1.15E-04	1.72E-06
1.86E-05	7.12E-07	1.80E-04	2.14E-06
4.09E-05	1.34E-06	2.70E-04	2.45E-06
1.12E-04	1.91E-06	3.57E-04	2.62E-06
2.74E-04	2.60E-06	7.99E-04	4.57E-06
3.52E-04	3.01E-06	1.27E-03	5.20E-06
7.77E-04	4.16E-06	1.74E-03	5.55E-06
1.21E-03	5.27E-06	2.22E-03	5.82E-06
1.66E-03	5.88E-06	2.70E-03	6.15E-06
2.11E-03	6.34E-06	3.20E-03	5.99E-06
2.58E-03	6.54E-06	-	-
3.05E-03	6.64E-06	-	-
3.52E-03	6.66E-06	-	-

*Data for Figure 8 – hydrogen evolution test results for the control, **5**, **14** and **15** (pH 8, 52 °C)*



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Control (no passivator)		Compound **5**		Compound **14**		Compound **15**	
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
0	0	0	0	0	0	0	0
38	14	35	2	15	1	30	0
41	17.5	41	4	50	2	45	0
43	23	50	8.5	60	12	150	9.5
45	27	63	12	80	42.5	160	15
49	37	76	18	85	54	175	23
51	46.5	83	21.5	90	65	180	26.5
53	49.5	92	26	92	72	185	31
55	55	112	37	93	74	205	49
57	62.5	130	46	94	76	210	54
59	69	154	58	95	80	215	61
61	75	172	66	-	-	220	66
64	80	183	71	-	-	225	72
-	-	195	76.5	-	-	230	76
-	-	200	80	-	-	235	80

*Data for Figure 9 – hydrogen evolution test results for **1**, **2**, **3**, **5** and **8** (pH 8, 52 °C)*

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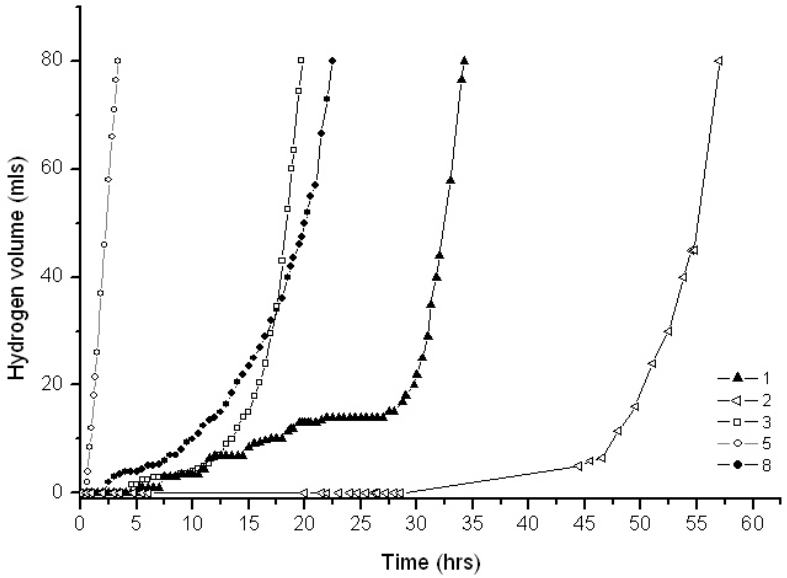

Compound **1**				Compound **2**		Compound **3**		Compound **5**		Compound **8**	
Time (mins)	**H_2 volume (ml)**	**Time (mins)**	**H_2 volume (ml)**	**Time (mins)**	**H_2 volume (ml)**	**Time (mins)**	**H_2 volume (ml)**	**Time (mins)**	**H_2 volume (ml)**	**Time (mins)**	**H_2 volume (ml)**
0	0	22.5	14	0	0	0	0	0	0	0	0
0.5	0	23	14	0.5	0	0.5	0	0.58	2	0.5	0
1	0	23.5	14	1	0	1	0	0.66	4	1	0
1.5	0	24	14	2	0	1.5	0	0.83	8.5	1.5	0
2	0	24.5	14	3	0	2	0	1	12	2	0
2.5	0	25	14	3.5	0	2.5	0	1.2	18	2.5	2
3	0	25.5	14	4.75	0	3	0	1.33	21.5	3	3
3.5	0	26	14	5.5	0	3.5	0	1.5	26	3.5	3.5
4	0	26.5	14	6	0	4	0	1.83	37	4	4
4.5	0	27	14	20	0	4.5	1.5	2.16	46	4.5	4
5	0	27.5	15	21.5	0	5	1.5	2.5	58	5	4
5.25	1	28	15	22	0	5.5	2.5	2.83	66	5.5	4.5
5.5	1	28.75	17	23	0	6	2.5	3	71	6	5
6	1	29	18	24	0	6.5	3	3.2	76.5	6.5	5
6.5	1	29.75	20	24.75	0	7	3	3.35	80	7	5.25
Compound **1**				Compound **2**		Compound **3**		Compound **5**		Compound **8**	

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Time (mins)	H_2 volume (ml)	Time (mins)	H_2 volume (ml)	Time (mins)	H_2 volume (ml)	Time (mins)	H_2 volume (ml)	Time (mins)	H_2 volume (ml)	Time (mins)	H_2 volume (ml)
7	1	30	22	25.5	0	7.5	3	-	-	7.5	6
7.5	3	30.5	25	26.25	0	8	3	-	-	8	7
8	3	31	29	26.5	0	8.5	3	-	-	8.5	7
8.5	3	31.25	35	27.25	0	9	3.5	-	-	9	8
9	3.5	31.75	40	28	0	9.5	3.5	-	-	9.5	9.5
9.5	3.5	32	44	28.5	0	10	4	-	-	10	10
10	3.5	33	58	44.5	5	10.5	4.5	-	-	10.5	11
10.5	3.5	34	76.5	45.5	6	11	5	-	-	11	12.5
11	4.5	34.25	80	46.5	6.5	11.5	5.5	-	-	11.5	13.5
11.5	6.5	-	-	48	11.5	12	6.5	-	-	12	14
12	7	-	-	49.5	16	12.5	7	-	-	12.5	15
12.5	7	-	-	51	24	13	9	-	-	13	16.5
13	7	-	-	52.5	30	13.5	10	-	-	13.5	18.5
13.5	7	-	-	53.75	40	14	12	-	-	14	20.5
14	7	-	-	54.5	45	14.5	14	-	-	14.5	22
14.5	7	-	-	54.75	45	15	15	-	-	15	23.5
15	8.5	-	-	57	80	15.5	18	-	-	15.5	25
15.5	9.25	-	-	-	-	16	20.5	-	-	16	27
16	9.5	-	-	-	-	16.5	24	-	-	16.5	29
16.5	9.75	-	-	-	-	17	29.5	-	-	17	32
17	10	-	-	-	-	17.5	34.5	-	-	17.5	34
17.5	10	-	-	-	-	18	43	-	-	18	36
18	10	-	-	-	-	18.5	52.5	-	-	18.5	40
18.5	11.5	-	-	-	-	18.8	60	-	-	18.8	42
18.8	12	-	-	-	-	19	63.5	-	-	19	43.5
19	12	-	-	-	-	19.5	74.5	-	-	19.5	46
19.5	13	-	-	-	-	19.75	80	-	-	19.75	47.5
19.75	13	-	-	-	-	-	-	-	-	20	50
20	13	-	-	-	-	-	-	-	-	20.25	52
20.25	13	-	-	-	-	-	-	-	-	20.5	55
20.5	13	-	-	-	-	-	-	-	-	21	57
21	13	-	-	-	-	-	-	-	-	21.5	66.5
21.5	13.5	-	-	-	-	-	-	-	-	22	73
22	14	-	-	-	-	-	-	-	-	22.5	80

*Data for Figure 11 – hydrogen evolution test results for **4** and **7** (pH 8, 52 °C)*

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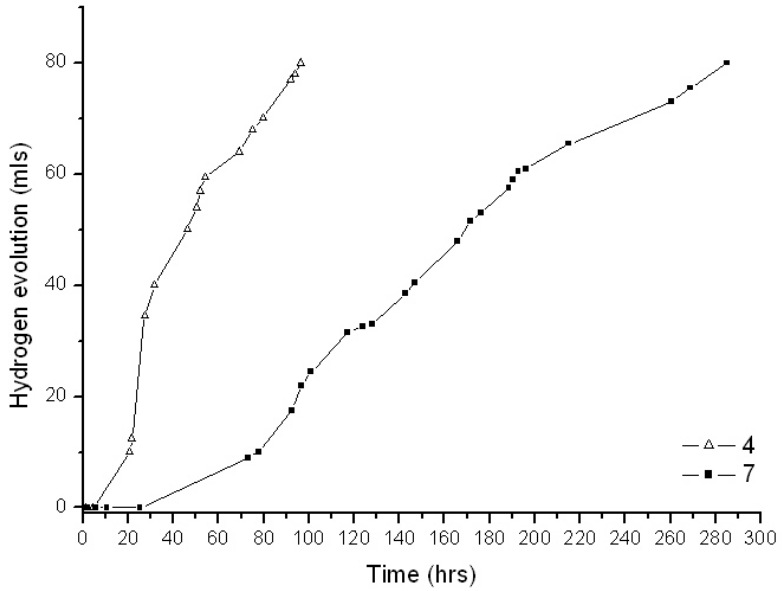
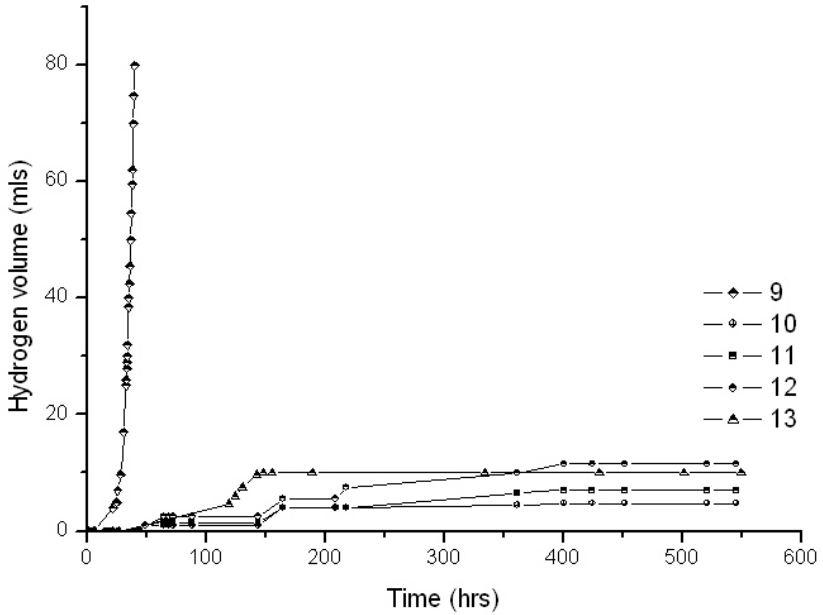


Compound **4**				Compound **7**			
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
0	0	94	78	0	0	142.5	38.5
1.25	0	96.25	80	1	0	147	40.5
4.5	0	-	-	1.5	0	165.75	48
20.75	10	-	-	2	0	171.5	51.5
21.75	12.5	-	-	5.5	0	176	53
27.25	34.5	-	-	10.5	0	188.5	57.5
31.5	40	-	-	25.25	0	190.5	59
46	50	-	-	73	9	192.75	60.5
50.5	54	-	-	77.75	10	196.25	61
52	57	-	-	92.5	17.5	215	65.5
54	59.5	-	-	96.75	22	260.5	73
69.25	64	-	-	101	24.5	268.75	75.5
75	68	-	-	117.25	31.5	285	80
79.5	70	-	-	123.75	32.5	-	-
92	77	-	-	128	33	-	-

*Data for Figure 12 – hydrogen evolution test results for **9**, **10**, **11**, **12** and **13** (pH 8, 52 °C)*



Compound **9**		Compound **10**		Compound **11**		Compound **12**		Compound **13**	
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
0	0	0	0	0	0	0	0	0	0
1	0	0.5	0	0.5	0	0.5	0	1.25	0
6.5	0	1	0	1	0	1	0	2	0
22	4	1.5	0	1.5	0	1.5	0	5.5	0
24	4.75	2	0	2	0	2	0	7	0
25	5	16.75	0	16.75	0	16.75	0	21.5	0
26	7	18.5	0	18.5	0	18.5	0	27.5	0
28.5	9.75	21.5	0	21.5	0	21.5	0	119.5	4.75
31.25	17	27	0	27	0	27	0	125	6
33	25	40.75	0	40.75	0	40.75	0	131	7.5
33.25	26	44.5	0	44.5	0	44.5	0	143	9.75
33.5	28	49.5	1	49.5	1	49.5	1	148.5	10
33.75	29	64.75	1	64.75	1.5	64.75	2.5	156	10

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34	30	69	1	69	1.5	69	2.5	189.5	10
Compound **9**		Compound **10**		Compound **11**		Compound **12**		Compound **13**	
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
34.25	32	72.5	1	72.5	1.5	72.5	2.5	334.5	10
35.25	38.5	88.5	1	88.5	1.5	88.5	2.5	430.5	10
35.5	40	144	1	144	1.5	144	2.5	501.5	10
35.75	42.5	164.75	4	164.75	4	164.75	5.5	549.5	10
36.5	45.5	209	4	209	4	209	5.5	-	-
37	50	217.75	4	217.75	4	217.75	7.5	-	-
37.5	54.5	361.5	4.5	361.5	6.5	361.5	10	-	-
38.25	59.5	400.5	4.75	400.5	7	400.5	11.5	-	-
38.5	62	424.5	4.75	424.5	7	424.5	11.5	-	-
39	70	452	4.75	452	7	452	11.5	-	-
39.5	74.75	521	4.75	521	7	521	11.5	-	-
40	80	545.5	4.75	545.5	7	545.5	11.5	-	-

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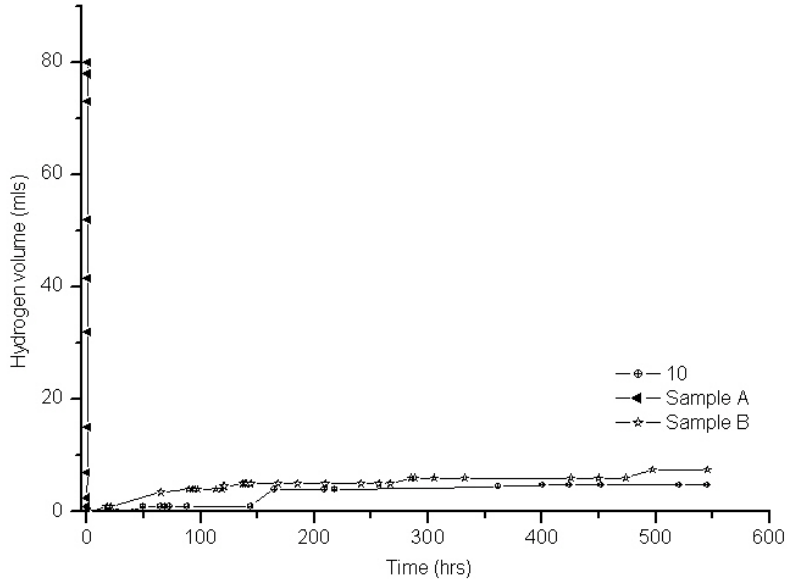
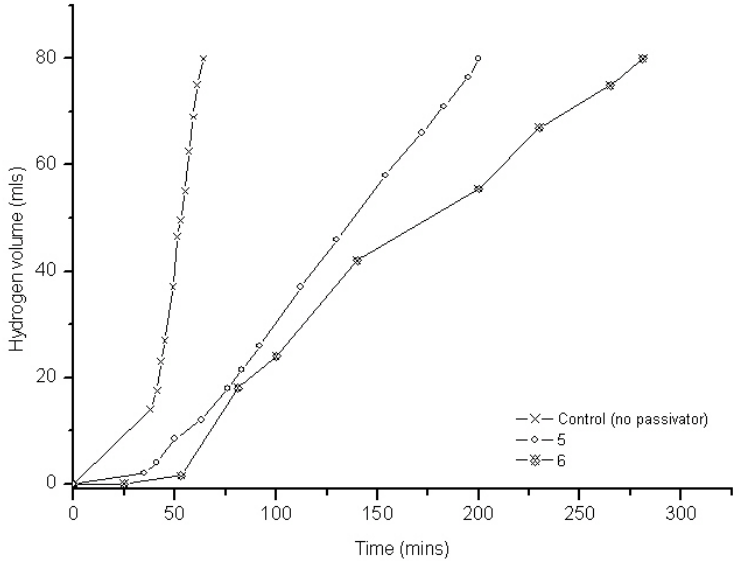
*Data for Figure 13 – hydrogen evolution test results for **10** and commercial samples **A** and **B** (pH 8, 52 °C)*



Compound **10**		Sample **A**		Sample **B**	
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
0	0	0	0	0	0
0.5	0	0.25	0	0.25	0
1	0	0.267	1	1	0
1.5	0	0.33	2.5	1.75	0
2	0	0.42	7	2.25	0
16.75	0	0.5	15	3.25	0
18.5	0	0.633	32	17.5	1
21.5	0	0.667	41.5	18.5	1
27	0	0.75	52	21	1
40.75	0	0.83	73	65.5	3.5
44.5	0	0.85	78	89.5	4
49.5	1	0.858	80	93	4
64.75	1	-	-	94.75	4

69	1	-	-	97.75	4
72.5	1	-	-	113.75	4
Compound **10**		Sample **A**		Sample **B**	
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
88.5	1	-	-	119.25	4
144	1	-	-	120.25	4.5
164.75	4	-	-	120.75	4.5
209	4	-	-	137	5
217.75	4	-	-	139.25	5
361.5	4.5	-	-	140.75	5
400.5	4.75	-	-	144	5
424.5	4.75	-	-	168	5
452	4.75	-	-	185	5
521	4.75	-	-	209.5	5
545.5	4.75	-	-	241	5
-	-	-	-	256.5	5
-	-	-	-	266.5	5
-	-	-	-	285	6
-	-	-	-	288.25	6
-	-	-	-	305	6
-	-	-	-	332	6
-	-	-	-	425.5	6
-	-	-	-	449.5	6
-	-	-	-	473.5	6
-	-	-	-	497.5	7.5
-	-	-	-	545.5	7.5

*Data for hydrogen evolution test of compound **6** (pH 8, 52 ℃)*



Control (no passivator)		Compound **5**		Compound **6**	
Time (mins)	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**	**Time (mins)**	**Hydrogen volume (ml)**
0	0	0	0	0	0
38	14	35	2	25	0
41	17.5	41	4	53	1.5
43	23	50	8.5	81	18
45	27	63	12	100	24
49	37	76	18	140	42
51	46.5	83	21.5	200	55.5
53	49.5	92	26	230	67
55	55	112	37	265	75
57	62.5	130	46	281	80
59	69	154	58	-	-

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61	75	172	66	-	-
64	80	183	71	-	-
		195	76.5	-	-
		200	80	-	-

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