

1 *Article*

2 **The impact of humic acid on metaldehyde adsorption onto**
3 **powdered activated carbon in aqueous solution†**

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7 **Zhuojun Li^a, Yuchen Yang^b, Ulises Jáuregui-Haza^c, Zhengxiao Guo^b, Luiza Cintra**
8 **Campos^{a*}**

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^a Department of Civil, Environmental and Geomatic Engineering, University College London, Gower Street, London WC1E 6BT, UK; Emails: zhuojun.li.09@ucl.ac.uk; l.campos@ucl.ac.uk

^b Department of Chemistry, University College London, Gower Street, London WC1E 6BT, UK; Email: yu.yang.13@ucl.ac.uk; x.guo@ucl.ac.uk

^c Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), Universidad de La Habana, La Habana, CP 10600, Cuba; Email: ulises.jauregui@infomed.sld.cu

* Author to whom correspondence should be addressed; Email: l.campos@ucl.ac.uk (L.C.C.); Tel.: +44-207-679-4162 (L.C.C)

† Electronic supplementary information (ESI) available.

26 **Adsorption experiment:**

27 For single adsorption of metaldehyde, three experiments were done: 1) PAC dosage was varied
28 from 0.005g to 0.5 g using 500 mL of 1 mg L⁻¹ metaldehyde solution without adjusting the pH
29 of the solution for a 2-hour reaction time; 2) sample solutions were taken at different time
30 intervals between 0 minutes and 2 hours using 500 mL of 1 mg L⁻¹ metaldehyde solution and
31 0.05 g PAC without adjusting the pH of the solution; 3) pH of metaldehyde solution was varied
32 from 4 to 12 using 500 mL of metaldehyde solution and 0.05 g PAC for a 2-hour reaction time.

33 For single adsorption of HA, two experiments were done: 1) PAC dosage was varied from 0.05
34 g to 1 g using 500 mL of 30 mg L⁻¹ HA solution without adjusting the pH of the solution for
35 the 2-hour reaction time; 2) the sample solutions were taken at different time intervals between
36 0 minutes and 30 days using 500 mL of 30 mg L⁻¹ HA solution without adjusting the pH of the
37 solution and 0.25 g PAC.

38 For binary adsorption of metaldehyde and HA, two experiments were done: 1) for the 500 mL
39 multi-component solution containing metaldehyde and HA, the concentration of HA in the
40 binary system was varied from 3 mg L⁻¹ to 90 mg L⁻¹ and the concentration of metaldehyde
41 was fixed at 1 mg L⁻¹ without adjusting the pH of the solution using 0.05 g PAC for a 2-hour
42 reaction time; 2) sample solutions were taken at different time intervals between 0 minutes to
43 2 hours using 500 mL of multi-component solution containing 1 mg L⁻¹ metaldehyde and 30
44 mg L⁻¹ HA without adjusting the pH of the solution and 0.05 g PAC.

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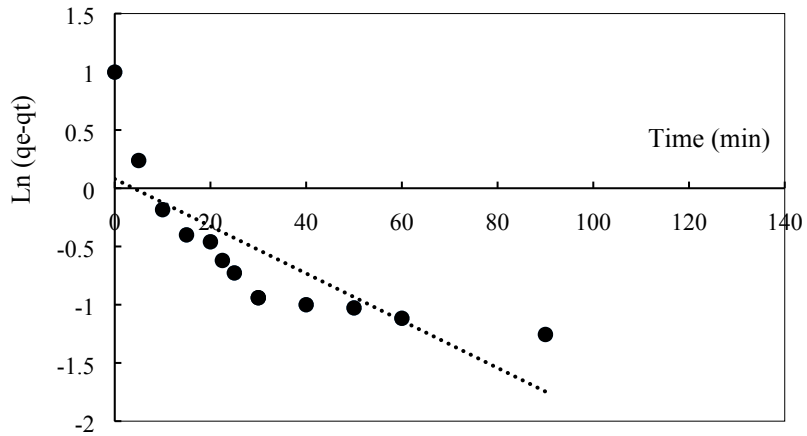
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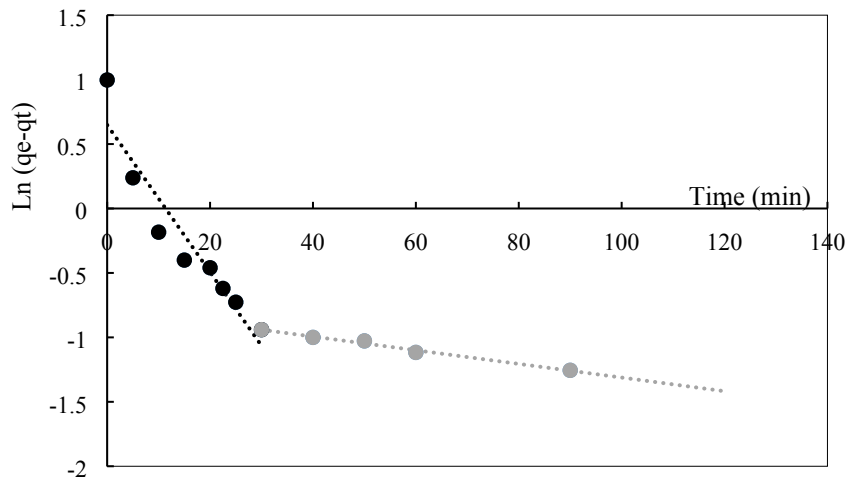
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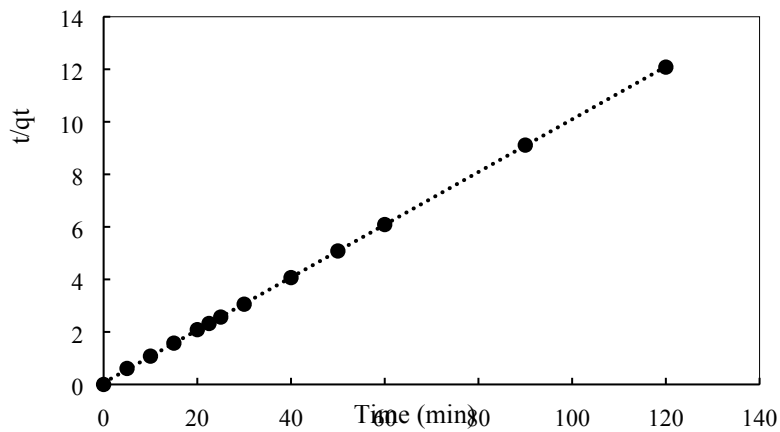
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55 Figure 1. Pseudo-first order kinetic model fitting of 1 mg L⁻¹ metaldehyde with 0.05g PAC in
 56 2-hour batch experiment in single system



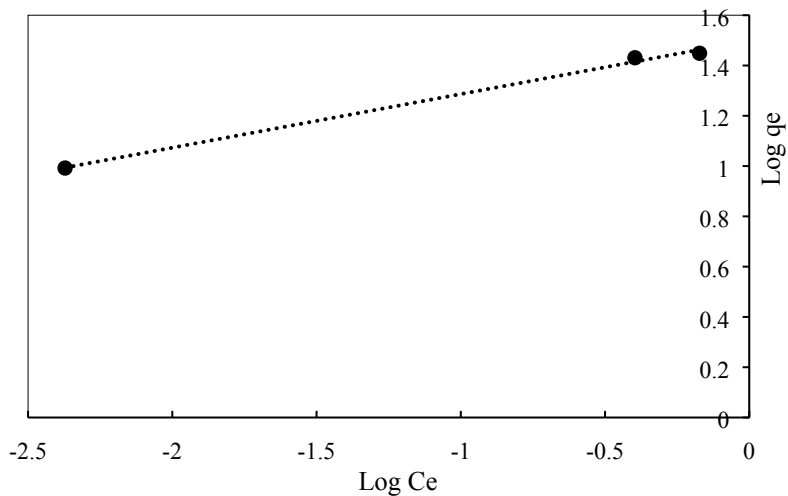
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58 Figure 2. Two gradients plotting of pseudo-first order kinetic model



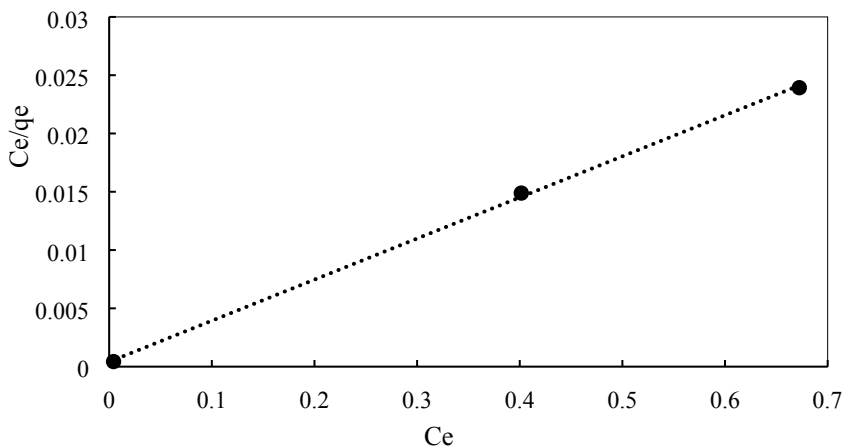
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60 Figure 3. Pseudo-second order kinetic model fitting of 1 mg L^{-1} metaldehyde with 0.05 g PAC
61 in 2-hour batch experiment in single system



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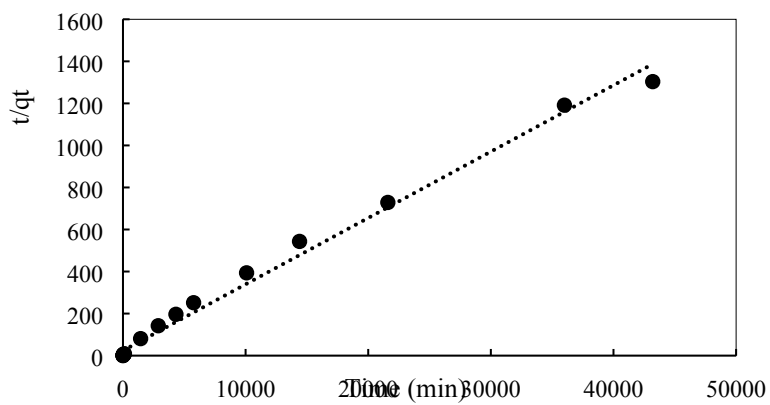
63 Figure 4. Freundlich isotherm fitting for single adsorption of metaldehyde



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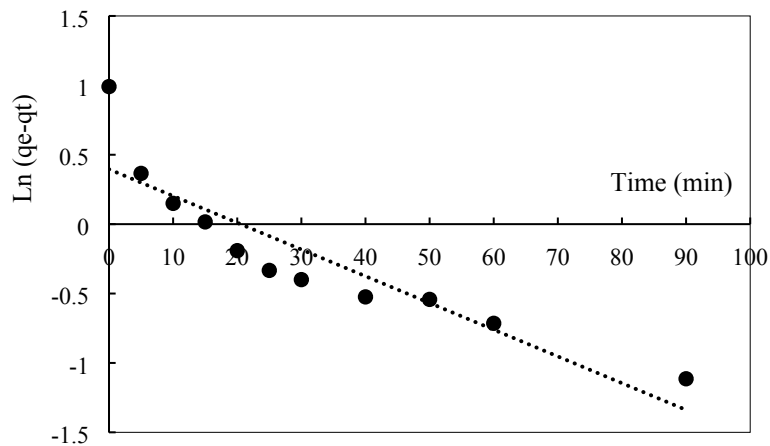
65 Figure 5. Langmuir isotherm fitting for single adsorption of metaldehyde

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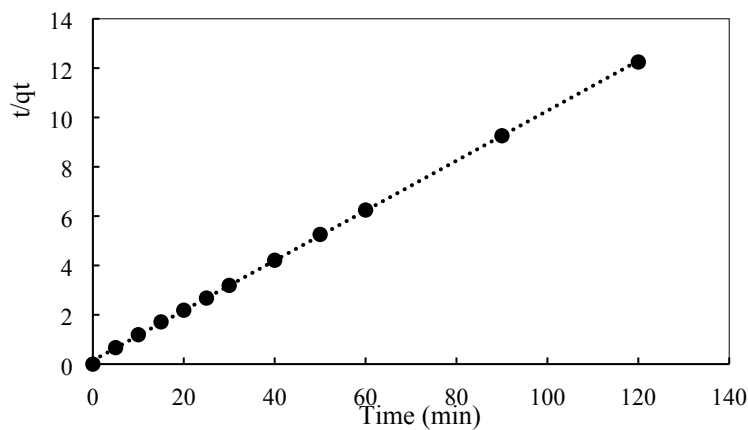
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68 Figure 6. Pseudo-second order kinetic fitting of 30 mg L^{-1} metaldehyde with 0.25g PAC in 2-
69 hour batch experiment in single system



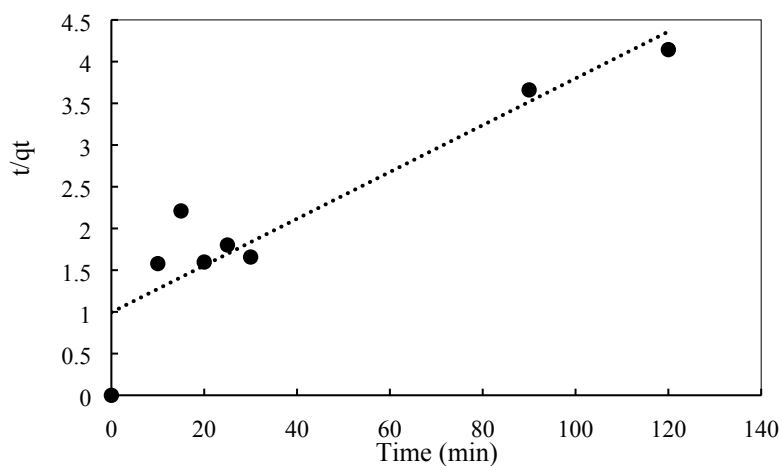
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71 Figure 7. Pseudo-first order kinetic model fitting for metaldehyde in binary system (1 mg L^{-1}
72 metaldehyde and 30 mg L^{-1} HA) with 0.05g PAC in 2-hour batch experiment



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74 Figure 8. Pseudo-second order kinetic model fitting for metaldehyde in binary system (1 mg L^{-1}
75 L^{-1} metaldehyde and 30 mg L^{-1} HA) with 0.05g PAC in 2-hour batch experiment



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77 Figure 9. Pseudo-second order kinetic model fitting for HA of in binary system (1 mg L^{-1}
78 metaldehyde and 30 mg L^{-1} HA) with 0.05g PAC in 2-hour batch experiment

80 Table 1. Removal of metaldehyde and HA under different experiment conditions (*p* values are
 81 from ANOVA single-factor statistic test for analysing concentrations of solutions before and

	Percentage removal (%)	Initial concentration (mg L ⁻¹)		PAC dosage (g L ⁻¹)	<i>p</i> value
		Metaldehyde	HA		
Removal of metaldehyde (single)	30.3 ± 6.4	1		0.01	2.28×10 ⁻⁷
	57.8 ± 2.7	1		0.02	1.07×10 ⁻⁹
	99.6 ± 0.0	1	n/a	0.1	4.07×10 ⁻¹²
	100.0 ± 0.0	1		0.2	8.24×10 ⁻¹⁶
	100.0 ± 0.0	1		1	1.45×10 ⁻¹²
Removal of HA (single)	9.8 ± 0.1		30	0.1	8.5×10 ⁻¹⁰
	14.8 ± 0.1		30	0.2	6.96×10 ⁻¹¹
	21.6 ± 0	n/a	30	0.5	6.72×10 ⁻¹¹
	25.1 ± 0.1		30	1	1.39×10 ⁻¹²
	32.0 ± 0.1		30	2	9.8×10 ⁻¹¹
Removal of metaldehyde (binary)	98.6 ± 0.2	1	3	0.1	1.24×10 ⁻¹⁸
	98.4 ± 0.3	1	9	0.1	8.48×10 ⁻¹⁶
	97.8 ± 0.5	1	15	0.1	2.53×10 ⁻¹⁸
	96.2 ± 0.5	1	30	0.1	1.37×10 ⁻¹⁸
	89.9 ± 1.4	1	60	0.1	9.76×10 ⁻¹⁶
	90.2 ± 1.0	1	90	0.1	1.31×10 ⁻¹⁴
Removal of HA (binary)	20.5 ± 0.5	1	3	0.1	1.98×10 ⁻⁷
	16.3 ± 0.4	1	9	0.1	2.71×10 ⁻⁷
	14.8 ± 0	1	15	0.1	6.53×10 ⁻¹¹
	11.3 ± 1.6	1	30	0.1	1.11×10 ⁻¹⁰
	7.7 ± 0	1	60	0.1	1.34×10 ⁻¹⁰
	6.5 ± 0	1	90	0.1	8.73×10 ⁻¹⁰

82 after treatments)

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95 Table 2. Comparison table of adsorption of metaldehyde and HA onto GAC and PAC

Sample solution (500 mL)	2 g/L GAC (purchased from sigma-aldrich, 20 mesh size, specific surface area = 650 m ² g ⁻¹)		0.1 g/L PAC (used in this study, specific surface area = 962 m ² g ⁻¹)		0.2 g/L PAC (used in this study, specific surface area = 962 m ² g ⁻¹)	
	Removal (%)		Removal (%)		Removal (%)	
	Metaldehyde	HA	Metaldehyde	HA	Metaldehyde	HA
Mono-component solution of metaldehyde (1 mg L⁻¹)	99.70±0.15		99.6		100	
Multi-component solution of metaldehyde (1 mg L⁻¹) and HA (30 mg L⁻¹)	98.99±0.58	21.56	96.2±0.5	11.3 ± 1.6		
	$k_2 = 0.016 \text{ g mg}^{-1} \text{ min}^{-1}$		$k_2 = 0.069 \text{ g mg}^{-1} \text{ min}^{-1}$			
Mono-component solution of HA (30 mg L⁻¹)		22.67		9.8 ± 0.1		14.8 ± 0.1

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