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DEVELOPMENT OF EFFECTIVE LEAD REMOVAL FROM WASTEWATER BY GRAPHENE OXIDE

Author: Nik Rashida Nik Abdul Ghani, Mohammed Saedi Jami, Md.Zahangir Alam, Wan Wardatul Amani Wan Salim, Nurul Sakinah Engliman

Affiliation: Biotechnology Engineering Department, Kuliyyah of Engineering, International Islamic University Malaysia, P.O Box 10, 50728 Kuala Lumpur.

(Company No. 101067-P)
الجامعة الإسلامية العالمية ماليزيا
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CONTEXT & OBJECTIVE

Heavy metals contamination in wastewater

- Environment and health concern; high toxicity
- Limitation of conventional methods; incomplete removal ,generation of toxic sludge
- High cost and high energy consumption

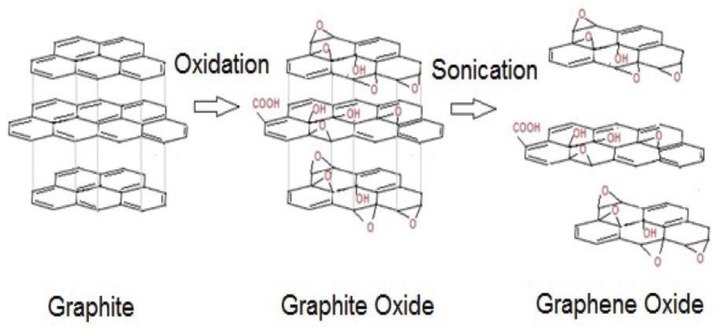
This study aims to remove lead from wastewater effluent by adsorption process using graphene oxide

- To synthesis and characterize high quality of graphene oxide
- To optimize the operating condition for lead removal by adsorption using graphene oxide
- To identify adsorption isotherm for lead removal using graphene oxide

EXPERIMENTAL SECTION

A) SYNTHESIS OF GRAPHENE OXIDE

The synthesis of GO involves oxidation of graphite into graphite oxide and exfoliation of graphite oxide into graphene oxide (Wahab et al. 2016).



B) CHARACTERIZATION OF GO

FTIR	to identify the chemical compound and organic molecules presence in GO using FTIR spectrometer (V70, Bruker Corp., Massachusetts, US).
SEM	GO powder sample was sprinkled on the sample holder using a double-sided tape, then coated using sputter coater device (Q-SC7620, QuorumTech Ltd., London). The morphology of GO was evaluated with a SEM (JSM-IT 100, Jeol, Japan)

C) BATCH ADSORPTION EXPERIMENT

Experiments were designed by DX6 software under fractional factorial design → Lead solution were prepared with different initial concentration (100-500 mg/L) → 0.01 g of GO was added to the conical flask containing lead solution → pH adjustment by NAOH and HCl (pH 5,7 and 9) → the mixture was stirred using a laboratory shaker at constant speed of 200 rpm until a pre-determined time (10-60 min) → samples were extracted and sent for analysis of the residual concentration of lead using an ICPMS

D) ADSORPTION ISOTHERM

4 different initial concentrations of lead (100, 300, 500 and 700 mg/L) were prepared. → 0.01 g of GO was added to each solution and run under the optimum condition (pH 9, 60 minutes) stirred at 200 rpm → Samples were extracted to determine the final concentration of lea using ICPMS → Adsorption isotherm was investigated using Langmuir and Freundlich models

Langmuir isotherm equation

$$\frac{1}{q_e} = \left(\frac{1}{bq_m}\right)\frac{1}{C_e} + \frac{1}{q_m}$$

Freundlich isotherm equation

$$\log q_e = \log K_f + \frac{1}{n}\log C_e$$

RESULTS AND DISCUSSION

A) GRAPHENE OXIDE

The SEM micrographs of GO powder displayed a randomly aggregated and crumpled structure, showed some wrinkle and fold area on the surface of GO and its confirmed that the graphite was well exfoliated during the oxidation process (Yusoff, Samad, Loh & Lee 2018).

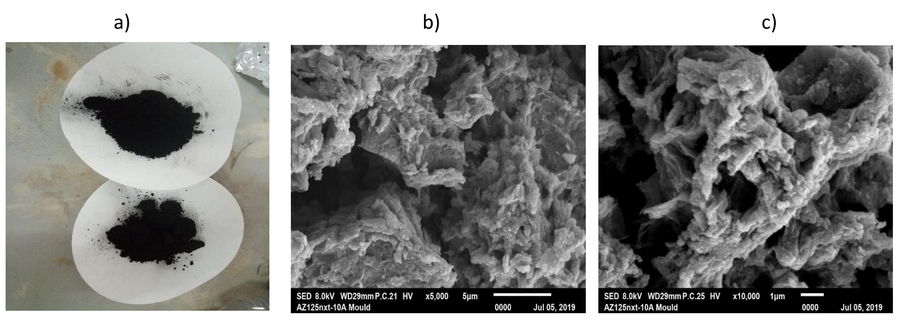


Fig 1: a) powder form of produced GO after freeze-dry and SEM images on the magnificent of b) 5k X and c)10k X

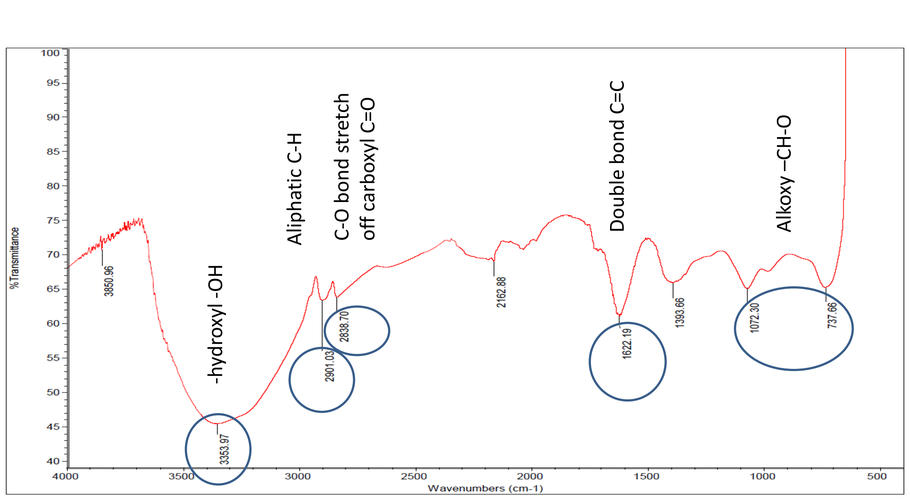


Fig 2: FTIR analysis of GO

B) BATCH ADSORPTION AND ISOTHERM

Table 1 : Batch adsorption experiment of GO for lead removal

Run	A:Contact time (min)	B:pH	C:Initial concentration of lead, C_o (mg/L)	Final concentration of lead, C_e (mg/L)	Percentage removal(%)
1	35	7	324.31	13.430	94.30
2	10	9	539.61	22.060	95.90
3	**60**	**9**	**107.21**	**0.024**	**99.98**
4	10	5	107.21	47.880	55.30
5	60	5	539.61	54.900	89.80
6	60	9	539.61	20.750	96.10
7	10	5	539.61	52.100	90.30
8	10	9	107.21	0.101	99.90
9	60	5	107.21	71.720	33.10
10	35	7	324.31	18.510	94.30

$$\%\ Removal = \frac{Co - Ce}{Co} \times 100$$

Optimum conditions for adsorption of lead by GO were at pH 9, contact time 60 minutes with 100 mg/L of initial concentration.

Table 2: Equilibrium data for Langmuir and Freundlich isotherms

Equilibrium		Langmuir		Freundlich	
C_e (mg/L)	Q_e (mg/g)	$1/C_e$	$1/q_e$	$\log C_e$	$\log q_e$
2.57	1046.4	0.3891	0.000956	0.4099	3.0197
15.92	3083.9	0.0628	0.000324	1.2019	3.4891
42.1	4975.1	0.0237	0.000201	1.6243	3.6968
276.6	4818.1	0.0036	0.000208	2.4419	3.6829

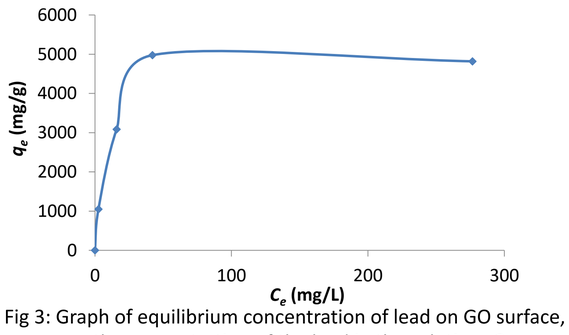


Fig 3: Graph of equilibrium concentration of lead on GO surface, q_e, versus the concentration of the lead in the solution, C_e

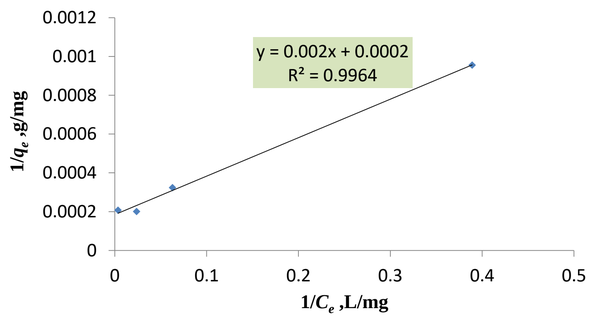


Fig 4: Graph of Langmuir isotherm;$1/q_e$ versus $1/C_e$

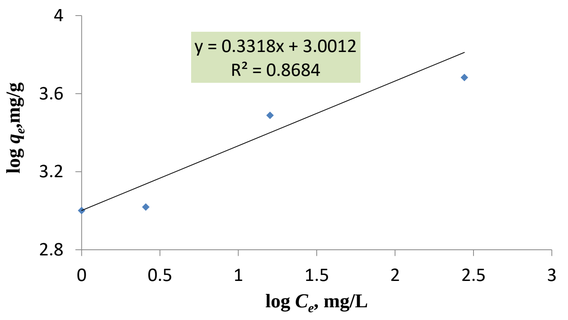


Fig 5: Graph of Freundlich isotherm; $1/q_e$ versus $1/C_e$

CONCLUSION

In conclusion, the operating conditions of adsorption by graphene oxide were optimized by fractional factorial design. The highest percentage removal with 99.9 % of lead removal was identified at pH 9, contact time 60 minutes with 100 mg/L of lead initial concentration. The adsorption study fitted well in Langmuir isotherm (R^2= 0.9964) and the maximum adsorption capacity of lead onto graphene oxide was 500 mg/g. It is therefore believed that utilization of GO is an excellent alternative to enhance adsorption performance towards efficient wastewater treatment. This work become a promising research direction for graphene-based membrane fabrication for heavy metals removal in current and future membrane applications.

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