Porous graphene – a potential sorbent for removing emerging contaminants from water

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1. Introduction – In recent years, graphene based materials (GBMs) have gained attention as attractive candidates for water treatment. In particular, treatment of emerging contaminants (ECs) in water using GBMs, specifically graphene oxide (GO), shared an increasing interest within the last decade [1]. These ECs have broadly undefined discharge limits and unknown impact on environment and human health. Additionally they are not readily biodegradable and cannot be removed fully at conventional wastewater treatment plants. An adsorption method using a novel GBM, such as porous graphene (PG), could present a promising treatment solution. PG is an enhanced graphene nanomaterial of microporous and mesoporous interconnected networks. Attributed to its chemical stability, high surface area (652 m^2/g), super hydrophobicity, porous morphology, non-toxic nature, and recyclability, PG has proved its efficacy in eliminating arsenic, fluoride, nitrate, methylene blue, rhodamine B and oil from water [2]. In addition, PG has an advantage over GO of its ease in filtration. In this study, PG and GO were applied as a water treatment option to remove ECs, e.g. pharmaceuticals commonly found water streams in India and the UK [3]: atenolol (ATL), carbamazepine (CBZ), ciprofloxacin (CIP), diclofenac (DCF), gemfibrozil (GEM) and ibuprofen (IBP). The main objectives of the study included: to compare the treatment performance, mode adsorption isotherms and kinetics and investigate dominate mechanism contributing to their removal.

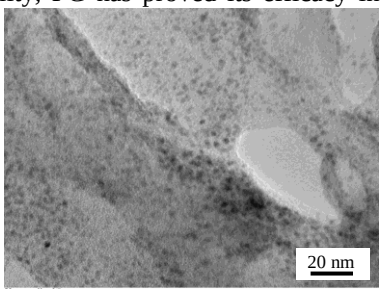

Image 1. TEM image of as-prepared PG.

2. Experimental - Highly PG was synthesized based on an inexpensive chemical oxidation – exfoliation – reduction – thermal treatment protocol. PG and GO and their spent particles were characterized to reveal their physical properties and identify major removal mechanisms. Batch adsorption experiments were carried out for different contact times in 20 mL pharmaceutical solution of 10 mg/L with added PG or GO dosage of 250 mg/L. The equilibrium adsorption studies were conducted at various ECs concentrations.

3. Results and Discussion – PG revealed porous nanosheet morphology as depicted in Image 1. GO competitively outperformed PG in adsorbing ECs of hydrophilic nature, such as ATL and CIP, presented in Table I. However, for other ECs, PG manifested higher removal efficiencies and better performance in general. Experimental results were found to be best fitted to pseudo second-order kinetic model and Toth/Sips isotherm model.

Table I. Maximum achieved adsorption capacities in experiments, mg-sorbate/g-sorbent.

Material	ATL	CBZ	CIP	DCF	GEM	IBP
GO	235	65	414	55	34	17
PG	136	147	329	76	40	29

4. Conclusions - Detailed experimental work and systematic studies tested the performance of as-prepared PG nanosheets, exhibiting remarkable adsorption capacities (exceeding 100 mg-EC/g-PG for some ECs) and fast adsorption kinetics. The investigated ECs adsorption on PG was dominated by heterogeneous physisorption processes, including electrostatic and π-π interactions and hydrogen bonding.

5. References

[1] C. Sophia and E.C. Lima, *Ecotox. Environ. Safe.*, **150**, (2018) p. 1-17.
[2] T. Tabish et al., *Sci. Rep.*, **8**(1), (2018) p. 1817.
[3] Fate and Management of Emerging Contaminants (2018). Available at http://fame-indouk.com/about-the-project.html [Accessed 1 March 2019].