Process intensification for removal of new pharmaceutical compounds from water

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Highlights

- Removal of emerging contaminants from water using new techniques.
- Process intensification for iopamidol and ibuprofen adsorption.
- Scalability of the adsorption process from batch to continuous flow.

1. Introduction

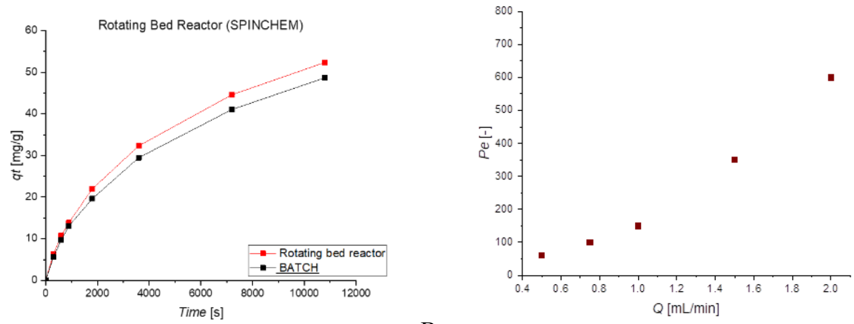
Nowadays, the diffusion of new emerging contaminants (ECs) (e.g. surfactants, pesticides, pharmaceutical compound, personal care product, etc.), present in the range concentration of ppt (ng/L) or ppb (μg/L), represent an environmental critical issue. Therefore, it is necessary find new technologies for drugs removal that escape by conventional wastewater treatment processes. Adsorption is the best technique to remove pollutants from water, due to its easy scalability, low cost, versatility, no undesired by-products generation and possibility to reuse the adsorbent into a new cycle of water treatment. Iopamidol (IPM) is a non-ionic X-ray contrast media, injected into the human body at high concentration (1.5 mol/L)[1], and relies into the aquatic environment in no-metabolized form [2]. The new challenge is to design a wastewater treatment plant capable to remove ECs efficiently, allowing the reuse of the aquatic matrix obtained. The best adsorbent for Iopamidol removal is activated carbon, so an adsorption study from batch to continuous flow was performed in this work. Ibuprofen (IBP) is a non-steroidal anti-inflammatory drug used in the treatment muscle pain and inflammation, which concentration in the wastewater is around 18–6297 ng/L[3]. Cellulose is a main component of natural plants, is the most abundant and renewable biomass resource on earth and is if pyrolyzed is a good adsorbent to remove IBP from water. For the intensification of the IPM and IBP adsorption process different kinetics were obtained using different devices, batch comparing a common stirrer with rotating bed reactor (RBR, Spinchem®), ultrasound probe merged into the aqueous solution and, finally, application of the continuous flow with and without ultrasound.

2. Methods

A jacketed glass vessel closed with a three-neck lid was used to obtain kinetic trends in time in bath mode. Adsorption kinetics were obtained using granular activated carbon (GAC), and iopamidol solution. Data were obtained changing IPM concentrations (20, 50 and 100 mg/L), stirring speed (400, 600 and 800 rpm) and fix both temperature (303K) and adsorbent amount (1g). At the same time an optimized experimental system was settled to perform adsorption test in continuous flow using IPM feed solution (10, 20, 40, 100, 1000 mg/L), peristaltic pump, adsorption column containing GAC, an ultrasound water bath, and a thermostat. Breakthrough curves were obtained to determine the best IPM feed concentrations, flow rate and NaCl 0.1 M in water was used as tracer to obtain Peclet number trend of the system realized. To study Ibuprofen adsorption initial concentration (5, 10 and 15 mg/L), pyrolyzed cellulose amount (0.01, 0.025 and 0.05g) and ultrasound amplitude percentage (30, 50 and 80%) were changed and studied.

3. Results and discussion

Batch experiments were performed with both a common stirrer and the rotating bed reactor (RBR), as is possible see from Figure 1A. The use of the RBR shows an increase of GAC adsorption performances of 8%. The use of the ultrasound during the adsorption process in continuous flow shows an increase of the IPM removal from water from 8% to 64%. Fluid dynamic tests performed with NaCl at different flow rate have given breakthrough curve showing an increase of Peclet number (Figure 1B) with the increase of flow rate solution into the system. Higher removal of IBP was observed increasing the cellulose amount into the system, and the qt (mg/g) value increases increasing the IBP initial concentration fixing the adsorbent amount. Furthermore, IBP removal from the aqueous solution increases with ultrasound amplitude generated by probe used in the process.



A B

Figure 1. Adsorption capacity (qt) value from the kinetics obtained using a common stirrer (batch) and RBR for IPM removal (A). Peclet number trend at different flow rate (Q) (B).

4. Conclusions

In this work several kinds of devices and technologies were tested aimed to find the best one for both iopamidol and ibuprofen adsorption. The use of an alternative stirrer, namely RBR, has shown a best IPM removal compared with a common stirrer, and a preliminary study was conducted to find the best working condition (e.g. flow rate, IPM feed solution concentration) for the system in continuous flow realized. At the same time the use of an ultrasound probe merged into ibuprofen solution gives an improvement of the cellulosic adsorbent performance due to the fragmentation in time so an increase of the liquid-solid mass transfer. IBP adsorption tests will be performed also in continuous flow using a similar IPM adsorption apparatus.

References

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Keywords

Emerging contaminants, wastewater treatment, process intensification, pharmaceutical compounds