ISGC 2022

N°288 / OC
TOPIC(s) : Waste and side streams valorization / Biomass conversion

Transformation of olive wastes into bio-sourced activated carbon and comparison with commercial one for adsorption of pollutants (Bisphenol A and Diuron)

AUTHORS

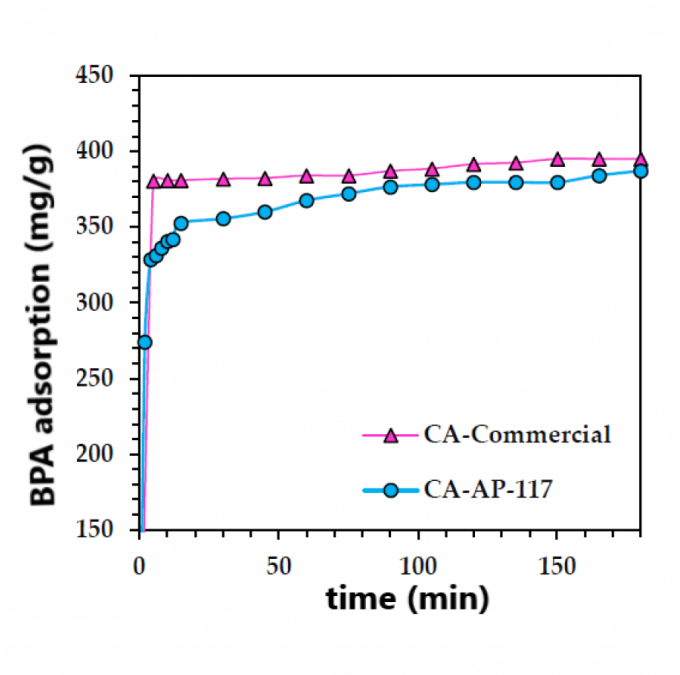
Laurence PIRAULT-ROY / IC2MP, UNIVERSITY OF POITIERS, 4, RUE MICHEL BRUNET, TSA 51106, POITIERS
Nadia EL OUAHEDY / IC2MP, UNIVERSITY OF POITIERS, 4, RUE MICHEL BRUNET, TSA 51106, POITIERS
Rachid BRAHMI / UNIVERSITY OF EL JADIDA, FACULTÉ DES SCIENCES ROUTE BEN MAACHOU, EL JADIDA

PURPOSE OF THE ABSTRACT

In 2018, world production capacities of activated carbon (AC) were 972,000 tonnes produced from charcoal mainly (52%), wood (23%), coconut (18%), lignite (5%) and various kernels and nut shells (2%) [1]. The AC are used in adsorption process for water or air depollution as effective pollutants removal can be achieved with low operating cost, simple design, easy use and less production of harmful by-products. To greener the depollution processes using AC, it would be preferable to move towards renewable carbon sources to produce AC. Among the carbonaceous sources, olive wastes represent one of the most abundant renewable resources in Mediterranean areas. Our objective was (1) the conversion of olive kernels into AC, (ii) the physico-chemical study of the material obtained (composition, textural and structural study, surface properties) and (iii) the comparison of its adsorption performances with the ones of a commercial sample. Two water pollutants were targeted: Bisphenol A (BPA), known as an endocrine disruptor [2] and Diuron still used as herbicide although its carcinogenic toxicity [3]. The results evidenced that our material can reach a specific surface area near to 1 500 g/m2 when the preparation method is optimal (phosphoric acid as activating agent with a mass ratio (H3PO4: olive kernels) equal to (1:1) and a thermal treatment at 700°C under nitrogen. The study of its performances for pollutants removal in water was performed using a concentration set at 20 mg/L for BPA and 35 mg/L for Diuron. The results [4] pointed out that (i) 92% of BPA introduced and 62% of Diuron can be removed from aqueous solution in 10 minutes (ii) maximum adsorption capacities per gram of adsorbent obtained were 476 and 434 mg/g for BPA and Diuron, respectively, which were among the highest values available in literature for bio-sourced sorbents (iii) kinetic studies revealed that sorption follows a pseudo-second-order kinetic model which indicates that the rate-limiting step is the chemisorption between adsorbent and adsorbate which was further confirmed by diffusion studies and IR analyses (iv) adsorption isotherm indicates a spontaneous and exothermic adsorption which fits with the Langmuir isotherm model. The comparison of our bio-sourced material with a commercial sample (Figure 1) demonstrated nearly the same behaviour for BPA adsorption (96% of abatement for commercial AC vs 92% for our material) but a lower performance for Diuron adsorption (80% vs 62%). Comparing the physico-chemical parameters of the materials studied (Table 1), the main difference comes from the pores size which was smaller in our material than in the commercial AC. Considering the size of the targeted pollutants i.e BPA length/width/height (nm): 1.07/0.59/0.38 and Diuron 1.29/0.77/0.74 and the results of the intraparticle diffusion studies indicating a fast adsorption on the external surface during the first minutes and a slower adsorption by the internal surface filling, the conclusion highlighted that pores size influences the diffusion rate and therefore the pollutants abatement difference between BPA and Diuron. Thus, our material obtained similar performances as commercial samples for smaller molecules whereas for larger compounds, the adsorption capacities decreased due to the reduction of diffusion rate. Further research will be dedicated to optimize the pore size for AC application to a large range of pollutants adsorption. To achieve a complete process of remediation, the pollutants desorption from AC followed by a catalytic oxidation were successfully performed.

This research work evidenced that the transformation of agricultural waste to useful high added-value adsorbent can be achieved and that an efficient AC made from olive kernels with similar properties than commercial sample prepared from fossil sources can be obtained. This study paves the way to more extensive valorization of biomass waste to produce green AC for pollution treatment.

FIGURES



	Commercial AC	CA-AP-117
BET surface area (m^2/g)	1 345	1 470
Pore volume (cm^3/g)	1.08	0.5
Mean pore size (nm)	6.4	1.1
pH_{PZC}	2.0-3.5	2.5
Elemental analysis	Commercial AC	CA-AP-117
C	74.6	69.8
N	0.0	0.3
O	13.8	28.5
S	0.0	0.0

FIGURE 1

Figure 1 : Adsorption kinetics of BPA on our bio-sourced activated carbon (CA-AP-117) and on the commercial one.

pink triangle : Commercial activated carbon

blue circle : CA-AP-117

FIGURE 2

Table 1: main physico-chemical parameters of our bio-sourced activated carbon (CA-AP-117) and a commercial one (DARCO KB-G from Fluka):

None

KEYWORDS

Bio sourced adsorbent | activated carbon | Water pollution treatment | BPA and Diuron adsorption

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