AN IRON-BASED BIOCHAR-SUPPORTED CATALYST FOR DICLOFENAC DEGRADATION

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Significance and Relevance

Photocatalytic degradation is considered an efficient strategy for the removal of organic pollutants. In this study, biochar— the carbonaceous by-product of thermochemical processes such as pyrolysis and gasification—is proposed as an innovative and sustainable support for catalyst development. Biochar advantageous characteristics, including high surface area and porous structure, make it an ideal candidate for developing a Fe-biochar catalyst aimed at removing Diclofenac (DFC) from contaminated water sources.

Preferred and 2nd choice for the topic: Water treatment, Photocatalysis and photoelectron catalytic approaches, solar energy utilization
Preferred presentation: Oral

Introduction and Motivations

Diclofenac (DFC) is a non-steroidal anti-inflammatory drug commonly found in wastewater and surface water, leading to negative effects on the environment and ecosystems[1]. Various strategies exist for removing DFC from wastewater; among these, photocatalytic degradation is considered one of the most promising technologies. For the photocatalyst several materials have been proposed as supports for the iron active phase[2]. However, due to concerns about cost and environmental impact, there is a growing need for greener and circular alternatives. In this context, biochar— a carbon-rich by-product of biomass gasification/pyrolysis—emerges as a potential eco-friendly substitute of conventional supports thanks to its high porosity and high surface area.

Materials and Methods

An iron-based biochar-supported catalyst (Fe-T) was prepared using a commercial biochar (T) obtained from fir tree biomass (supplied by Cogen, Terni (IT)). The catalyst was prepared according to the incipient wetness technique[3] using $Fe(NO_3)_3 \cdot 9H_2O$ as Fe precursor, to reach a final Fe nominal content of the 2% (w/w) on the total weight of the sample. Pristine biochar and Fe-T catalyst were characterized by means of Zeta Potential (ZP), Surface Area (SA), Pores Volume (PV), XRPD, SEM-EDX, FT-IR, TG-DTG. Photocatalytic and adsorption tests were performed in batch, at RT, and atmospheric pressure. In a typical photocatalytic experiment, 0.1 g of the Fe-T catalyst were suspended in 100 mL of deionized water. Subsequently, 100 $mg \cdot L^{-1}$ of DFC were added to the suspension just before it was illuminated with 367 nm UV light, and the stoichiometric H_2O_2 content for full DFC oxidation was added. In case of DFC adsorption by pristine biochar (T) and Fe-T, the reaction occurred without UV light and H_2O_2 application. Reaction progress was followed by collecting aliquots of the suspension with a syringe equipped with a PTFE filter at different time intervals. The residual amount of DFC in the solution was analyzed by HPLC equipped with a C18 column.

Results and Discussion

Pristine biochar is characterized by a high surface area (658 m^2/g) where micropores contribution is dominant, and such morphological characteristics are preserved upon iron impregnation (Table 1).

Table 1. Morphological properties of biochar (T) and the iron-based biochar-supported catalyst (Fe-T).

Material	SA_{BET} m^2/g	SA_{micro} m^2/g	SA_{ext} m^2/g	Vp_{micro} cm^3/g	Vp_{meso} cm^3/g	Vp_{Macro} cm^3/g
T	658	590	68	0.26	0.11	0.22
Fe-T	613	556	55	0.25	0.08	0.38

SEM-EDX analysis shows that T and Fe-T before the photocatalytic reaction have similar morphological structure, characterized by channels and pores of different dimensions, typical of biochar (Figure 1 a-c). Moreover, Fe is homogeneously distributed in Fe-T (fig. 1d).

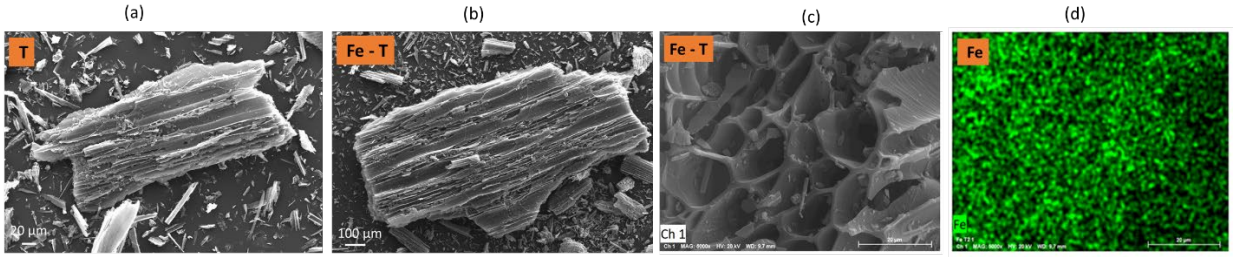

Figure 1. SEM analysis of: (a) the support (T) at 500X, and of the catalyst (Fe-T) at different magnifications (b) 250X, (c) 5,000 X; (d) EDX map of Fe ions in Fe-T catalysts.

Both the pristine support and the catalyst are able to adsorb up to 60 % of DFC from a solution containing 100 $mg \cdot L^{-1}$ in 1 h (Figure 2a). Thereafter, a plateau is reached, and no further adsorption occurred. When the photocatalytic reaction is performed, further DFC removal was observed up to 99% of DFC (Figure 2b). However, a low H_2O_2 consumption (<25%; Figure 2c) suggests that adsorption might always be co-present and predominant. In any case, the photocatalytic reaction addressed the total removal of DFC, which was not possible by adsorption standalone.

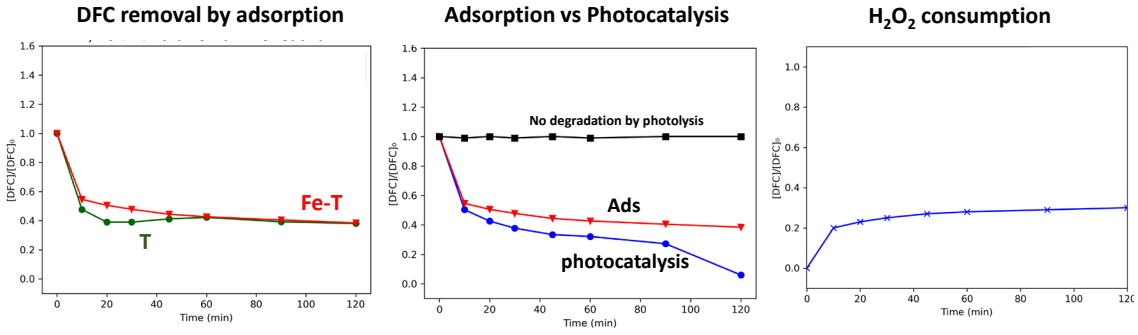

Figure 2. Removal of DFC by T and Fe-T via a) adsorption, b) photocatalysis, and c) H_2O_2 consumption in this process.

References

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