Activation of persulfate by different biochars for the degradation of sulfamethoxazole

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Biochars, the solid residue produced from biomass thermal decomposition with no or little oxygen at moderate temperatures, are low-cost materials with high surface area and desirable physicochemical properties in terms of pore size distribution, the number of functional groups, and minerals that can be employed as catalytic supports.

The aim of this work is to test whether biochar produced from malt spent rootlets (MSR) and olive kernels are suitable activators of persulfates for the degradation of sulfamethoxazole (SMX) under various operating conditions and aqueous matrices.

Experimental Procedure

Results

Conclusions

Biochar preparation

- Malt spent rootlets sieved (0.150-1.18 mm), Olive stones from table olives
- Drying at 50°C
- Pyrolysis at 850°C in a special handmade container under limited oxygen conditions
- Biochar powder

Malt spent rootlets (MSR)

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Experimental procedure

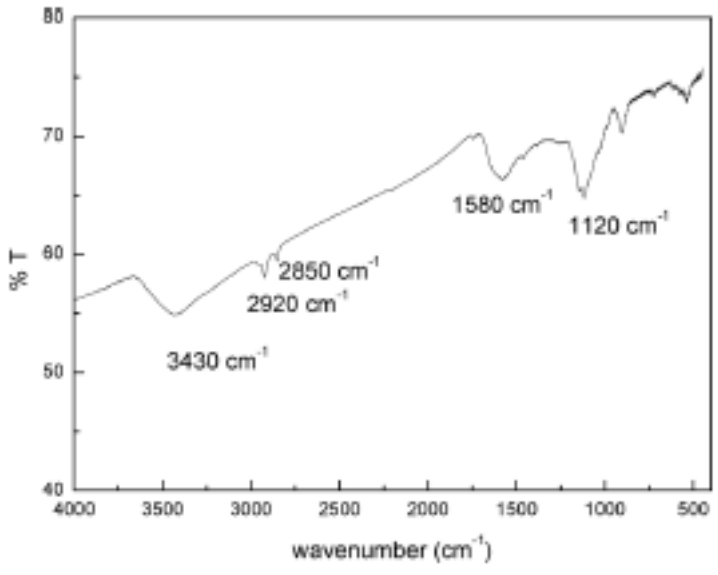
Experiments were conducted in a cylindrical glass reaction vessel of a 250 mL capacity that was open to the atmosphere (open air equilibrium).

A stock SMX solution was prepared in ultrapure water (UPW), and a measured volume was mixed with the water matrix to achieve the desired SMX concentration (from 250 to 2000 g/L).

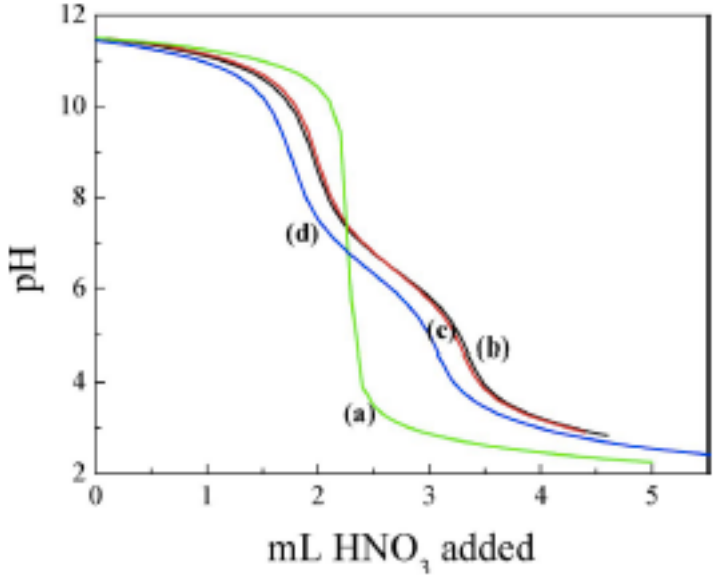
The solution was then supplemented with SPS to achieve the desired concentration of up to 1500 mg/L biochar to start the reaction under magnetic stirring (400 rpm) and at ambient temperature.

Samples of 1.2 mL were periodically withdrawn from the vessel (every 2.5 min in the first 10 min of reaction and every 15 min from 15 to 120 min of reaction), filtered and analyzed by liquid chromatography

Biochar from Malt spent rootlets

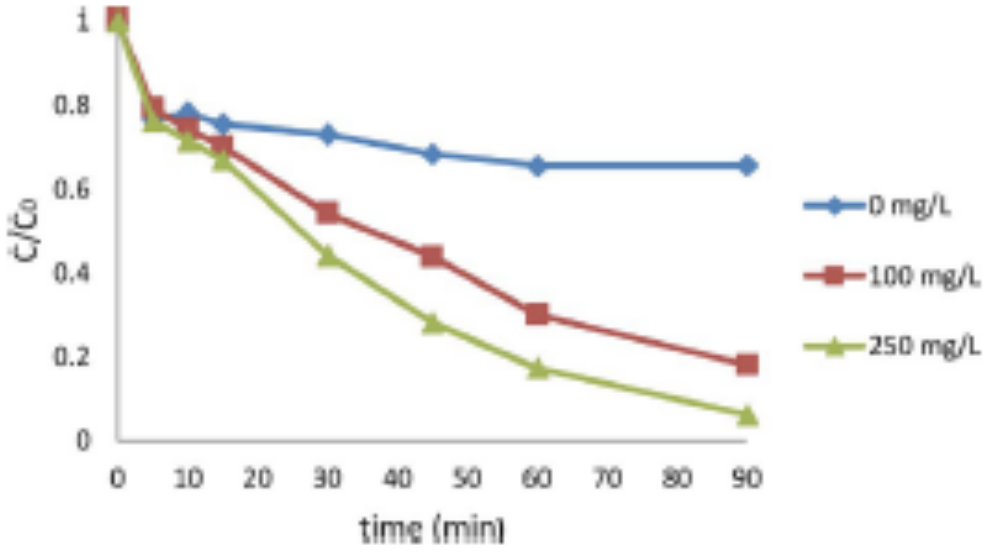


FTIR spectrum of the MSR biochar.

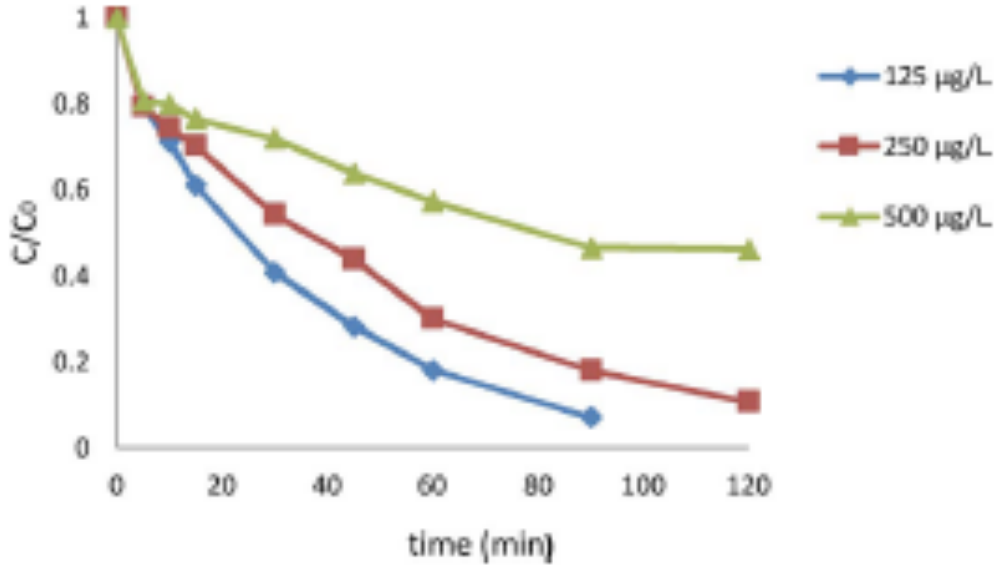


PMT curves for (a) blank solution, (b) BC in the presence of SPS, (c) BC in the presence of SPS and t-butanol and (d) BC in the presence of SPS and HA. In all cases, the biochar concentration was 1150 mg/L.

Biochar from Malt spent rootlets

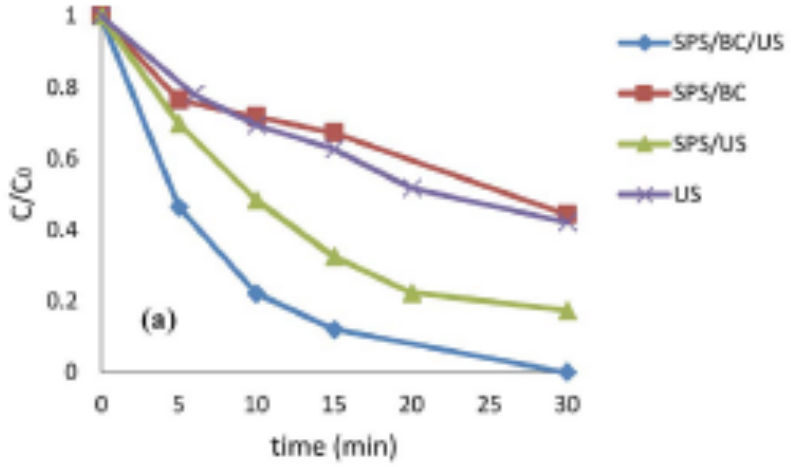


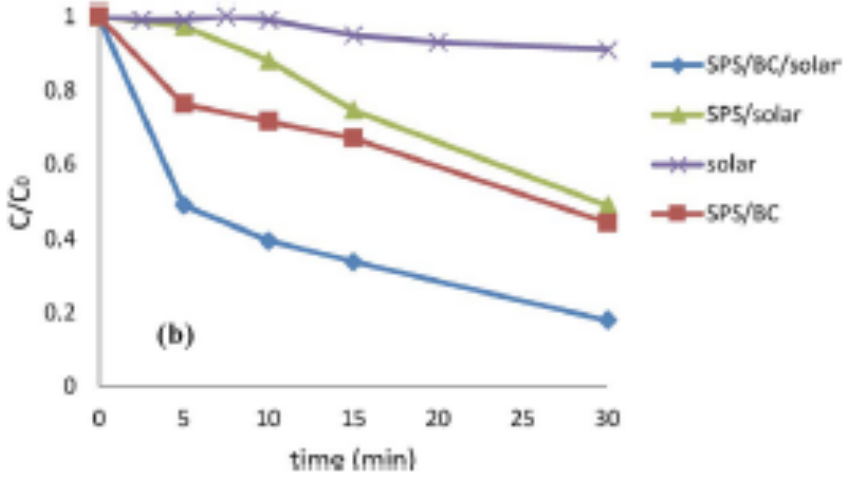
Effect of SPS concentration on 250 μg/L SMX degradation with 90 mg/L BC in UPW.



Effect of SMX concentration on its degradation with 100 mg/L SPS and 90 mg/L BC in UPW.

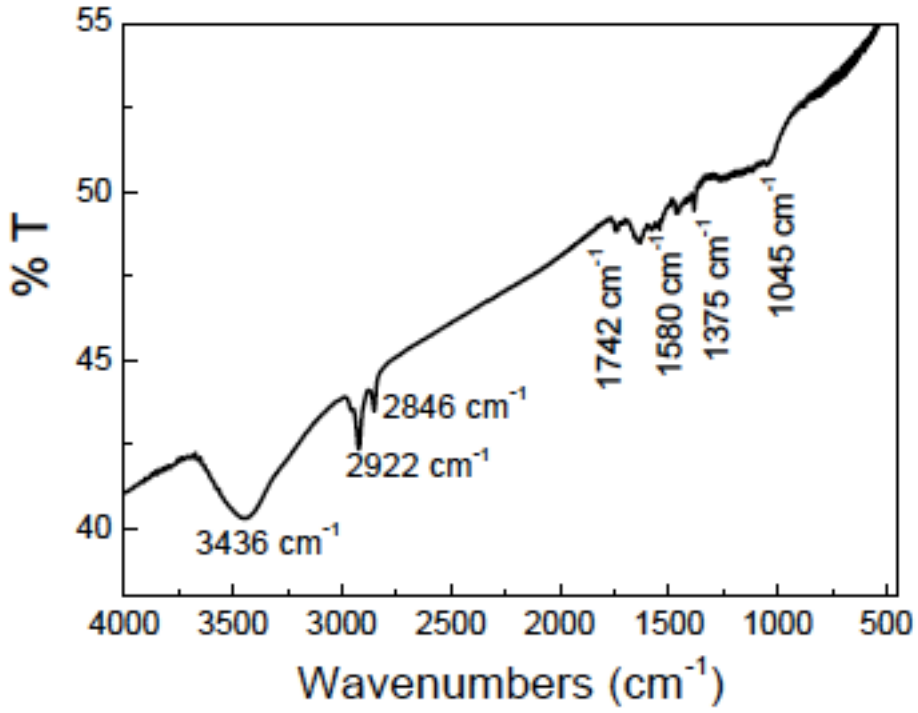
Biochar from Malt spent rootlets



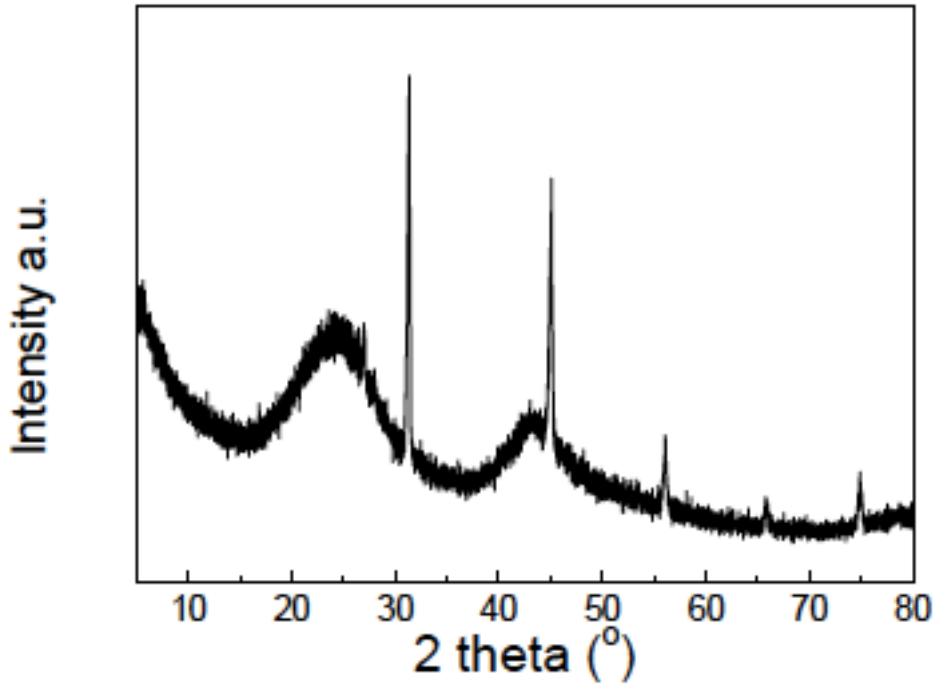


Degradation of 250 μg/L SMX in UPW by the combined action of (a) BC and US and (b) BC and solar irradiation. Biochar and SPS concentration was 90 and 250 mg/L, respectively.

Biochar from Olive Stones

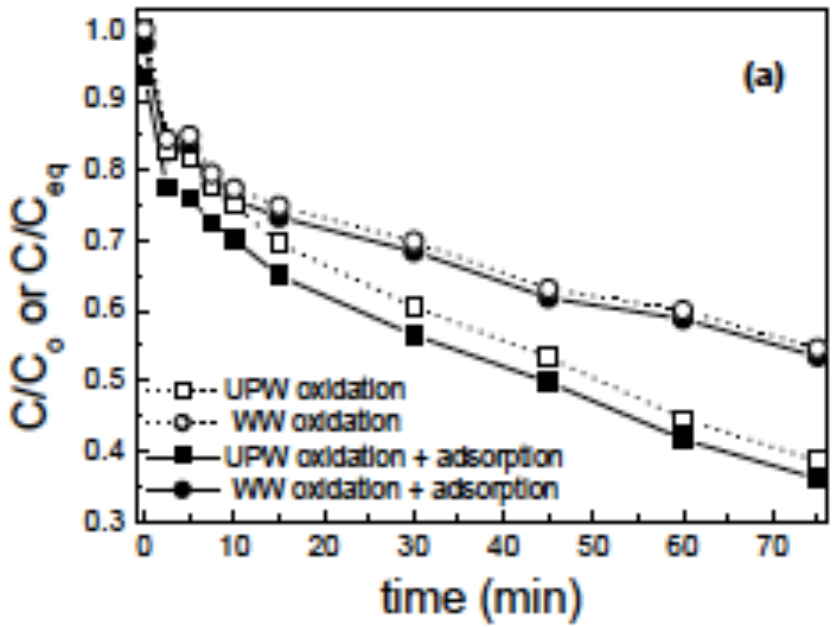


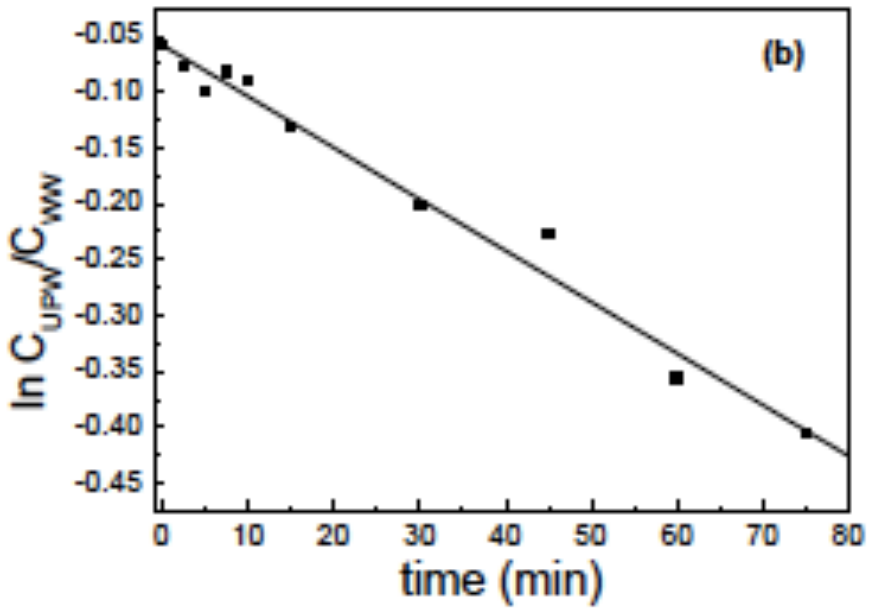
FTIR of olive stones biochar.



XRD pattern of olive stones biochar.

Biochar from Olive Stones





Comparison between the actual oxidation and adsorption process and oxidation alone for SMX removal in UPW and wastewater (WW) with 200 mg/L biochar and 1000 mg/L SPS. (b) The linear dependence of the logarithm of SMX concentration ratio in UPW and WW.

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Conclusions

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- Biochars from food industry are capable of activating persulfate, thus inducing SMX oxidative degradation.
- Degradation rates depend on factors, such as biochar, oxidant, and substrate concentration. An increase in the concentration of the latter retards degradation, while the opposite occurs for the other two factors.
- Based on the PMT method, persulfate interacts with the functional groups of the biochar surface to produce reactive radicals that are not released in the solution; this is consistent with the fact that the presence of common radical scavengers had no effect on degradation. Moreover, the presence of humic acid, a representative NOM/ EfOM macromolecule, seems to catalyze persulfate activation on the biochar surface.
- Environmental matrices such as bottled water and wastewater have no or a moderately detrimental effect on degradation; this is encouraging since the process could be applied in real life applications.

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