Continuous CWPO reaction using new developed foam supported catalysts

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WORKSHOP REMTAVARES-BIOTRES
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Innovative technologies for sustainable management of urban and industrial waste streams

REMTAVARES
Red Madrileña de Tratamientos Avanzados de Aguas Residuales

UAM
Universidad Autónoma de Madrid

INTRODUCTION

EMERGING POLLUTANTS

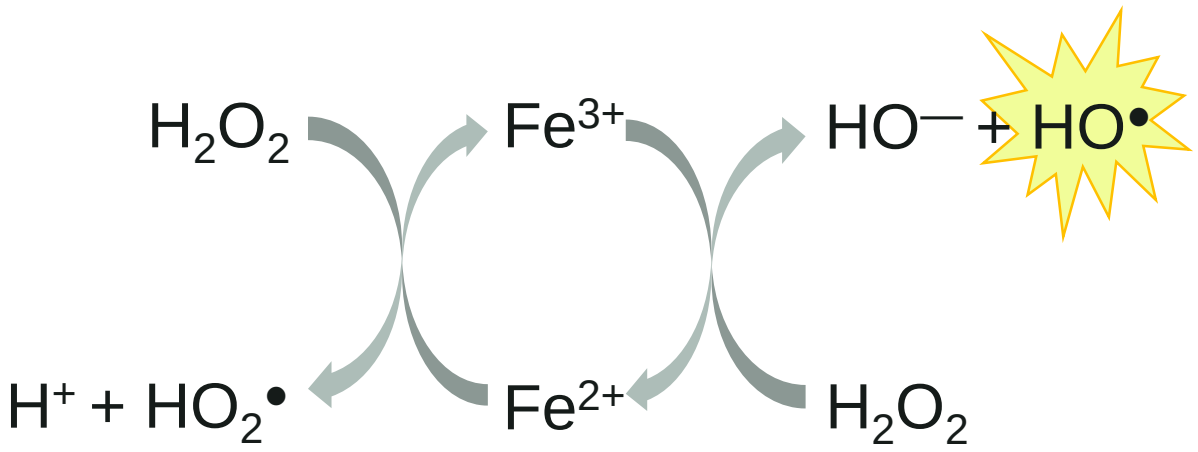
ngL^{-1} — μgL^{-1}

- Pharmaceuticals
- Drugs
- Endocrine or hormonal disruptors
- Industrial additives
- Pesticides
- Microplastics
- ...

INTRODUCTION

ADVANCED OXIDATION PROCESSES

- Ozonization
- Photocatalysis
- Electrooxidation
- **Fenton Process**



√ Eco friendly non-toxic H_2O_2

X Iron sludge

- Heterogeneous Fenton

Catalytic Wet Peroxide Oxidation
CWPO

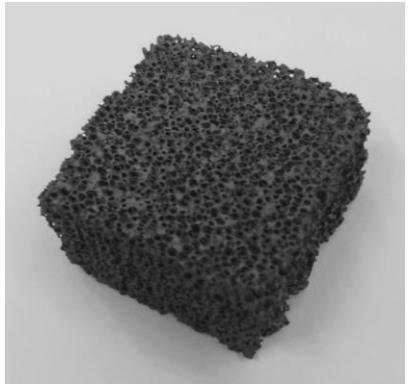
Powder catalysts

√ Recovery

X Scale-up in continuous reactions

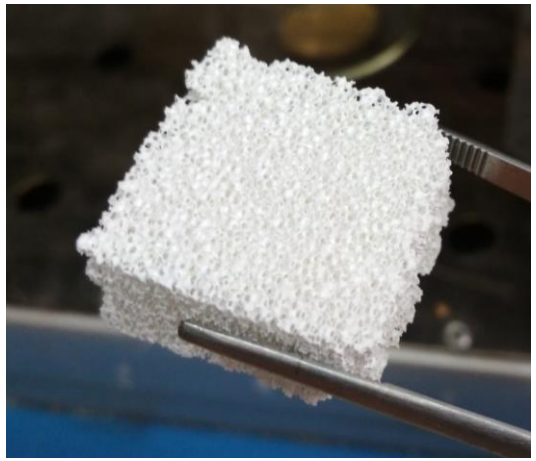
Structured catalysts

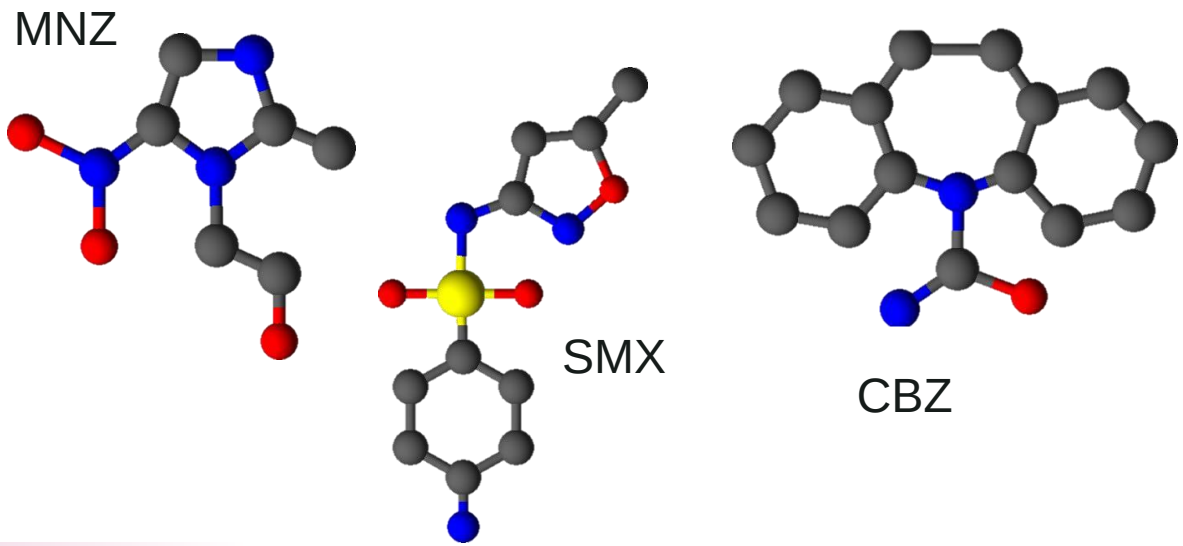
Open Cell FOAMS



OBJECTIVE

To develop homogeneous structured catalysts based on Al_2O_3, SiC and ZrO_2 foam supports coated with an active phase of iron oxide. New catalysts were applied in the CWPO process for the removal of a mixture of pharmaceuticals in order to evaluate catalytic performance and stability and the effect of different operating conditions



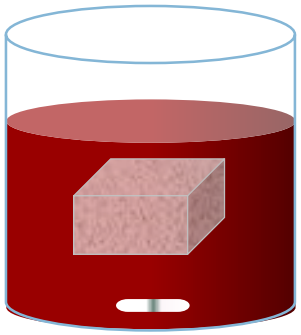


Pharmaceuticals compounds concentration in wastewater

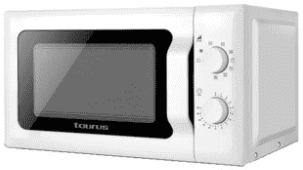
MNZ	1.8 μg L^{-1}
SMX	6.0 μg L^{-1}
CBZ	2.3 μg L^{-1}

CATALYSTS PREPARATION

ION ADSORPTION



30 min



10 min

	Fresh support	Ion adsorption	Calcination	Reduction
Al_2O_3				
SiC				
ZrO_2				

CATALYSTS CHARACTERIZATION

Final catalysts appearance

Fe/Al_2O_3

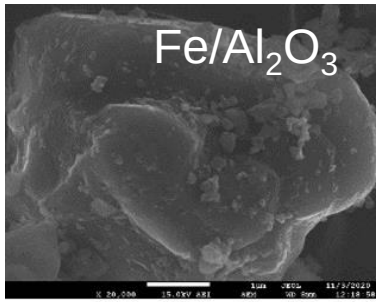
Fe/SiC

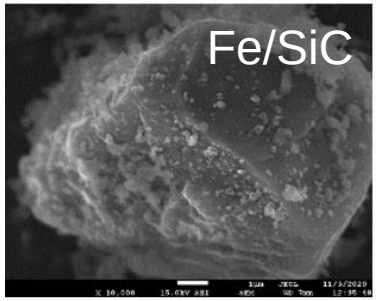
Fe/ZrO_2

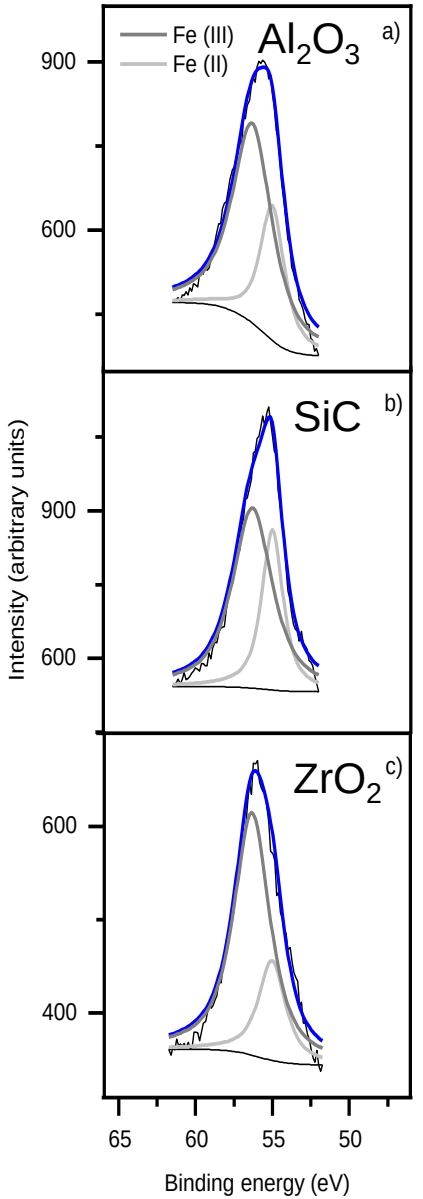
Low BET Surface area for all supports tested

	Fe load (%)	Nanoparticle size (nm)	XPS – ratio Fe(II) : Fe (III)
Fe/Al_2O_3	2.50	100-200	0.30 : 0.70
Fe/SiC	2.12	100-200	0.32 : 0.68
Fe/ZrO_2	0.90	150-400	0.24 : 0.76

Magnetite
0.33 : 0.67

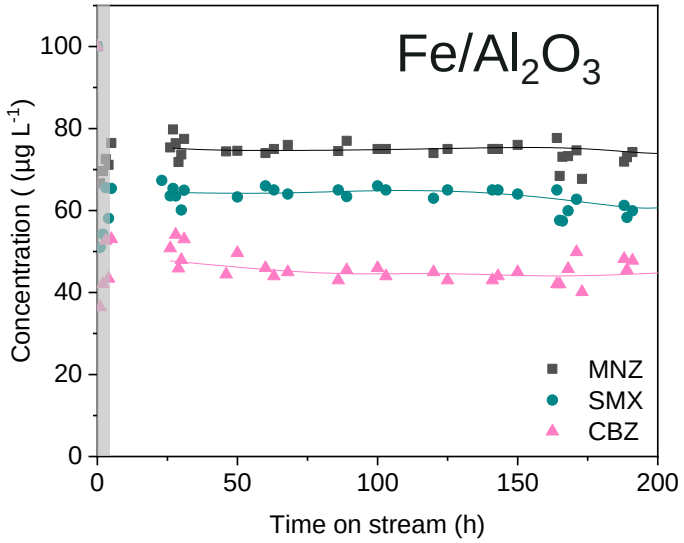


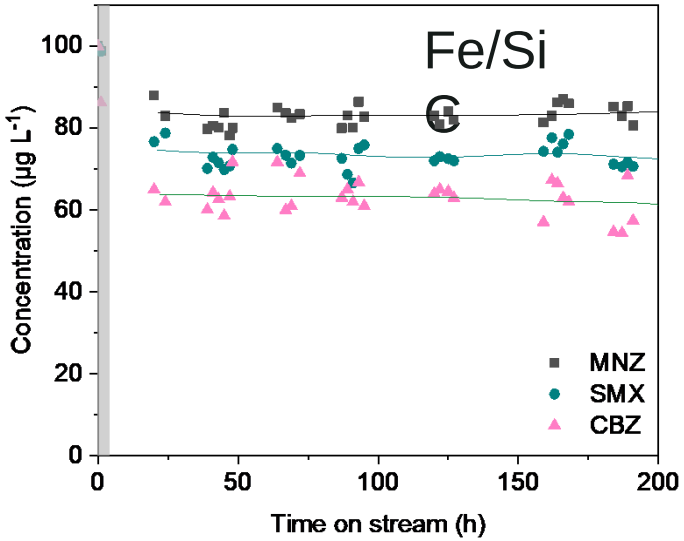


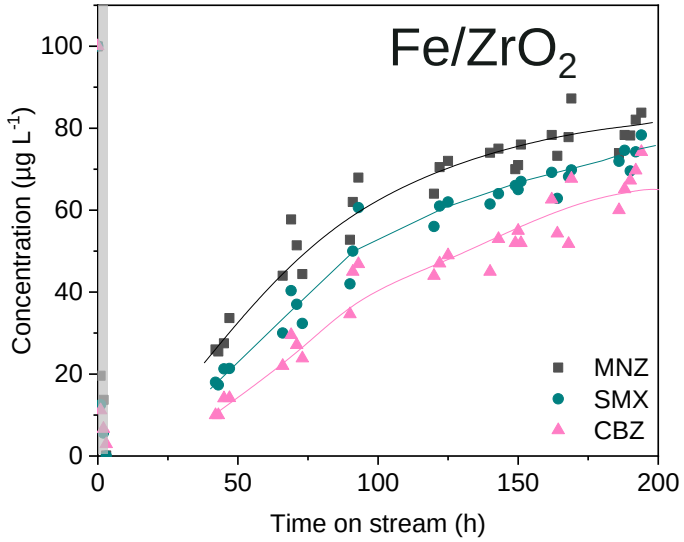


CWPO EXPERIMENTS

CATALYTIC ACTIVITY OF STRUCTURED CATALYSTIS

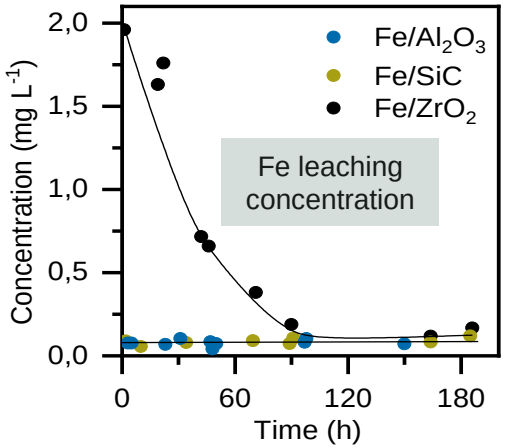






Operating conditions:
$[MNZ,SMX,CBZ]_0$= 100µg L^{-1}
[%Fe-foam]=0.9 – 2.5 %
H_2O_2= 1,49 mg L^{-1}
pH_0=5
20^{0}C
Q=1mL min^{-1}

Conversion (%)	Fe/Al_2O_3	Fe/SiC	Fe/ZrO_2
MNZ	25	15	--
SMX	35	25	--
CBZ	50	40	--

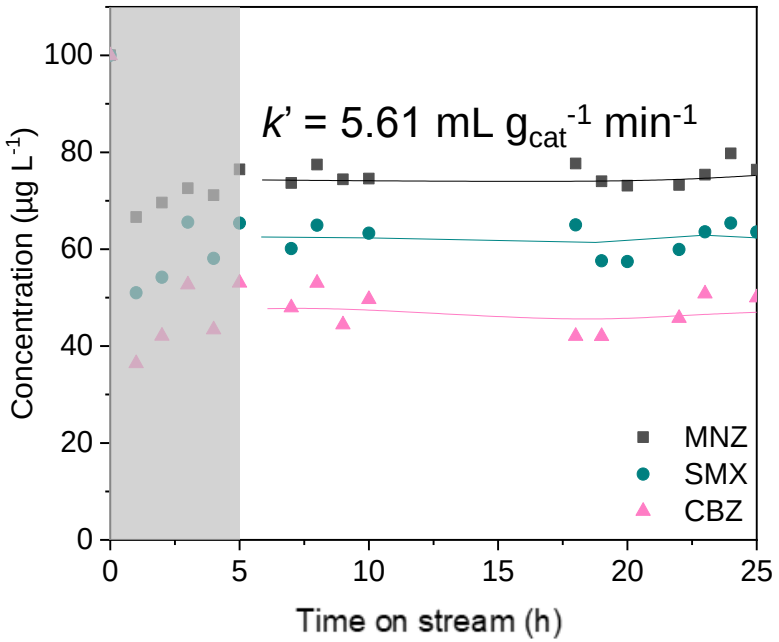


Fe load (%)	Prepared catalysts	Used catalysts
Fe/Al_2O_3	2.5	2.2
Fe/SiC	2.1	2.0
Fe/ZrO_2	0.9	0.5

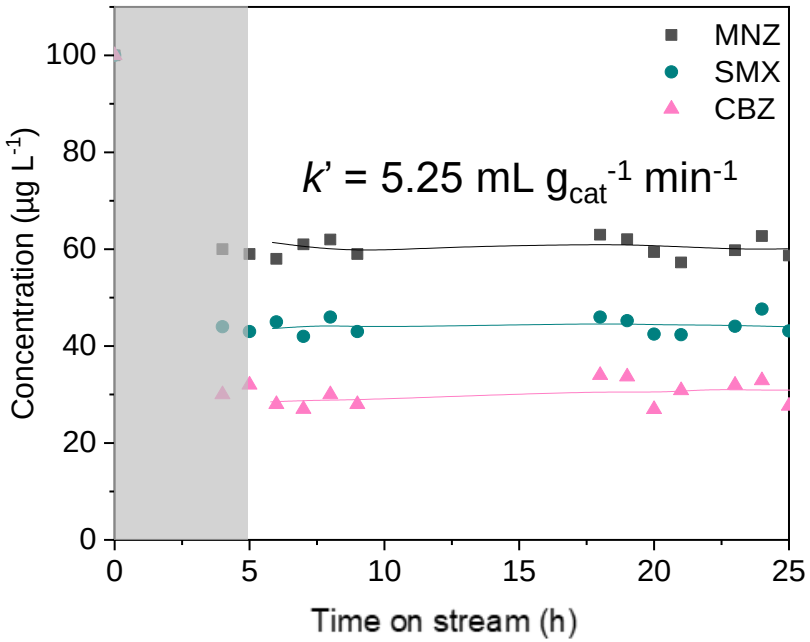
CWPO EXPERIMENTS

EFFECT FLOW RATE – Fe/Al_2O_3 foam

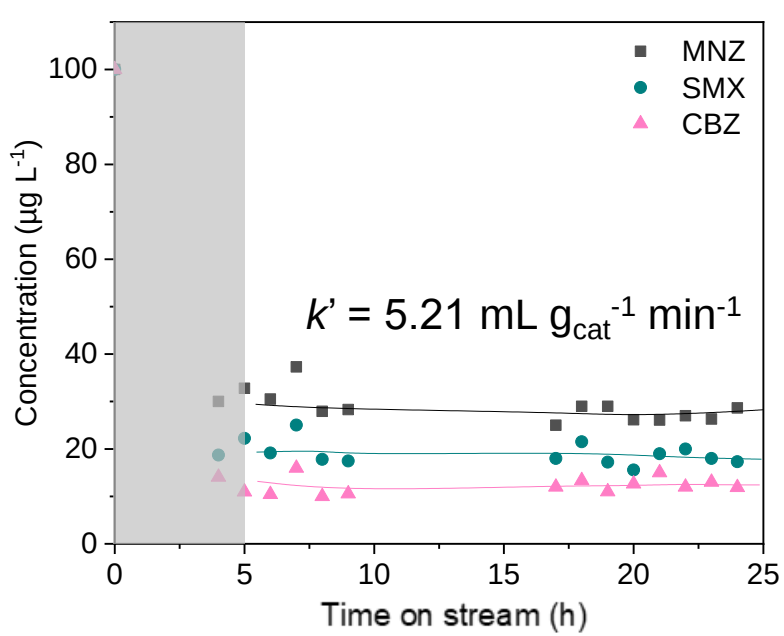
Q = 1 mL min^{-1}



Q = 0.5 mL min^{-1}



Q = 0.2 mL min^{-1}

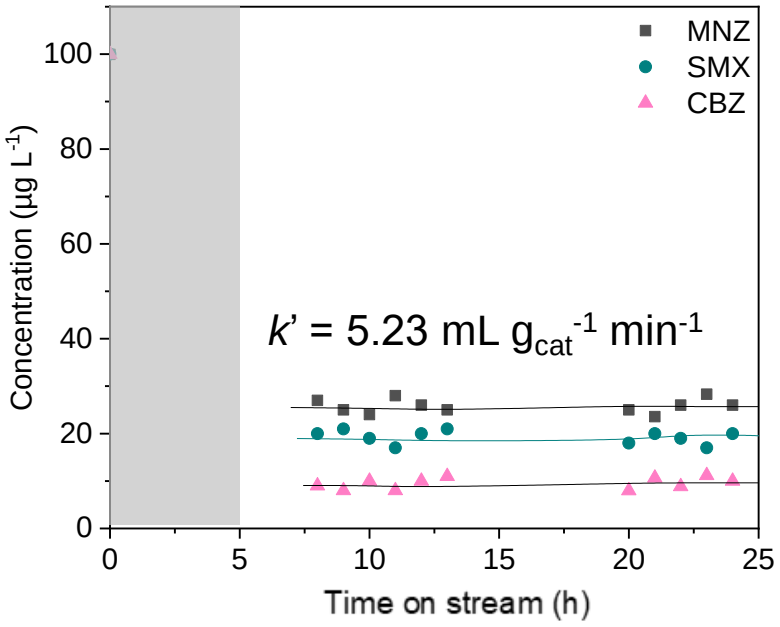


↑ Flow rate → ↓ Conversion

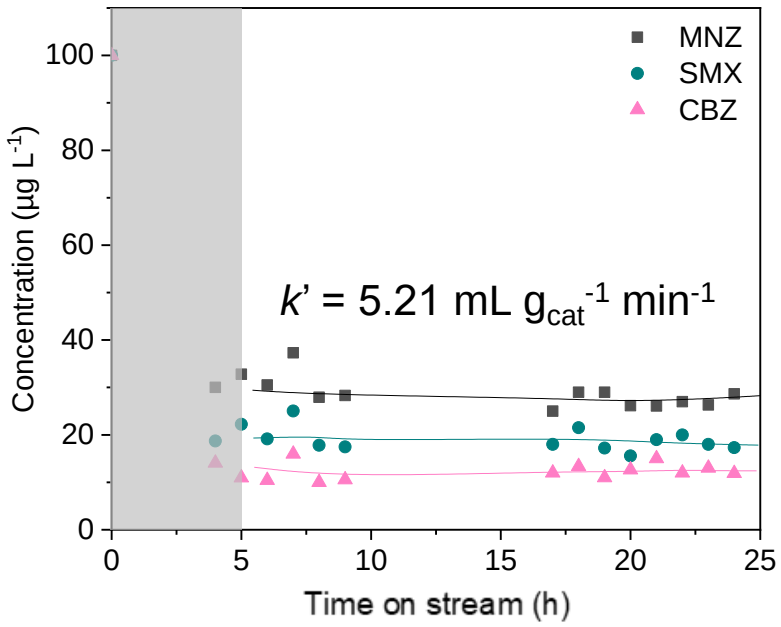
CWPO EXPERIMENTS

EFFECT H_2O_2 – Fe/Al_2O_3 foam

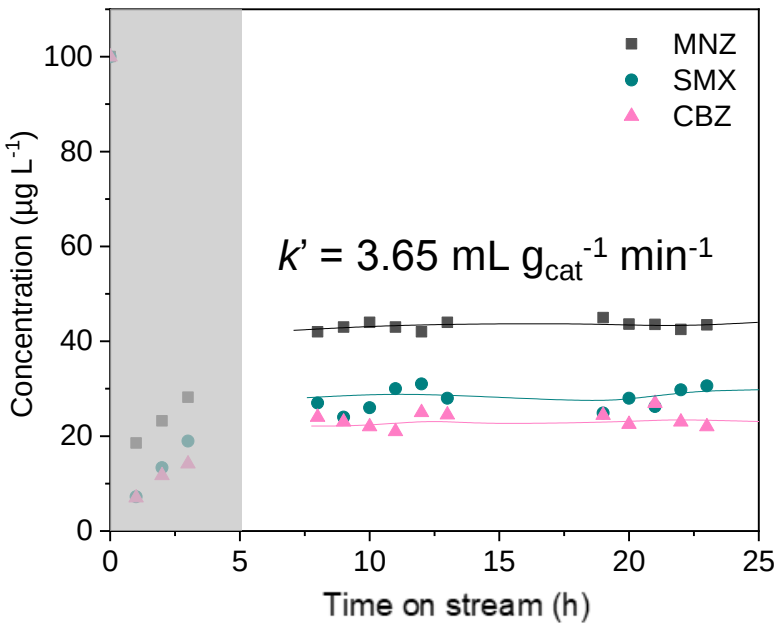
$[H_2O_2]$ = 0.75 mg L^{-1}



$[H_2O_2]$ = 1.49 mg L^{-1}



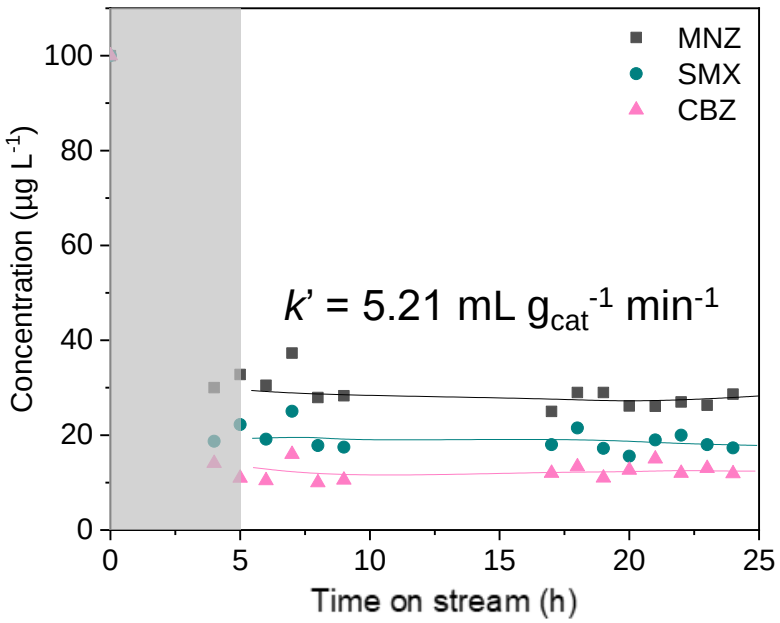
$[H_2O_2]$ = 2.98 mg L^{-1}



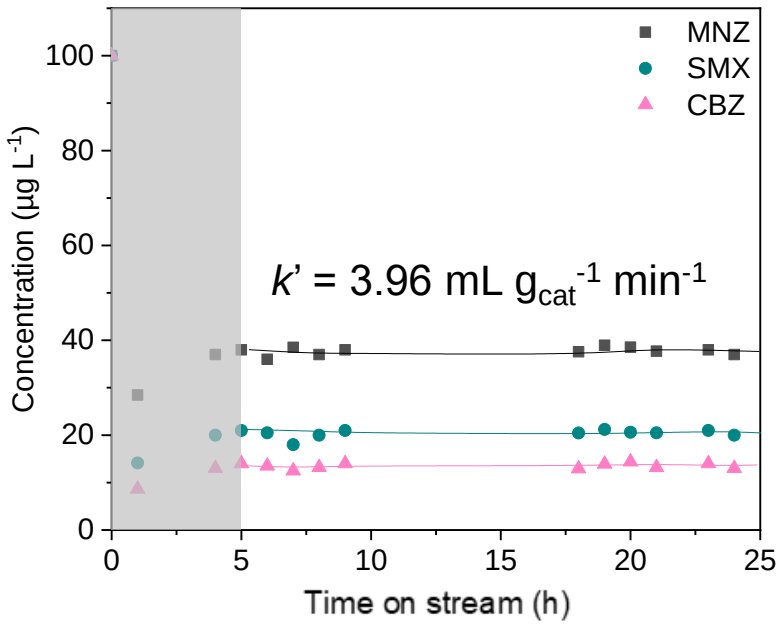
CWPO EXPERIMENTS

EFFECT of ORGANIC MATTER – Fe/Al_2O_3 foam

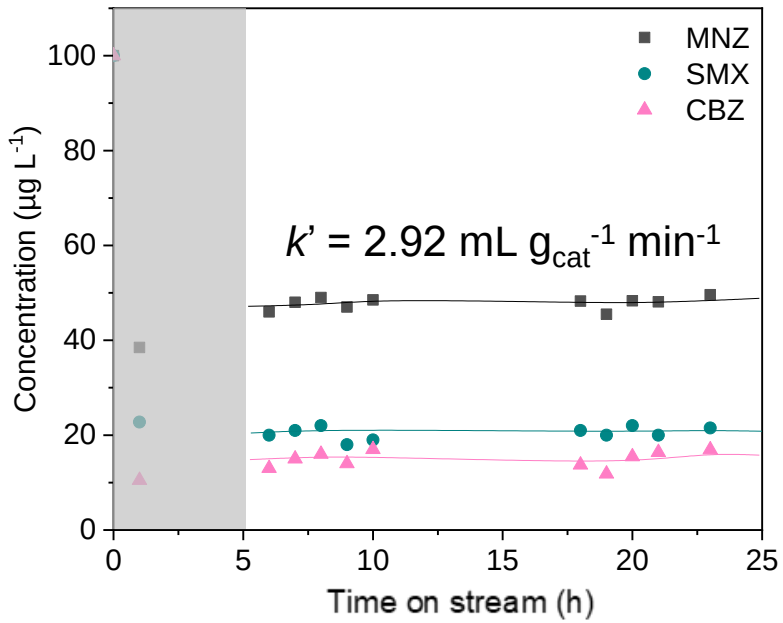
Deoinized water



[NOM] = 1 mg L^{-1}



[NOM] = 5 mg L^{-1}



CONCLUSIONS

- Structured foam catalysts were prepared by the coating with an active phase of iron oxide of Al_2O_3, SiC and ZrO_2 supports, showing an adequate homogeneity.
- Fe/Al_2O_3 and Fe/SiC catalysts, were active for the degradation of three pharmaceuticals (MNZ, SMX and CBZ) upon a continuous Fenton reaction up to 200 h, exhibiting a notably catalyst stability.
- The decrease of the feed flow led to higher activities and demonstrate the absence of mass transfer limitations.
- The presence of NOM in the reaction medium showed a positive stability and just a slight decrease in the MNZ reactivity was obtained, demonstrating the versatility of the system.

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