Orange peel waste using to obtain catalysts for caffeine degradation

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In 2021, 16 214 982 Tons of oranges were produced in Brazil, with the South Region responsible for 6.25% of production (IBGE, 2021). Even with defined destinations (i.e. export and commercialization within the country), it is natural that a lot of waste is generated due to the amount of production. With this in mind, research is needed to better use solid orange waste, specifically orange peel. This waste can be used for water treatment, such as textile industry wastewater (BEDOYA BETANCUR *et al.*, 2022), to remove toluidine blue (LAFI; REZMA; HAFIANE, 2015), methylene blue (GIRALDO *et al.*, 2022; MECHATI *et al.*, 2023), Cd^{2+} (GIRALDO *et al.*, 2022), and dyes (GUIZA; FRANCK; BAGANÉ, 2018) from aqueous solutions.

Magnetic nanocatalysts can be produced using orange peel extract for water treatment, due to advantages such as easy recovery at the end of the process and the efficiency of the catalytic activity of the metals that compose them (OLIVEIRA *et al.*, 2023; R.P. OLIVEIRA; G. LENZI, 2023). This application, in addition to being efficient for water treatment, promotes sustainability minimally by the application of the Principle of the Green Chemistry 3, 5, 7, and 9 (“Less hazardous chemical synthesis”, “Safer solvents and auxiliaries”, “Use of renewable feedstocks”, and “Catalysis”, respectively)(ANASTAS; WARNER, 1998) and the Sustainable Development Goals 6 and 12 ("Clean water and sanitation" and "Responsible consumption and production", respectively)(UNITED NATIONS DEVELOPMENT PROGRAMME, 2015).

Over 2.25 billion cups of coffee are consumed in the world daily (DRIVERESEARCH, 2024). Of course, coffee is not the only product that is caffeine-containing. But as a consequence of the high ingestion daily of this compound (by drinks, foods, drugs, among others), caffeine is one more emerging pollutant. Like other emerging pollutants, it involves research to know different ways to degrade it (DE ALMEIDA *et al.*, 2021).

In this research, magnetic nanocatalysts synthesized with orange peel, cobalt ferrite and niobium pentoxide was applied to the degradation of Caffeine by CWPO (Catalytic Wet Peroxide Oxidation), Figure 1. A design of experiments (DoE) was performed to evaluate the influence of temperature, pH and catalyst concentration in solution, Table1. Testing revealed that more than 70% of the caffeine was degraded. The study is being improved by degradation optimizations, as indicated by the results of DoE.

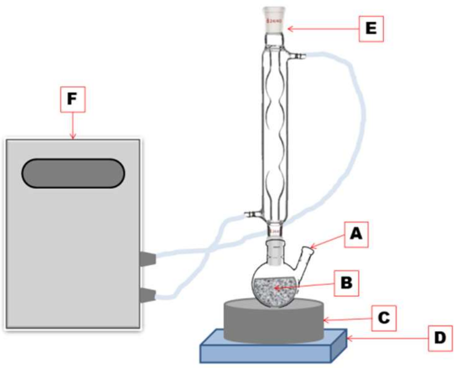

Figure 1. Scheme illustration of CWPO reaction. A) Reactor B) Solution with caffeine and catalysts C) Glycerin bath D) Stirring and temperature control plate E) Condenser F) Ultrathermostatic bath.

Table 1. Values of design of experiments to evaluate the caffeine degradation by CWPO.

Run	pH	Temperature (K)	catalyst concentration ($mg.L^{-1}$)	catalyst weight (g)
A	7.00	333	302	0.045
B	1.95	333	1000	0.150
C	4.00	353	1415	0.212
D	10.00	353	1415	0.212
E	4.00	353	585	0.088

F	12.05	333	1000	0.150
G	4.00	313	1415	0.212
H	4.00	313	585	0.088
I	10.00	353	585	0.088
J	10.00	313	585	0.088
K	10.00	313	1415	0.212
L	7.00	367	1000	0.150
M	7.00	299	1000	0.150
N	7.00	333	1698	0.255
O	7.00	333	1000	0.150
P	7.00	333	1000	0.150

Source: Authors (2024).

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