Electronic supplementary Information (ESI)

A sustainable waste plastic valorisation: Conversion of discarded polyurethane into active micro-cleaner using DES system

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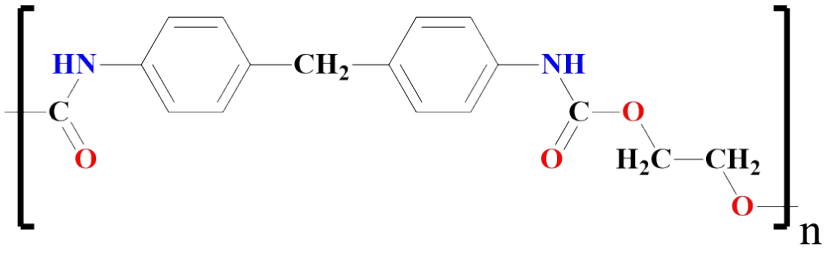
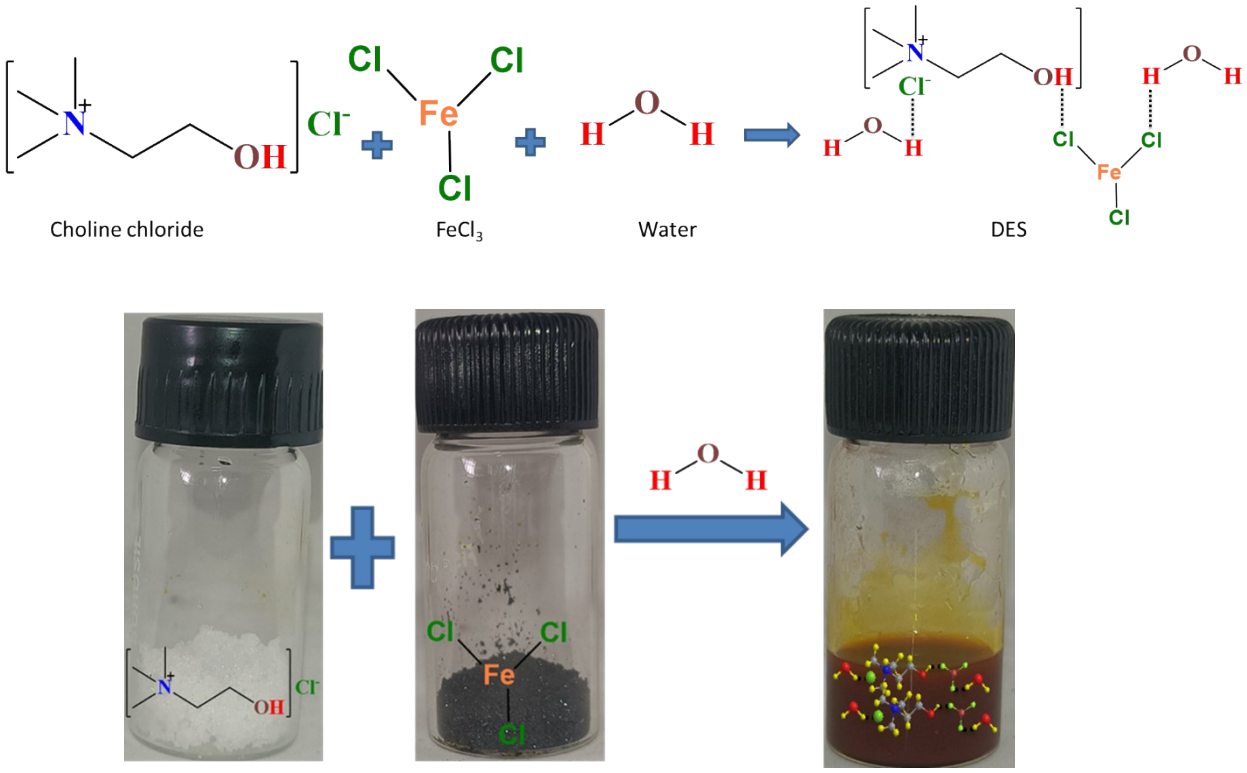
Table s1: Material code and composition of their reaction mass

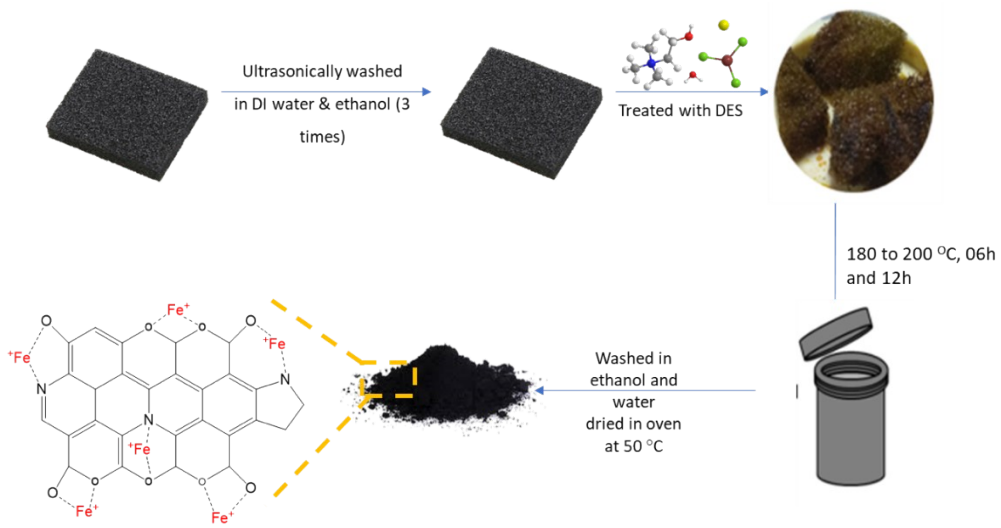
Code	Material in g	DES (CC-$FeCl_3$) in mL	Water in mL	% of DES	Reaction duration	Temp in °C	% Yield
PUC-0	3g PU	00	16	0	12h	180	--
PUC-1	3g PU	00	16	0	12h	200	35
PUC-2	3g PU	12	4	75	12h	200	33
PUC-3	3g PU	16	0	100	12h	200	34



Scheme s1: Chemical structure of the polyurethane



Scheme s2: Pictorial representation and reaction scheme of the DES preparation



Scheme s3: Schematic representation of the preparation of the active micro cleaners

Table S2: Detail of the contaminates

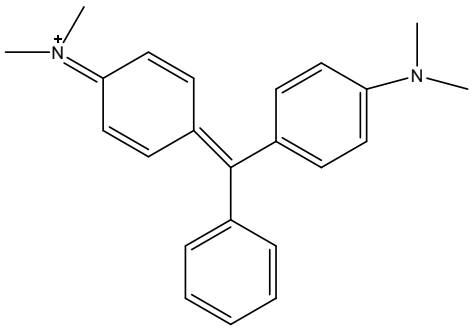
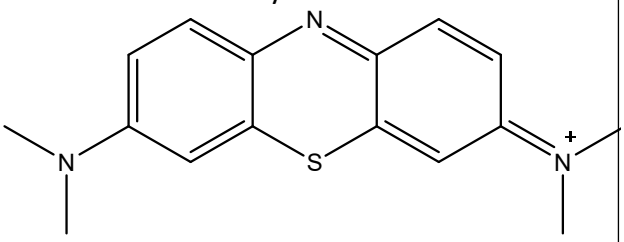
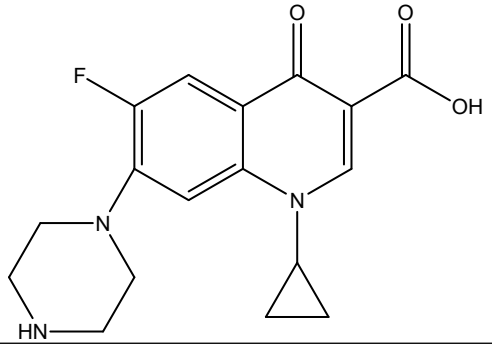
Sl no	Dye structure	Mol wt Mol/g	Charge	λ_{max} in nm
1	Malachite Green 	364.8 ($C_{23}H_{25}ClN_2$)	+	617
2	Methylene Blue 	319.85 ($C_{16}H_{18}ClN_3S$)	+	665
3	Ciprofloxacin 	331.34 ($C_{17}H_{19}ClFN_3O_3$)	Zwitter ion	276

Table S3: BET Surface area, pore volume and pore diameter of the materials.

Sl. no.	Sample code	Surface area ($m^2 g^{-1}$)	Pore volume ($cm^3 g^{-1}$)	Pore diameter (nm)
1	PUC-1	2.2609	0.00045041	0.7968
2	PUC-2	9.9629	0.014808	5.9451
3	PUC-3	2.0138	0.0012703	2.5233

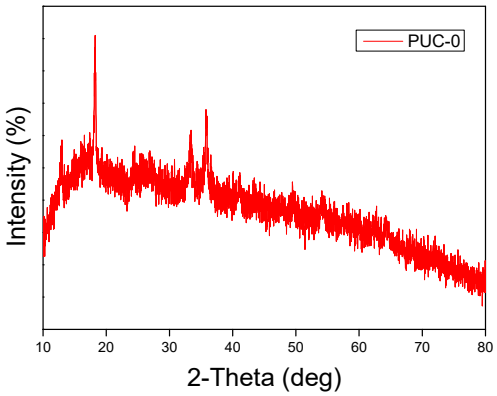


Figure s1: XRD data of PUC-0.

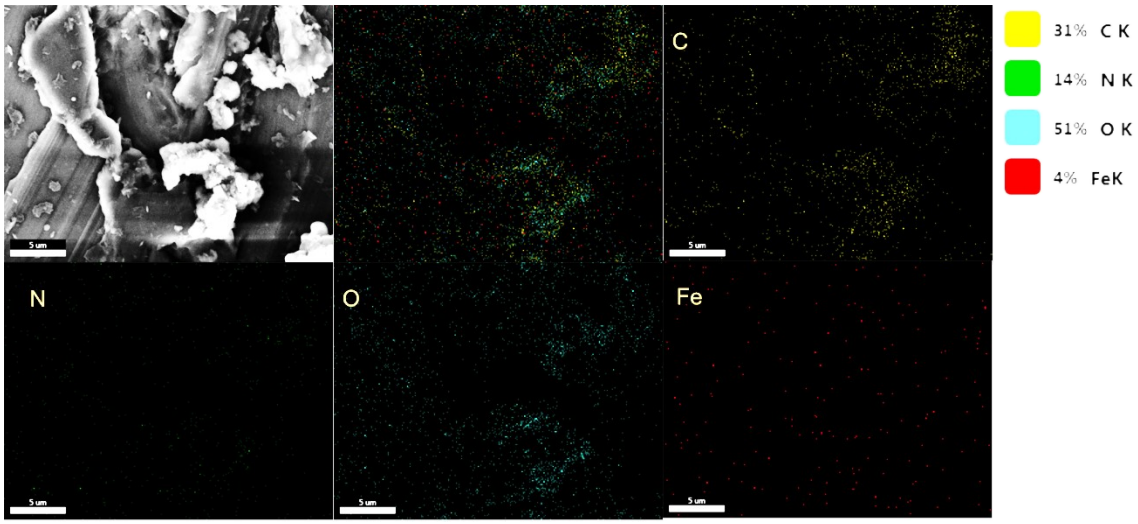


Figure-s2: EDAX mapping of the PUC-2 active micro cleaner

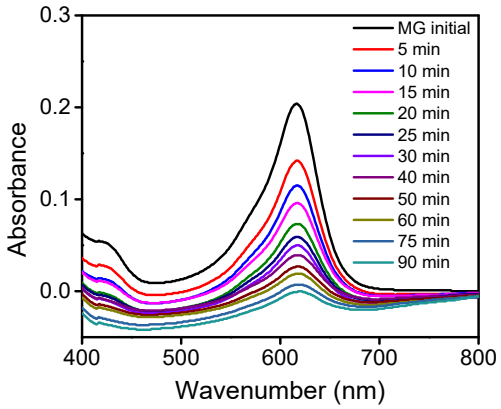


Figure-s3: UV spectra of the time dependent study PUC-3 active microcleaner

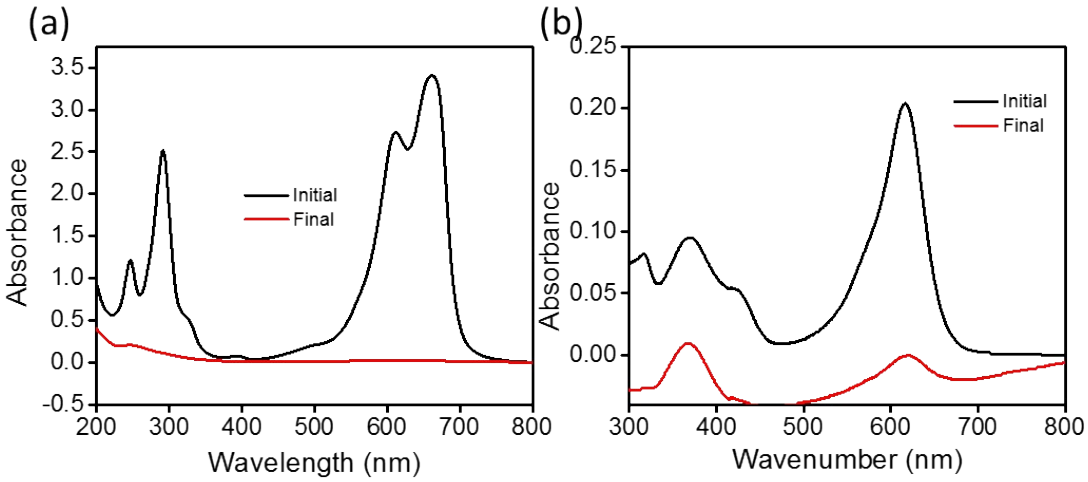


Figure-s4: Uv spectra of the (a) MB dye (b) MG dye

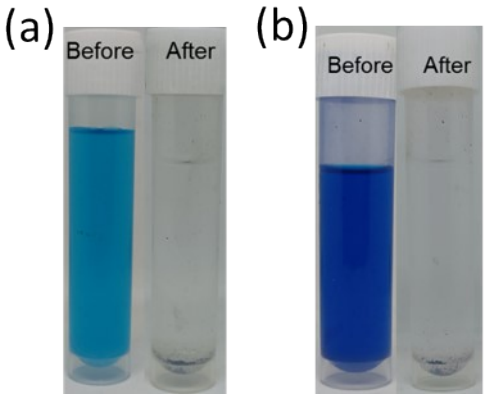


Figure-s5: Photographic images of the (a) MG dye before and after, (b) MB dye before and after

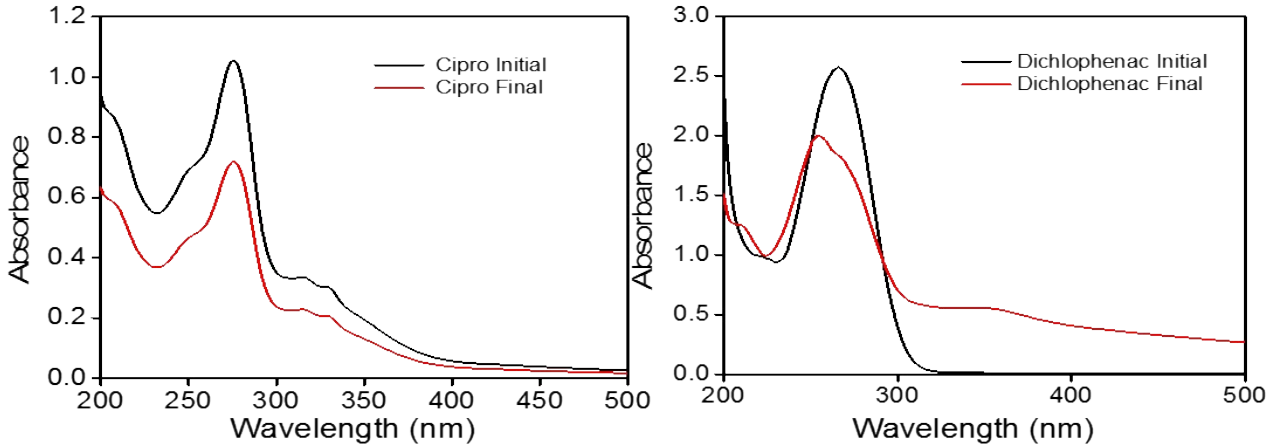


Figure-s6: UV spectra of the (a) ciprofloxacin (b) Dichlophenac

Section s1: Mechanisms of photo-Fenton self-cleaning

On the basis of the above results, an overview of possible mechanisms of photo-Fenton self-cleaning was described in following reaction process

$$Fe^{3+} + hv \rightarrow e^- + h^+ \quad (Ⅰ)$$

$$e^- + H_2O_2 \rightarrow {}^{\bullet}OH + OH^- \quad (Ⅱ)$$

$$h^+ + OH^- \rightarrow {}^{\bullet}OH \quad (Ⅲ)$$

$$^{\bullet}OH + R \rightarrow \text{Degraded products} \quad (Ⅳ)$$

In detail, Fe^{3+} is first excited and generated photo generated electrons (e-) and holes (h+) under Sunlight, which will trigger a series of reactions for the degradation of dye foulants (R). Subsequently, the e- could be transferred to the Fe^{3+} surface reacting with H_2O_2 to form the •OH radicals. In addition, the h+ on the valence band of Fe^{3+} also reacts with OH- to generate •OH radical. The strong oxidizing and non-selective •OH radicals can readily decompose dye foulants into H_2O and CO_2 completely. The excellent photo-Fenton self-cleaning performance of the PUC-2 membrane shows promising prospect in dye separation. In MB dye degradation initially, the $OH^{\bullet}$ and $O_2^{\bullet}$ radicals produced by the photo-Fenton reaction could destroy the chromophore canter of the MG molecule by demethylation cleavage and release, leading to the formation of small molecules. Finally destroy the aromatic ring intermediate leading into the small molecules.

Table s4: Comparison table with active micro cleaner.

Material	Contaminates	Adsorption Conditions	Adsorption Isotherm Model	Adsorption Kinetics	Maximum Adsorption Capacity, $mg.g^{-1}$	References
STC-2	MG	pH=7	Freundlich	Pseudo Second Order	689	1
C- HCS	RhB	pH=7	Langmuir	Pseudo Second Order	105.3	2
HM-CFB-FA	Cd^{2+}	pH=7	Langmuir	Pseudo Second Order	183.7	3
MNSBC	TC	pH=7	Langmuir	Pseudo Second Order	--	4

Rice straw hydrochars	CR	pH=7	Langmuir	Pseudo Second Order	222.1	5
Mn_3O_4/ AHC	MB	pH = 7 T = 298 K	Langmuir	Pseudo Second Order	113.37	6
PUC-2	MG MB	pH = 7 T = 298 K	Langmuir	Pseudo Second Order	144 128	**Present work**

In this work, we compared with different hydrothermal prepared active microcleaners and their performance described in the literature (Table s3). One such study by Manohar et al. used the Solvothermal approach in conjunction with a glucose-based eutectic system and $FeSO^4$. The synthesised compound exhibited a 689.7 mg g^{-1} adsorptive capacity. According to Wu et al., a straightforward hydrothermal carbonization process was used to manufacture cassava slag biochar from agricultural waste cassava slag. removed 96% of Rhodamine B from an aqueous solution; the largest amount of Rhodamine B that could be adsorbed was 105.3 $mg.g^{-1}$ [2]. In another study, Qiu et al. used hydrothermally modified CFB fly ash as an adsorbent material to remove Cd2+ from wastewater. The maximum amount of Cd2+ that could be absorbed was 183.7 mg/g [3]. According to Ma et al., simple one-pot hydrothermal technology was used for the first time to create Magnetic N-doped sludge biochar (MNSBC). MNSBC has a maximum adsorption capacity of 197.3 mg/g at 298 K [4]. According to Li et al., a microwave-assisted hydrothermal treatment method was used to manufacture a number of rice straw hydrochars. Congo red has a maximum adsorption capacity of 222.1 $mg.g^{-1}$ [5]. According to Smitha et al., a more environmentally friendly solvothermal approach was used to create functional carbon helices (HTCs) that resemble tendrils using the deadly bio-weed Parthenium hysterophorus as the carbon source. a strong Mn_3O_4/AHC composite with 113 mg g^{-1} of MG dye adsorption capability [6].

References:

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3. R. Qiu, F. Cheng and H. Huang, *Journal of Cleaner Production*, 2018, **172**, 1918-1927.
4. Y. Ma, T. Lu, J. Tang, P. Li, O. Mašek, L. Yang, L. Wu, L. He, Y. Ding, F. Gao, X. Qi and Z. Zhang, *Separation and Purification Technology*, 2022, **297**, 121426.
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