Electronic Supplementary Material (ESI) for Environmental Science: Nano.

Supplementary Information for: Sustainable and scalable development of PVDF-OH Ag/TiO_x nanocomposites for simultaneous oil/water separation and pollutant degradation

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1. **Permeate flux**

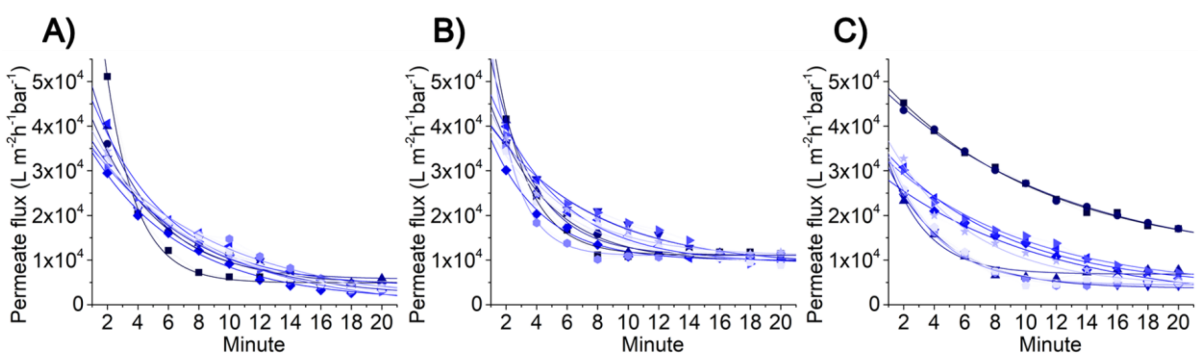

Figure S1: Set of graphs displaying the fitted permeate fluxes of the nanocomposites prepared at the pH 2 (A), original pH (B), and pH 11 (C).

Table S1. Fitting of permeate flux in each cycle

Sample	Cycle	Permeate flux fit	Estimated permeate after 1 month
pH 2	1	4932+127848 · exp(-0.51184 · x)	**4932**
	2	4522+46256 · exp(-0.22075 · x)	**4522**
	3	5670+56482 · exp(-0.2673 · x)	**5670**
	4	1641+40887 · exp(-0.15555 · x)	**1641**
	5	887+39190 · exp(-0.1644 · x)	**887**
	6	4044+50908 · exp(-0.19875 · x)	**4044**
	7	-604+40835 · exp(-0.13084 · x)	**0**
	8	305+38729 · exp(-0.11574 · x)	**305**

	9	2811+42907 · exp(-0.17186 · x)	**2811**
	10	-44+40914 · exp(-0.13024 · x)	**0**
pH 7.1	1	11115+78943 · exp(-0.47383 · x)	**11115**
	2	9650+44919 · exp(-0.26282 · x)	**9650**
	3	11042+61360 · exp(-0.35609 · x)	**11042**
	4	8754+36420 · exp(-0.15094 · x)	**8754**
	5	9915+35917 · exp(-0.2914 · x)	**9915**
	6	9260+46570 · exp(-0.21775 · x)	**9260**
	7	8485+36210 · exp(-0.1458 · x)	**8485**
	8	11000+81971 · exp(-0.60588 · x)	**11000**
	9	10994+39650 · exp(-0.22358 · x)	**10994**
	10	9050+36071 · exp(-0.20097 · x)	**9050**
pH 11	1	10325+41971 · exp(-0.09362 · x)	**10325**
	2	9209+41255 · exp(-0.08432 · x)	**9209**
	3	6861+37369 · exp(-0.39876 · x)	**6861**
	4	3676+35050 · exp(-0.26109 · x)	**3676**
	5	245+30314 · exp(-0.0923 · x)	**245**
	6	3773+33858 · exp(-0.12639 · x)	**3773**
	7	3466+31820 · exp(-0.10741 · x)	**3466**
	8	4374+39204 · exp(-0.30942 · x)	**4374**
	9	4025+39178 · exp(-0.18341 · x)	**4025**
	10	4612+40266 · exp(-0.30791 · x)	**4612**

2. **Rejection rates details**

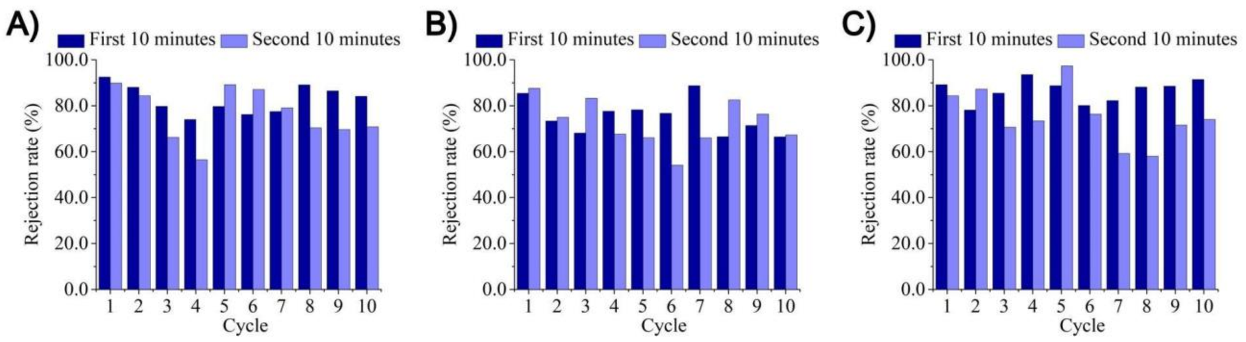

Figure S2: Set of graphs displaying the rejection rates of the nanocomposites prepared at the pH 2 (A), original pH (B), and pH 11 (C) over a period of first and second 10 minutes in 20 min cycles.

3. **Catalytic contact time**

The calculation of the catalytic contact time is determined according to the following set of formulas, where the volumetric flux can be described as the rate of volume flow across a unit area *S*, which is, in our case, the effective membrane area.

$$volumetric\ flux = \frac{rate\ of\ volume\ flow}{S} \qquad (S1)$$

$$t = \frac{h}{volumetrix\ flux} \qquad (S2)$$

The catalytic contact time is the ratio between the decorated membrane thickness h and the calculated volumetric flux. The values for each cycle are displayed in Fig.S3.

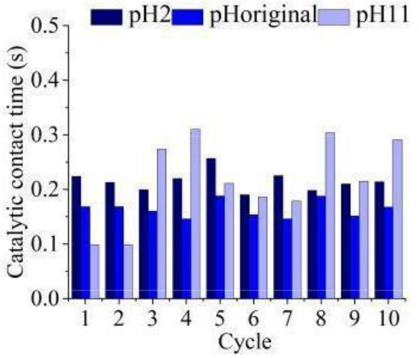

Figure S3: Catalytic contact time

4. **Economic sustainable footprint analysis**

Table S2. Material cost

Material	Amount	Price (€)	Supplier
$AgNO_3$	per 1 g	3.3	SigmaAldrich
Ti foil	per 1 g	1.1	SigmaAldrich
dH_2O	per 1 L	0.11	Envichem
Isopropanol	per 1 L	9.4	Penta s.r.o.
KOH	per 1 g	2.5	Fluka
PET support	per 10 m^2	3.75	Mogul
Adhesive web	per 10 m^2	0.98	-
Glass bathtub	1 piece	10.9	P-Lab
Laser batch	1 piece	8.8	Thermofisher

Table S3. Instruments cost

Instrument	Price (€)	Supplier
Laser and optical system	112 558	NKT Photonics
Magnetic stirrer	162	Vevor

Table S4. Instruments' lifetime

Instrument	Time (h)
Laser and optical system	100 000
Magnetic stirrer	10 000
Laser batch	2 600
Glass bathtub	2 600

Table S5. Energy consumption of different parts of the setup, while the cost of 1 kWh in Czechia was 0.11599 EUR during 2022 (www.kurzy.cz/komodity/cena-elektriny-graf-vyvoje-ceny/).

Item	Power (kWh)
Laser	0.5
Computer	0.2
Scanning head	0.3
Magnetic stirrer	0.02
Heating (Heat-press process)	1.0
Pressing (Heat-press process)	7.2

Table S6. Non-industrially-optimized laser production

Material	Production (mg/h)
NPs	5.8
Ag	2.0
Ti	3.8

Table S7. Non-industrially-optimized laser irradiation times, which are necessary for the preparation of 1 m^2 nanocomposite. Since the element distributions on the nanocomposites vary depending on the employed pH, different irradiation times are necessary for producing the required amount of material.

Modification pH	**Time (h)**
2	24.4
original	3.6
11	36.9

Table S8. Additional parameters associated with the preparation of 1 m^2 membrane. The PVDF nanofibers are prepared by electrospinning, then integrated into a PET nonwoven support by a heat-press process, and finally dehydrofluorinated to allow the addition of NPs.

Item	**Cost (€)**	**Preparation time (h)**	**Amount of material**	**Supplier**
PVDF nanofibers	8.54	-	-	Elmarco
Heat-press	0.95	1	-	Pracovní stroje Teplice s.r.o.
Adhesive web	0.98	-	per 10 m^2	Sigma Aldrich
PET support	3.75	-	per 10 m^2	Mogul
Consumed KOH	0.09	1	0.04 g	Fluka
Consumed isopropanol	0.11	1	30 mL	Penta s.r.o.

Table S9. PVDF microfilter membranes available on the market.

Product	**Dimensions**	**Supplier**	**Price**
PVDF membrane, pore size 0.45 µm	diameter 4.7 cm, 200 pcs	Membrane Solutions	115 €
PVDF membrane, pore size 0.3 µm	30.5 x 30.5 cm	Synder filtration	102 €
PVDF membrane, pore size 0.45 µm	diameter 14.2 cm, 50 pcs	Durapore	656 €
PVDF membrane, pore size 0.45 µm	26.5 cm x 375 cm	Thermo Scientific	452 €

a. RLAL OPEX and CAPEX calculations

Note that IRT represents irradiation time.

$$IRT = \mathrm{MAX}\left(\frac{amount\ of\ element\ (Ag,Ti)\ on\ the\ membrane}{production\ of\ element\,(Ag,Ti)\ \ per\ hour}\right) \qquad \text{(S3)}$$

$$Energy\ cost\ of\ RLAL = \ cost\ per\ kWh\ x\ laser\ setup\ power\ x\ IRT \qquad \text{(S4)}$$

$$Ag\ cost = AgNO3\ price\ x\ \frac{M(AgNO3)}{M(Ag)}\ x\ silver\ production\ x\ IRT \qquad \text{(S5)}$$

$$Ti\ cost = \ titanium\ foil\ price\ x\ titanium\ production\ x\ IRT \qquad \text{(S6)}$$

$$dH2O\ cost = \ dH2O\ price\ x\ volume\ of\ dH2O\ consumed\ during\ IRT \qquad \text{(S7)}$$

$$RLAL\ OPEX = Energy\ cost\ of\ RLAL + Ag\ cost + Ti\ cost + dH2O\ cost \quad (S8)$$

$$Laser\ usage\ cost = \frac{Laser\ setup\ cost}{Laser\ setup\ lifetime}\ x\ IRT \quad (S9)$$

$$Other\ RLAL\ CAPEX = \left(\frac{Magnetic\ stirrer\ cost}{Magnetic\ stirrer\ lifetime} + \frac{Laser\ batch\ cost}{Batch\ lifetime}\right)\ x\ IRT \quad (S10)$$

$$RLAL\ CAPEX = Laser\ usage\ cost + Other\ CAPEX \quad (S11)$$

b. **Heat-press process and alkalizations process cost calculations**

Note that HP is an abbreviation for heat-press process and AT represents alkalization time.

$$Energy\ cost\ of\ HP = HP\ time\ x\ cost\ per\ kWh\ x\ HP\ power \quad (S12)$$

$$HP\ cost = Energy\ cost\ of\ HP + Adhesive\ web\ price + PET\ price \quad (S13)$$

$$KOH\ cost = KOH\ price\ x\ amount\ of\ KOH\ on\ the\ membrane \quad (S14)$$

$$Isopropanol\ cost = Isopropanol\ price\ x\ consumed\ isopropanol \quad (S15)$$

$$Alkalization\ cost = KOH\ cost + Isopropanol\ cost + \left(\frac{Glass\ bathtub}{Bathtub\ lifetime} + \frac{Magnetic\ stirrer\ cost}{Magnetic\ stirrer\ lifetime} + magnetic\ stirrer\ power\ x\ cost\ per\ kWh\right)\ x\ AT \quad (S16)$$

5. **Table of Content**

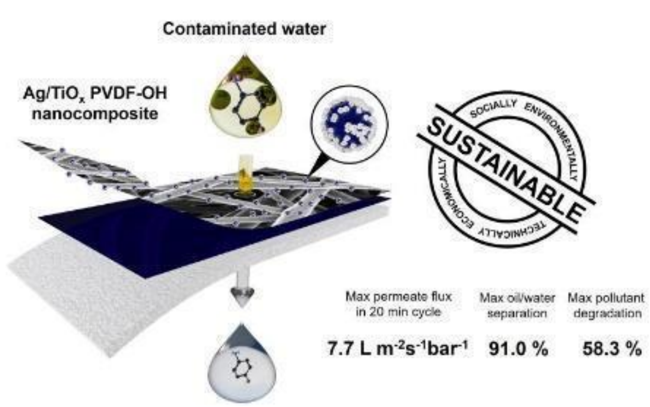

Figure S4: Freshwater scarcity remains a global challenge, often exacerbated by oil contamination. The current study tackles this issue by cleaning oily wastewater while removing its dissolved organic pollutants with PVDF-OH Ag/TiO_x sustainable nanocomposites.