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**Biocatalytic degradation of pharmaceuticals, personal care products,
industrial chemicals, steroid hormones and pesticides in a membrane
distillation-enzymatic bioreactor**

(Supplementary Data)

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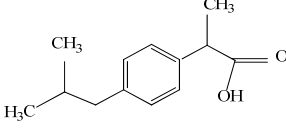
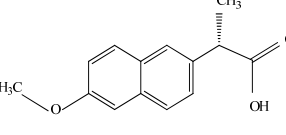
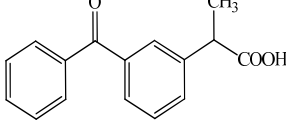
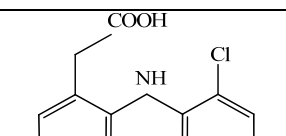
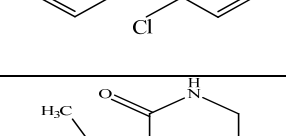
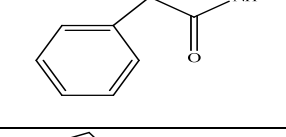
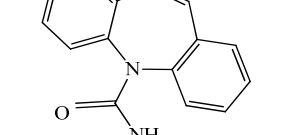
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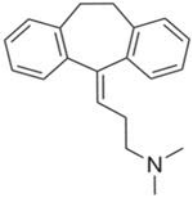
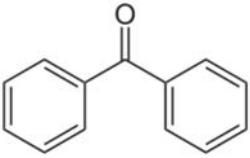
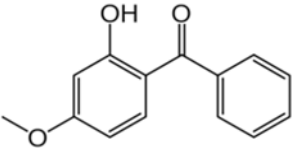
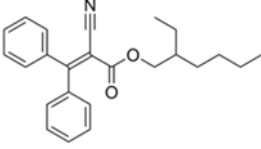
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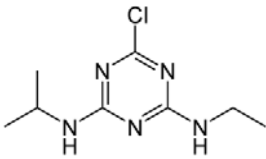
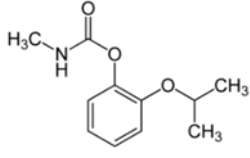
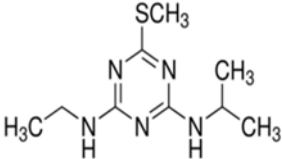
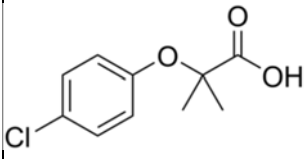
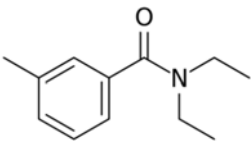
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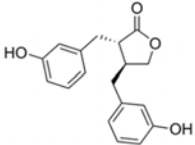
Table S1: Physicochemical properties of the selected trace organic contaminants (TrOCs)

Category	Compound (Formula) (CAS number)	Molecular weight (g/mol)	Log K _{OW} ^a	Log D (pH 7) ^a	Dissociation constant (pK _a) ^a	Limit of detection (ng/L) ^b	Chemical structure
Pharmaceuticals	Ibuprofen (C ₁₃ H ₁₈ O ₂) (5687-27-1)	206.28	3.50 ± 0.23	0.94	4.41 ± 0.10	20	
	Naproxen (C ₁₄ H ₁₄ O ₃) (22204-53-1)	230.26	2.88 ± 0.24	0.73	4.84 ± 0.30	1	
	Ketoprofen (C ₁₆ H ₁₄ O ₃) (22071-15-4)	254.28	2.91 ± 0.33	0.19	4.23 ± 0.10	20	
	Diclofenac (C ₁₄ H ₁₁ Cl ₂ NO ₂) (15307-86-5)	296.15	4.55 ± 0.57	1.77	4.18 ± 0.10 -2.26 ± 0.50	5	
	Primidone (C ₁₂ H ₁₄ N ₂ O ₂) (125-33-7)	218.25	0.83 ± 0.50	0.83	12.26 ± 0.40 -1.07 ± 0.40	10	
	Carbamazepine (C ₁₅ H ₁₂ N ₂ O) (298-46-4)	236.27	1.89 ± 0.59	1.89	13.94 ± 0.20 -0.49 ± 0.20	10	
	Salicylic acid (C ₇ H ₆ O ₃) (69-72-7)	138.12	2.01 ± 0.25	-1.13	3.01 ± 0.10	1	

	Metronidazole (C ₆ H ₉ N ₃ O ₃) (443-48-1)	171.15	-0.14 ± 0.30	-0.14	14.44 ± 0.10 2.58 ± 0.34	20	
	Gemfibrozil (C ₁₅ H ₂₂ O ₃) (25812-30-0)	250.33	4.30 ± 0.32	2.07	4.75	1	
	Amitriptyline C ₂₀ H ₂₃ N (50-48-6)	277.40	4.40±0.26	2.28	9.18±0.28	1	
Personal care products	Triclosan (C ₁₂ H ₇ Cl ₃ O ₂) (3380-34-5)	289.54	5.34 ± 0.79	5.28	7.80 ± 0.35	1	
	Benzophenone C ₁₃ H ₁₀ O (119-61-9)	182.22	3.21 ± 0.29	3.21	-	5	
	Oxybenzone C ₁₄ H ₁₂ O ₃ (131-57-7)	228.24	3.99±0.36	3.89	7.56±0.35	5	
	Octocrylene C ₂₄ H ₂₇ N O ₂ (6197-30-4)	361.48	6.89±0.33	6.89	-	10	

Pesticides	Fenoprop (C ₉ H ₇ Cl ₃ O ₃) (93-72-1)	269.51	3.45 ± 0.37	-0.13	2.93	20	
	Pentachloro-phenol (C ₆ HCl ₅ O) (87-86-5)	266.34	5.12 ± 0.36	2.85	4.68 ± 0.33	1	
	Atrazine (C ₈ H ₁₄ ClN ₅) (1912-24-9)	215.68	2.636±0.205	2.64	2.27±0.10	10	
	Propoxur (C ₁₁ H ₁₅ NO ₃) (114-26-1)	209.24	1.538±0.229	1.54	12.28±0.46 - 1.49±0.70	1	
	Ametryn (C ₉ H ₁₇ N ₅ S) (843-12-8)	227.33	2.967±0.12	2.97	3.71±0.41	10	
	Clofibric acid (C ₁₀ H ₁₁ ClO ₃) (882-09-7)	214.65	2.425±0.273	-1.06	3.18 ±0.10	1	
	DEET (C ₁₂ H ₁₇ NO) (134-62-3)	191.27	2.42 ± 0.23	2.42	-1.37 ± 0.7	1	

Industrial chemicals	4-tert-butylphenol (C ₁₀ H ₁₄ O) (98-54-4)	150.22	3.39 ± 0.21	3.40	10.13 ± 0.13	1	
	4-tert-octylphenol (C ₁₄ H ₂₂ O) (140-66-9)	206.32	5.18 ± 0.20	5.18	10.15 ± 0.15	1	
	Bisphenol A (C ₁₅ H ₁₆ O ₂) (80-05-7)	228.29	3.64 ± 0.23	3.64	10.29 ± 0.10	1	
Steroid hormones	Estrone (C ₁₈ H ₂₂ O ₂) (53-16-7)	270.37	3.62 ± 0.37	3.62	10.25 ± 0.40	5	
	17β-estradiol (C ₁₈ H ₂₄ O ₂) (50-28-2)	272.38	4.15 ± 0.26	4.15	10.27	5	
	17β-estradiol 17-acetate (C ₂₀ H ₂₆ O ₃) (1743-60-8)	314.42	5.11 ± 0.28	5.11	10.26 ± 0.60	5	
	17α-ethinylestradiol (C ₂₀ H ₂₄ O ₂) (57-63-6)	269.40	4.10 ± 0.31	4.11	10.24 ± 0.60	10	
	Estriol (E3) (C ₁₈ H ₂₄ O ₃) (50-27-1)	288.38	2.53 ± 0.28	2.53	10.25 ± 0.70	10	

Phytoestrogens	Enterolactone C ₁₈ H ₁₈ O ₄ (78473-71-9)	298.33	1.89± 0.37	1.89	9.93± 0.10	10	
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^a Source: SciFinder database <https://scifinder.cas.org/scifinder/view/scifinder/scifinderExplore.jsf>

Log *D* is logarithm of the distribution coefficient which is the ratio of the sum of concentrations of all forms of the compound (ionised and unionised) in octanol and water at a given pH.

^bLimit of detection (LOD) of the compounds during GC-MS analysis as described in Section 2.5.2. LOD is defined as the concentration of an analyte giving a signal to noise (S/N) ratio greater than 3. The limit of reporting was determined using an S/N ration of greater than 10.

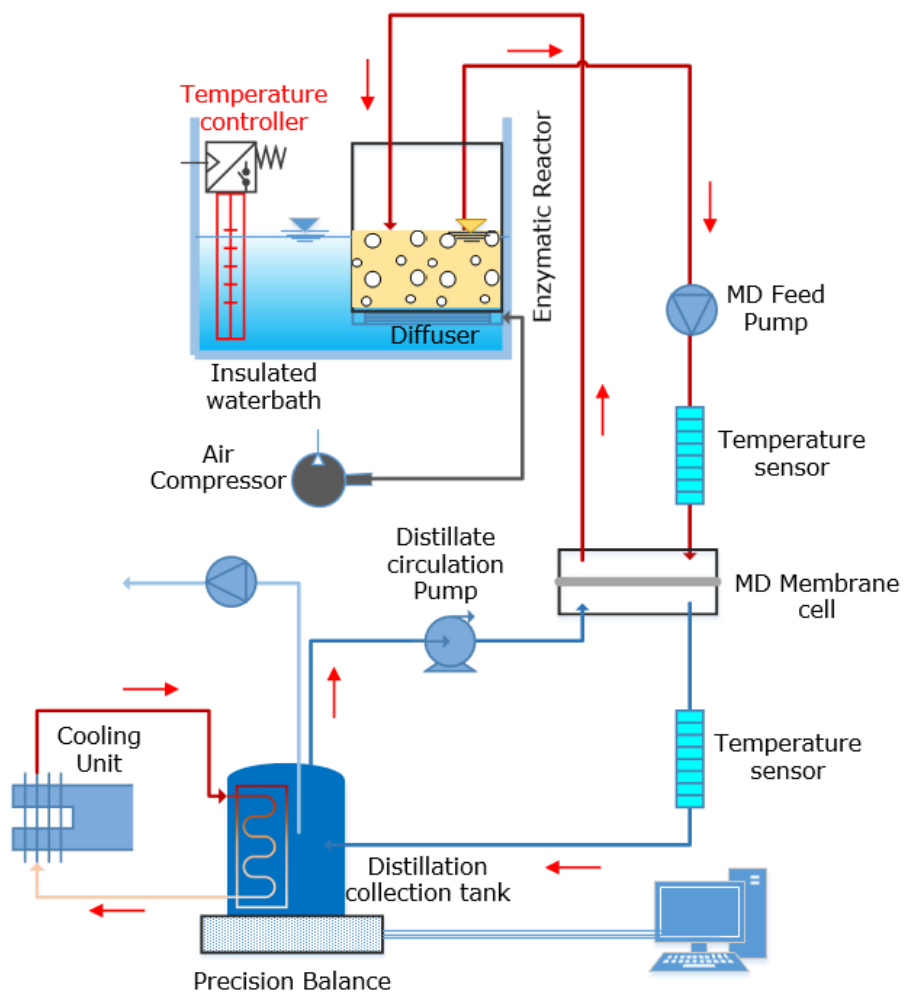


Figure S2. Lab-scale membrane distillation – enzymatic membrane bioreactor (MD-EMBR)

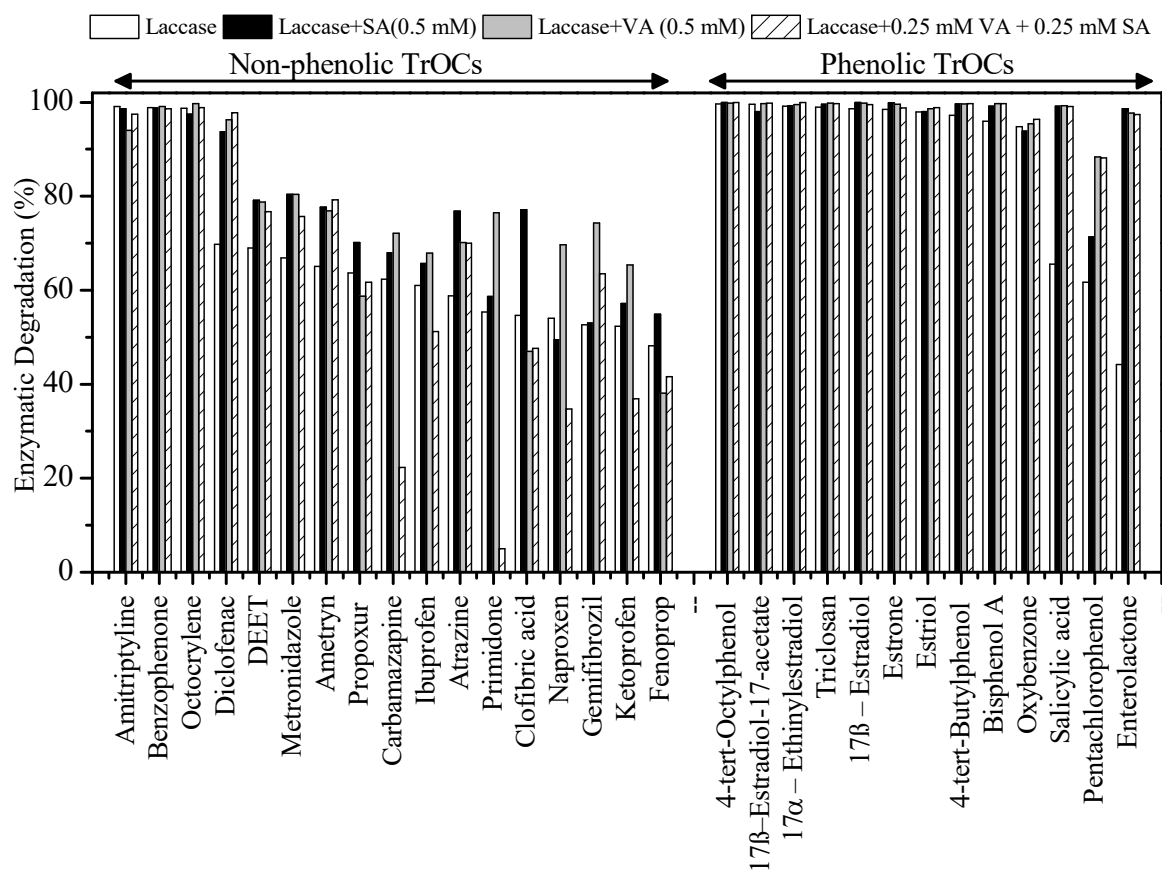


Figure S3. Comparison of the degradation capacity of laccase, SA, VA and SA-VA mixture.

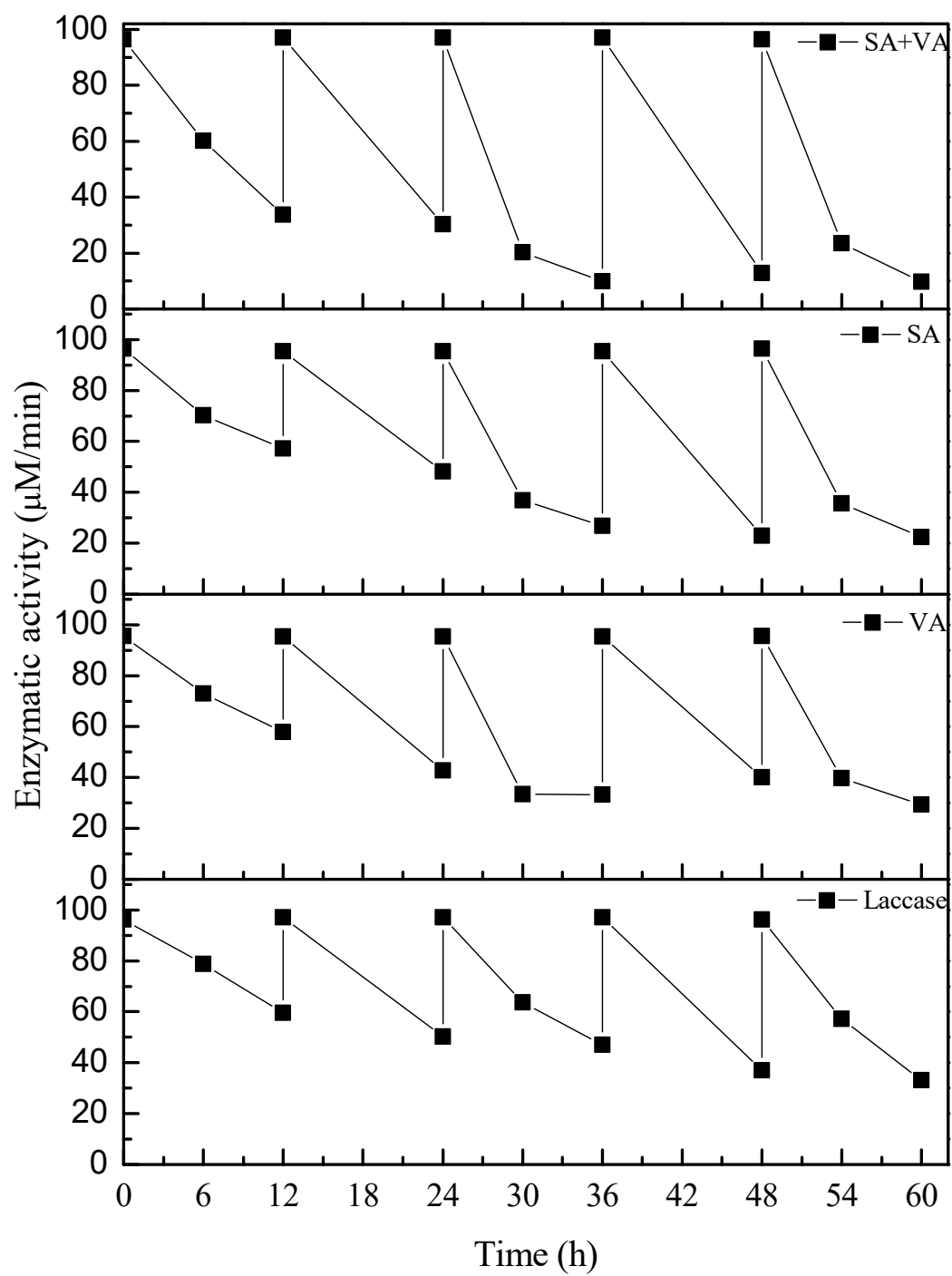


Figure S4. Enzymatic activity profiles with and without the addition of redox mediator(s).

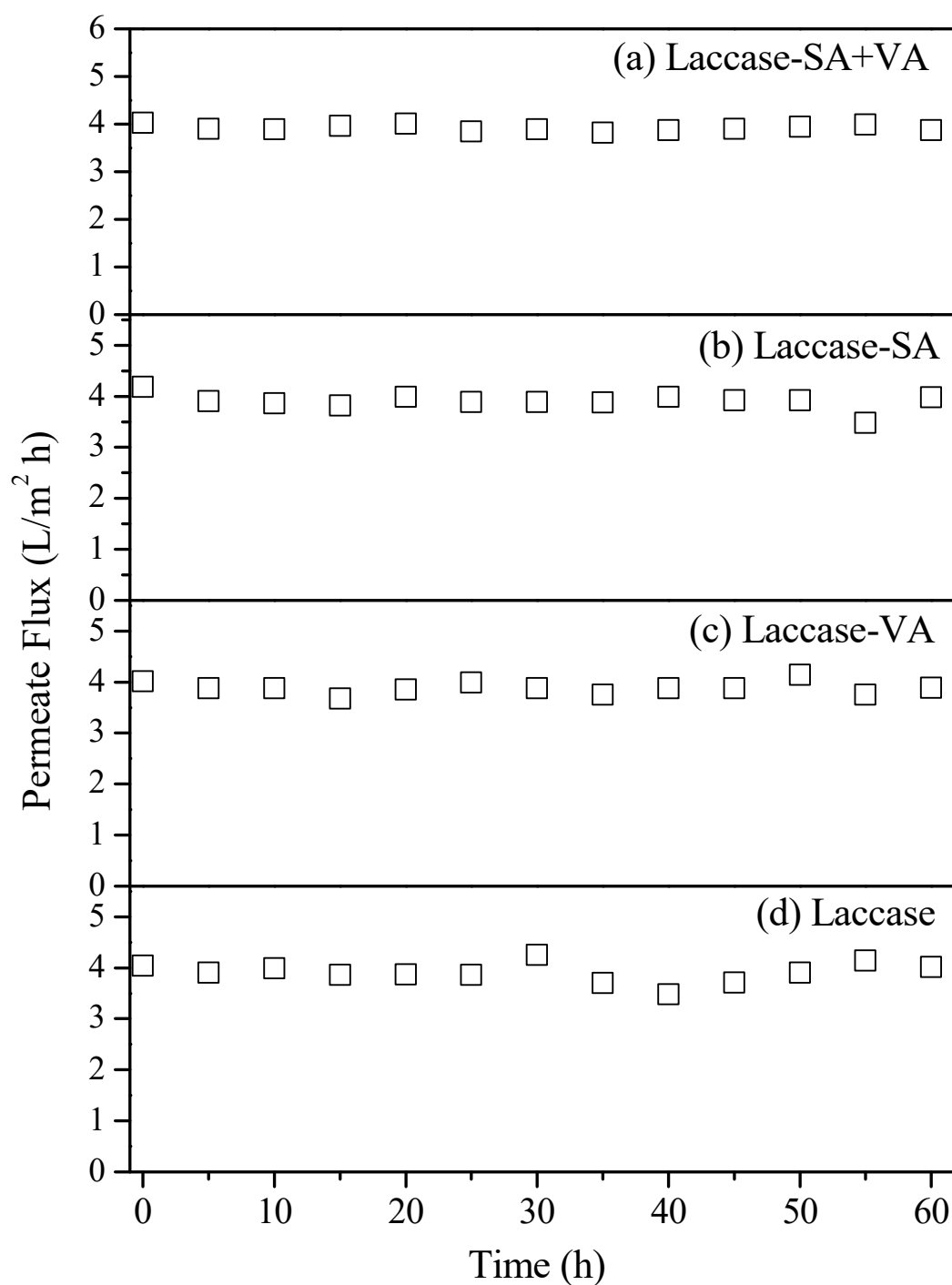


Figure S5. Permeate flux obtained during the operation of enzymatic membrane distillation (MD-EMR) with and without the addition of mediators. Feed and distillate temperature were controlled at 30 and 10 °C, respectively during all experiments. The cross-flow rate of both feed and distillate side was set at 1 L/min (corresponding to a cross-flow velocity of 9 cm/s).