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Co-immobilization of PPL and GOx on DUT-5/PVDF hybrid membranes and the catalytic activity in the cascade oxidation of glucose and styrene

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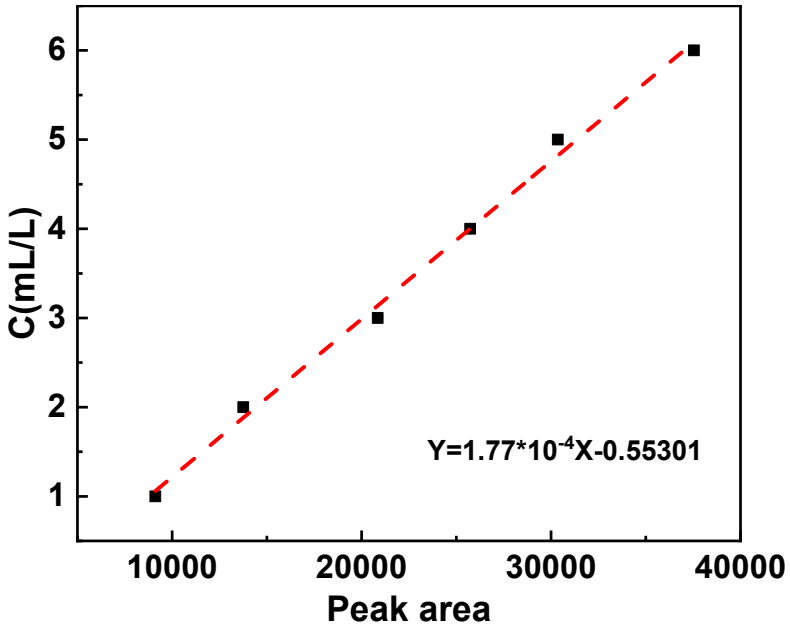

Fig. S1 The working curve of styrene oxide obtained from GC analyses. The standard curve equation is Y=0.000177*X-0.55301, and the linear correlation coefficient R^2 = 0.9944.

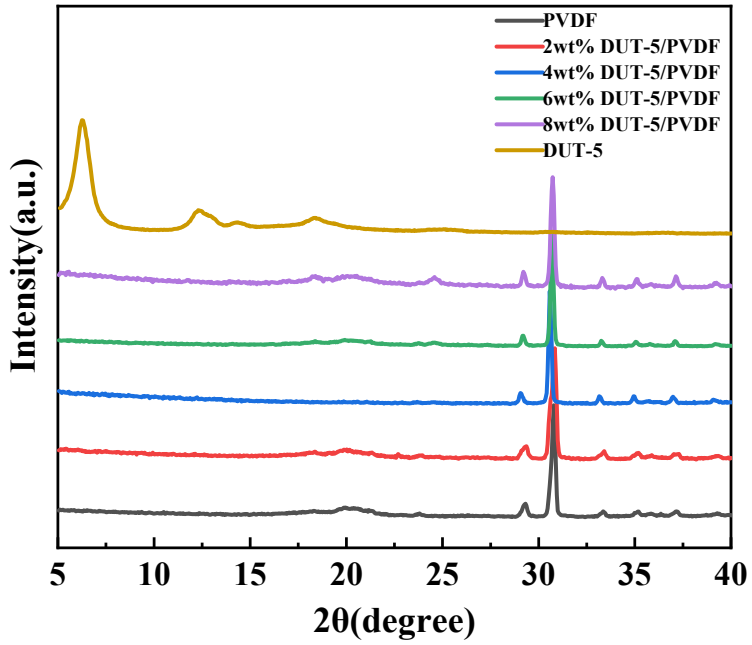

Fig. S2 The XRD patterns of DUT-5, PVDF and DUT-5/PVDF hybrid membranes

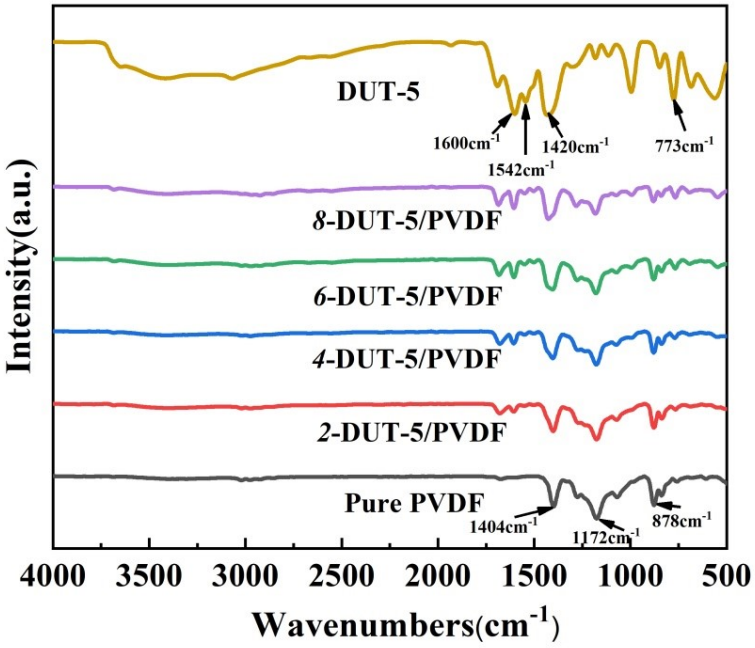

Fig. S3 The FT-IR spectra of PVDF, DUT-5 and DUT-5/PVDF hybrid membranes

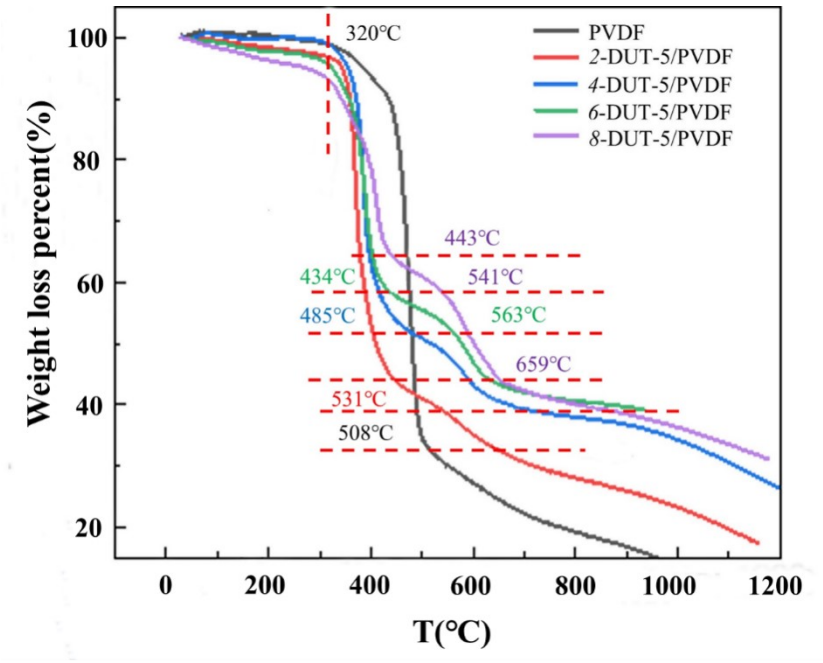

Fig. S4 TG curves of PVDF and DUT-5/PVDF hybrid membranes

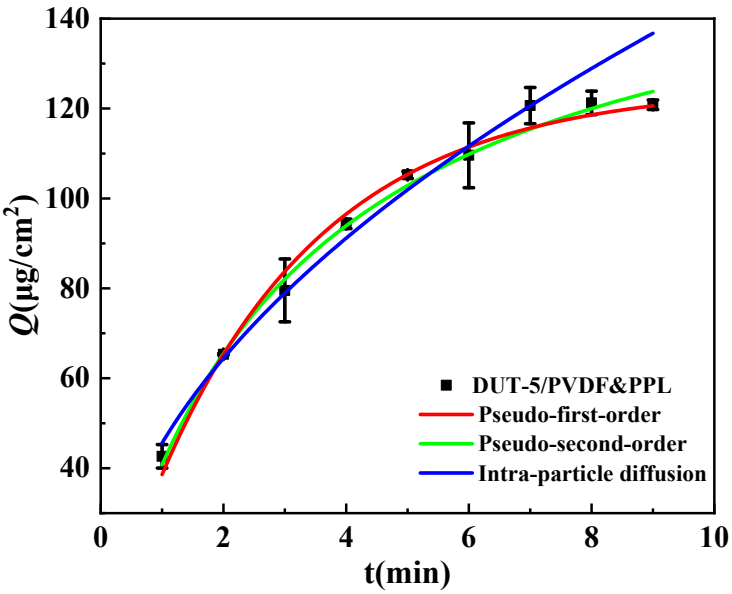

Fig. S5 Fitting curves of the adsorption kinetics of PPL on hybrid membranes by using pseudo-first, pseudo-second, and intra-particle models

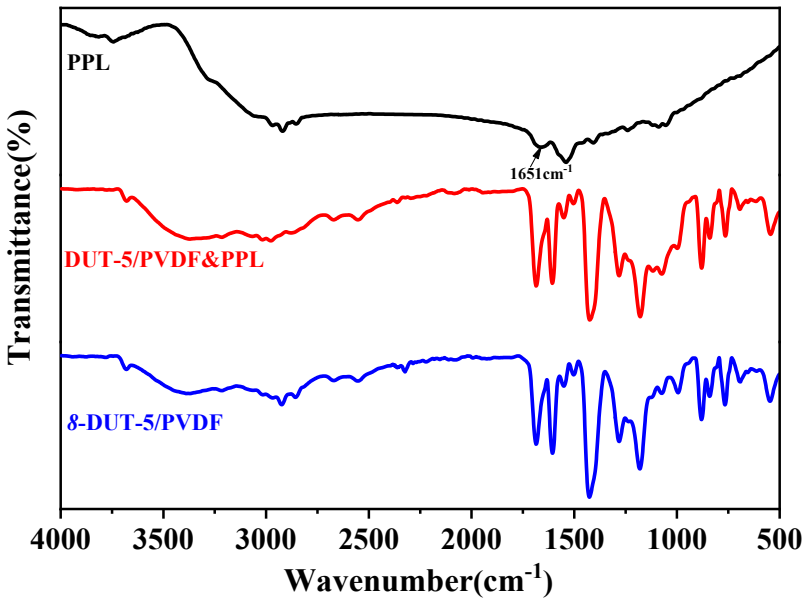

Fig. S6 The FT-IR spectra of PPL, *8*-DUT-5/PVDF and DUT-5/PVDF&PPL hybrid membranes

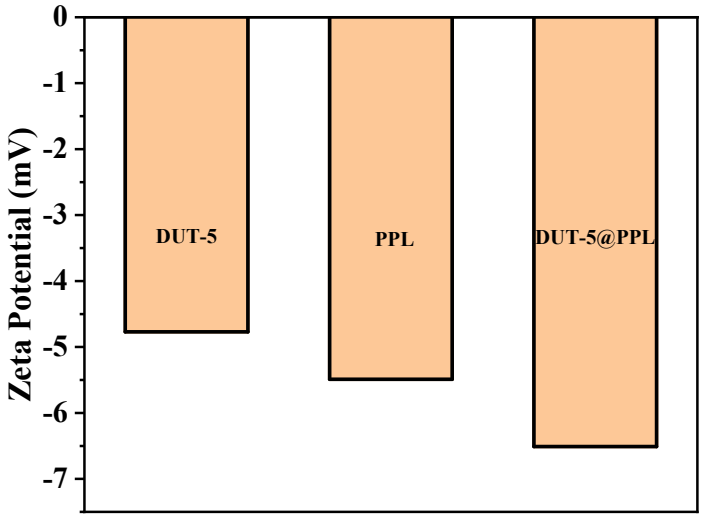

Fig. S7 Zeta potentials of DUT-5, PPL and DUT-5@PPL

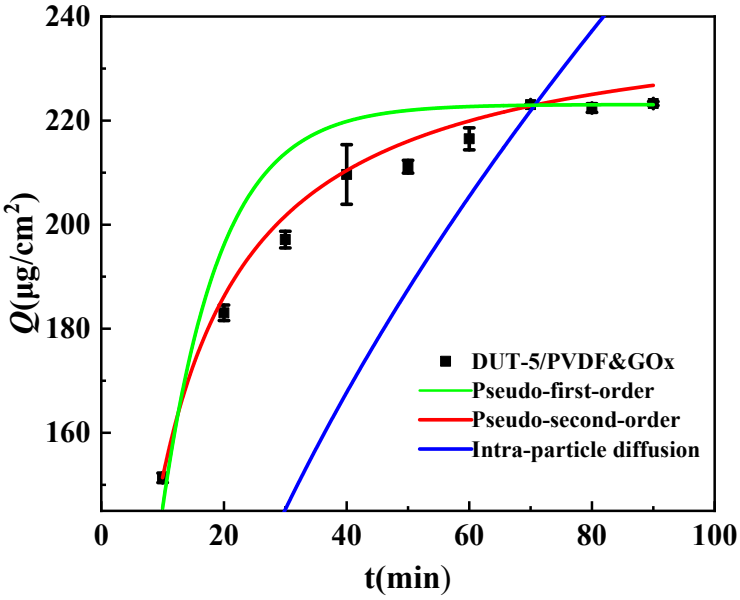

Fig. S8 Fitting curves of GO_X on hybrid membranes by using pseudo-first, pseudo-second and intra-particle models

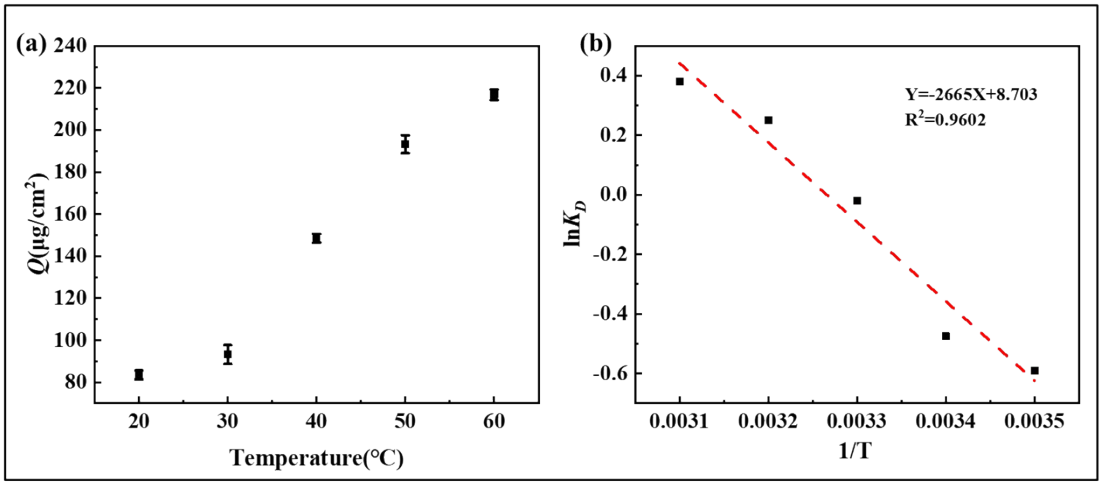

Fig. S9 (a) Adsorption capacities of GOx on DUT-5 /PVDF at different temperature; (b) Plots of $\ln K_D$ versus $1/T$ for GOX adsorption on DUT-5/PVDF

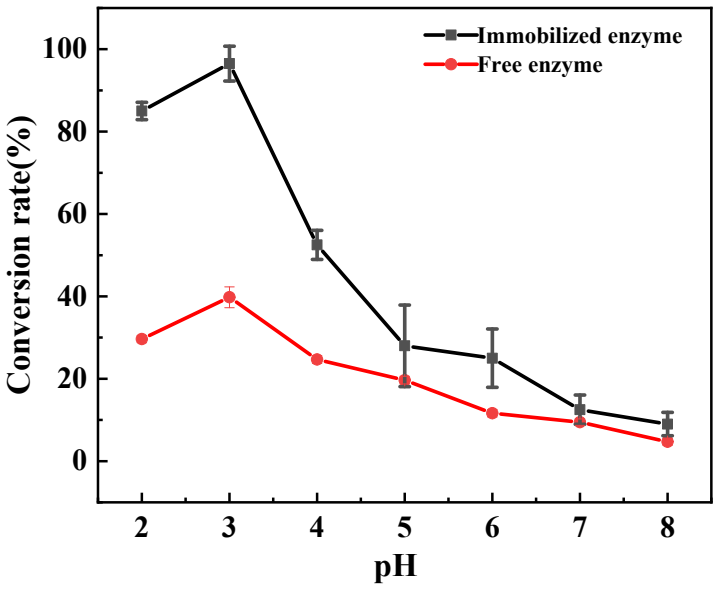

Fig. S10 The conversion rates of styrene catalyzed by the co-immobilized enzymes and free enzymes at changed pH varied from 2.0 to 8.0.

Table. S1 Simulating parameters of the adsorption isotherm for PPL on the hybrid membranes by using Langmuir and Freundlich models

Enzyme	Langmiur			Freundlich		
	Q_m (μg/cm^2)	K_a (L/mg)	R^2	K_F (mg$^{1-1/n}$L$^{1/n}$/g)	n	R^2
PPL	154.17	3.23	0.9812	116.45	3.21	0.9161

Table. S2 Simulating parameters of the adsorption kinetic of GO_X on DUT-5/PVDF by using the kinetics models

Sample		*6*-DUT-5/PVDF&GOx
pseudo-first order	q_e(μg·cm^{-2})	223.08
	k_1(min^{-1})	0.1056
	R^2	0.9484
pseudo-second order	q_e(μg·cm^{-2})	244.83
	k_2(cm^2·μg^{-1}min^{-1})	0.0069
	R^2	0.9786
Internal diffusion	K_d(μg·cm^{-2}min$^{-1/2}$)	26.5224
	R^2	-1.07

Table. S3 Calculated adsorption isotherm parameters for GO_X on DUT-5/PVDF by using the Langmuir and Freudlich equations

Sample	Langmiur			Freundlich		
	Q_m (μg/cm^2)	K_a (L/mg)	R^2	K_F (mg$^{1-1/n}$L$^{1/n}$/g)	n	R^2
GO_X	330.05	2.1239	0.9695	217.18	3.195	0.8760

Table. S4 The thermodynamic parameters for GOx adsorption on DUT-5/PVDF

Adsorbents	Temperature (K)	ΔH^Θ (kJ·mol^{-1})	ΔS^Θ (J·mol^{-1}·K^{-1})	ΔG^Θ (kJ·mol^{-1})
DUT-5/PVDF&GO_X	293	22.156	72.357	0.956
	303			0.233
	313			-0.491
	323			-1.214
	333			-1.938