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Lipase immobilization on UiO-66/poly(vinylidene fluoride) hybrid membranes and active catalysis in vegetable oil hydrolysis

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Table S1 The detailed conditions for the synthesis of U-*x*/PVDF hybrid membranes

membranes	m (UiO-66 particles, g)	m (PVDF, g)	m (PVP, g)	V (DMF, mL)
PVDF	0	7.0	1.0	43.30
U-1/PVDF	0.07	6.93	1.0	42.87
U-3/PVDF	0.21	6.79	1.0	42.00
U-10/PVDF	0.70	6.30	1.0	38.97
U-15/PVDF	1.05	5.95	1.0	36.81

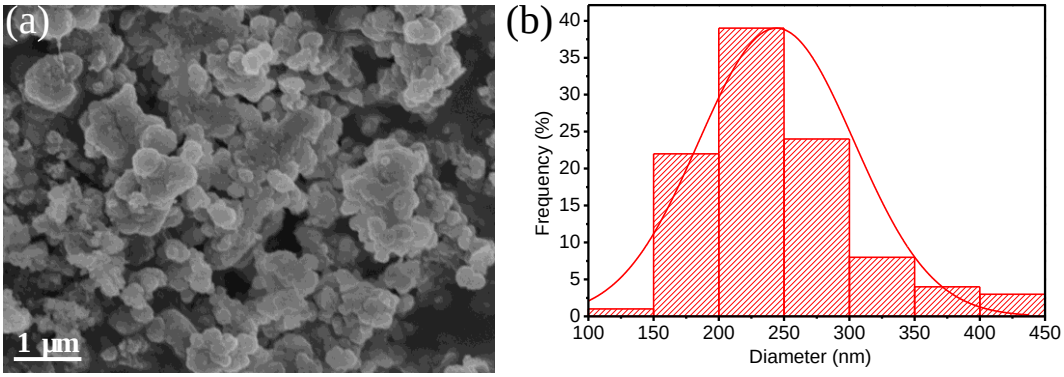

Fig. S1 (a) SEM image of UiO-66 particles and (b) corresponding size distribution.

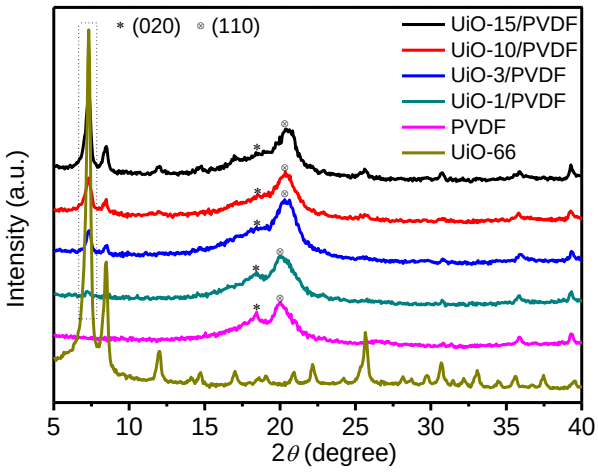

Fig. S2 XRD patterns of pristine UiO-66, PVDF and U-*x*/PVDF hybrid membranes.

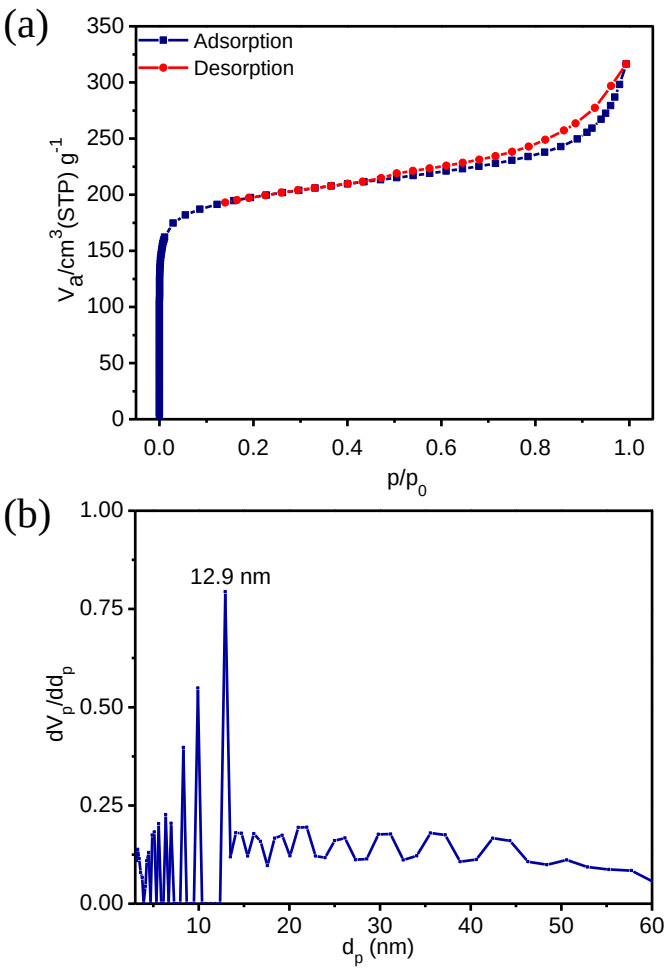

Fig. S3 (a) N_2 adsorption-desorption curves and (b) corresponding pore size distribution of UiO-66 particles.

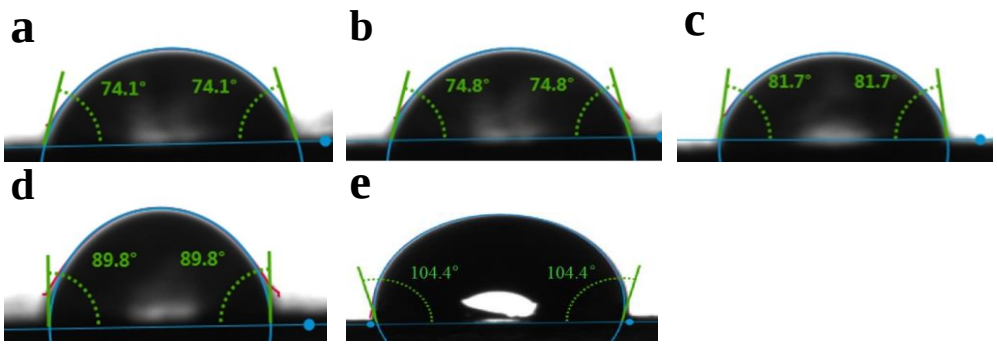

Fig. S4 The surface water contact angle (CA) of PVDF (a) and U-*x*/PVDF (b-e): (b) U-1/PVDF; (c) U-3/PVDF; (d) U-10/PVDF; (e) U-15/PVDF.

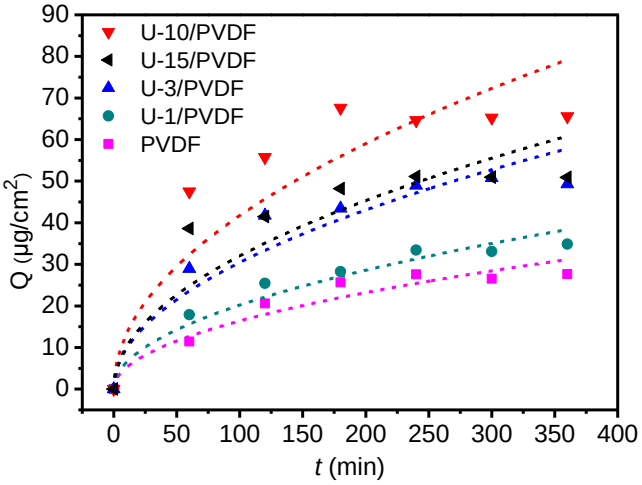

Fig. S5 Non-linear fitting curves for the adsorption of lipase on PVDF and U-*x*/PVDF using intra-particle diffusion models.

Table S2 The simulating parameters of adsorption kinetics of the membranes using three kinetics models

Sample		PVDF	U-1/PVDF	U-3/PVDF	U-10/PVDF	U-15/PVDF
pseudo-first order	Q_e(μg cm^{-2})	29.08	34.85	50.07	65.72	50.08
	k_1(min^{-1})	0.00997	0.01101	0.01414	0.02004	0.02114
	R^2	0.98619	0.99191	0.99352	0.98882	0.98069
pseudo-second order	Q_e(μg cm^{-2})	37.45	43.23	59.41	73.23	55.62
	k_2(cm^2 μg^{-1} min^{-1})	2.53×10^{-4}	2.71×10^{-4}	2.88×10^{-4}	4.31×10^{-4}	6.08×10^{-4}
	R^2	0.97355	0.9949	0.99262	0.98717	0.99113
Intra-particle diffusion	k_d(μg cm^{-2} min$^{-1/2}$)	1.6419	2.0225	3.0473	4.1758	3.2067
	R^2	0.93685	0.95934	0.90686	0.80021	0.81347

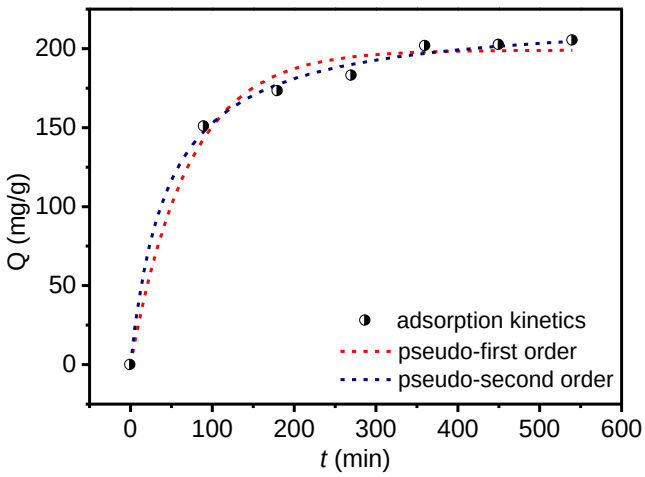

Fig. S6 Adsorption kinetics of lipase on UiO-66, and Non-linear fitting curves for the adsorption of lipase on UiO-66 using pseudo-first order and pseudo-second order models.

Table S3 The simulating parameters of adsorption kinetics of lipase on UiO-66 using pseudo-first order and pseudo-second order models

Kinetics model	pseudo-first order			pseudo-second order		
parameters	Q_e(mg g^{-1})	k_1(min^{-1})	R^2	Q_e(mg g^{-1})	k_2(g mg^{-1} min^{-1})	R^2
	199.01	0.01417	0.98617	221.63	1.00189×10^{-4}	0.99628

Table S4 Simulating parameters of the adsorption isotherm of lipase on U-10/PVDF hybrid membranes using Langmuir and Freundlich models

Sample	Langmuir			Freundlich		
	q_m (μg cm^{-2})	K_L (mL μg^{-1})	R^2	K_F (μg$^{(1-1/n)}$mL$^{1/n}$ cm^{-2})	n	R^2
U-10/PVDF	75.31	0.014	0.967	8.651	3.017	0.88576

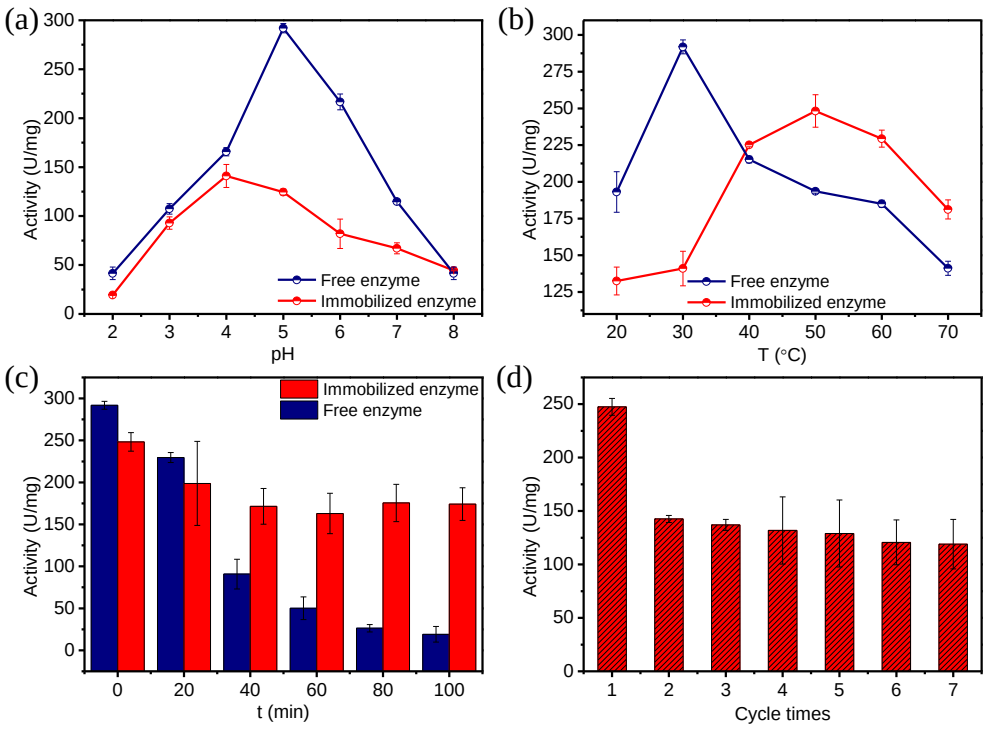

Fig. S7 The absolute catalytic activities of immobilized and free lipase upon different conditions (a–c): (a) pH values in the range of 2.0–8.0; (b) Reaction temperature varied from 20 ℃ to 70 ℃; (c) Thermostability comparison of free and membrane-immobilized lipase; (d) The cyclic catalytic activities of immobilized lipase.

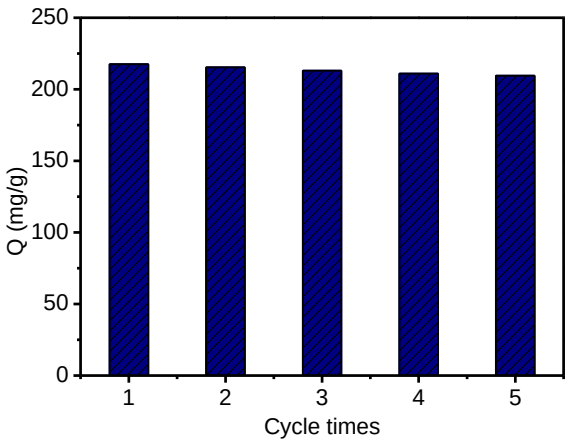

Fig. S8 The cyclic adsorption of lipase on UiO-66.