

Supplementary Materials

Reagent-Free Immobilization of Industrial Lipases to Develop Lipolytic Membranes with Self-Cleaning Surfaces

Martin Schmidt ¹, Andrea Prager ¹, Nadja Schönherr ¹, Roger Gläser ² and Agnes Schulze ^{1,*}

¹ Leibniz Institute of Surface Engineering (IOM), Permoserstr. 15, 04318 Leipzig, Germany; martin.schmidt@iom-leipzig.de (M.S.); andrea.prager@iom-leipzig.de (A.P.); nadja.schoenherr@iom-leipzig.de (N.S.)

² Institute of Chemical Technology, Leipzig University, Linnéstraße 3, 04103 Leipzig, Germany; roger.glaeser@uni-leipzig.de

* Correspondence: agnes.schulze@iom-leipzig.de

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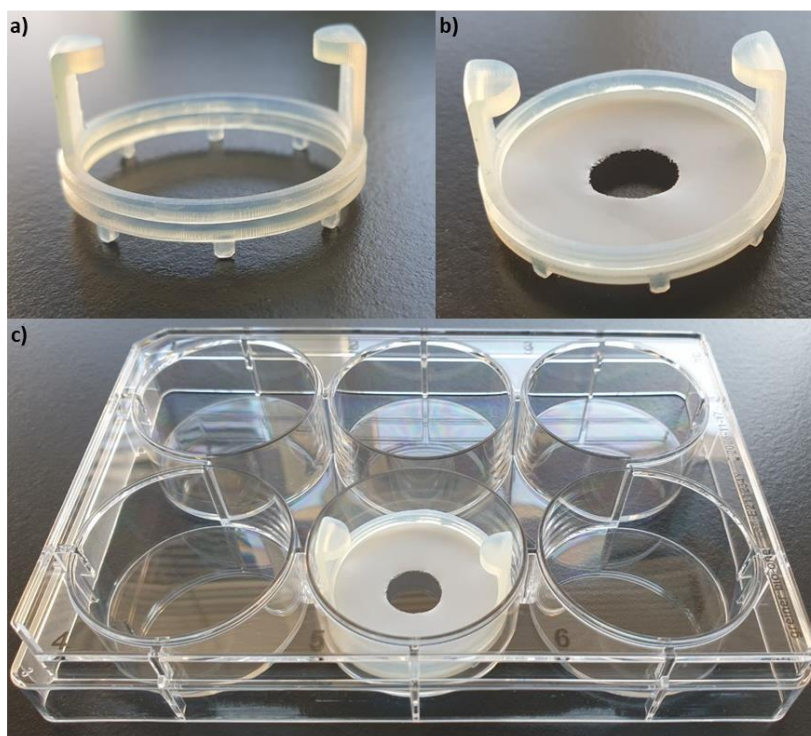


Figure S1. Implementation of the kinetic assay. For the tests, (a) a 3D-printed scaffold was used, into which (b) a membrane sample with a centered hole was inserted, and (c) placed into a 6-well plate. Finally, the chromogenic substrate solution was added and the release of the dye 4-nitrophenol was continuously measured photometrically.

```

[task]
  task = fit
  data = generic
[parameters]
  t, So
  Vmax, Km
  D
[model] ;units:  $\mu\text{M}$ , s,  $\mu\text{M/s}$ 
  So = 200
  Km = 10 ??
  Vmax = 1 ??
  D = 0.0001 ? (-1 .. +1)
  P = So - Km*W(So/Km*exp((So - Vmax*t)/Km)) + D*t
[data]
  variable t
  directory ./projects/lipase/data
  sheet data.csv
  column 2
[output]
  directory ./projects/lipase/output/
[settings]
{ConfidenceIntervals}
  SquaresIncreasePercent = 10
{Filter}
  XMin = 30
{Output}
  XAxisLabel = t, sec
  YAxisLabel = c,  $\mu\text{M}$ 
[end]

```

Figure S2. DynaFit script. The integrated closed-form Michaelis-Menten rate equation was used according to the manuscript. Please note that a correction term, D , was added to account for non-specific effects such as adsorption of the dye or substrate, product inhibition, *etc.*

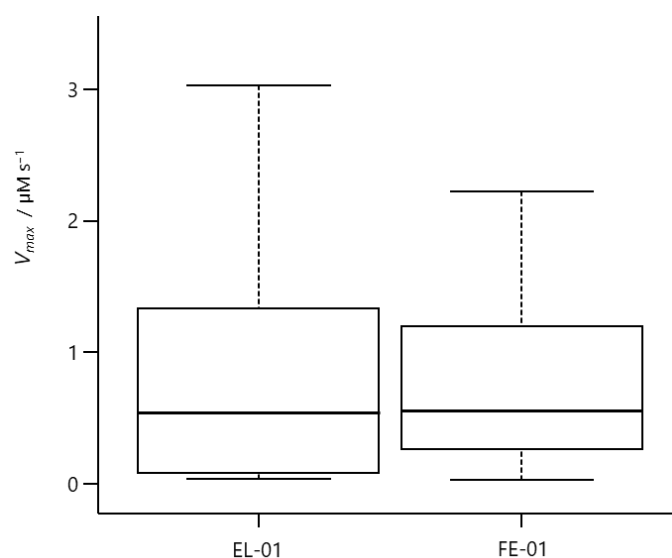


Figure S3. Boxplots of reaction rates. Both enzymes, EL-01 and FE-01, give the same average V_{max} , with EL-01 showing slightly higher maximum values.

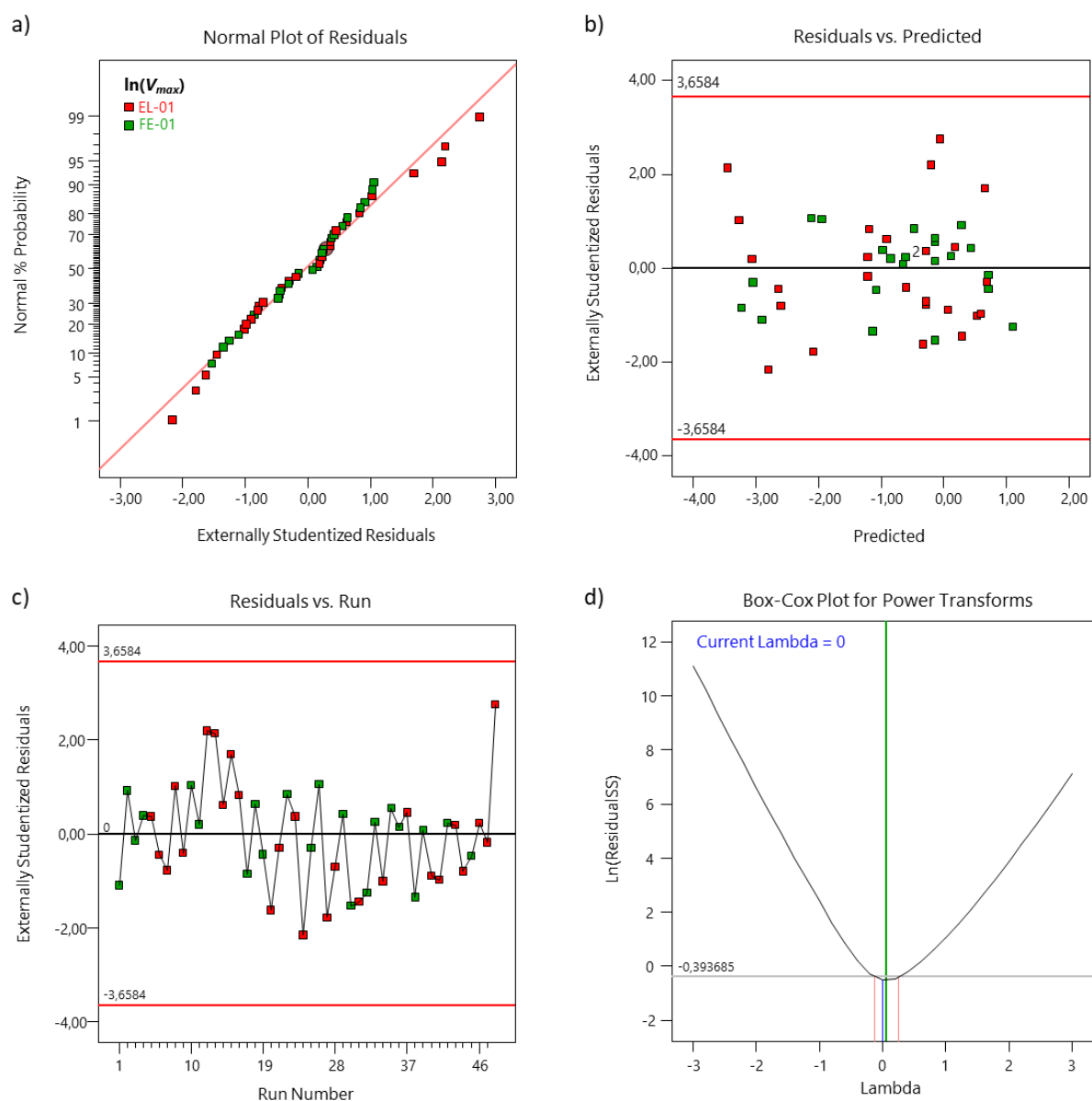


Figure S4. Diagnostics of RSM design. The final model was supported by several diagnostics in Design-Expert 13, *e.g.*, (a) test for normal distribution with normal probability plot; (b) test for homoscedasticity with residual plot; (c) test for randomness with residual-run plot; and (d) test for data transformation with Box-Cox plot (all after \ln transformation).

Table S1. Data of RSM design. Given are the factor settings per run and the responses (kinetic parameters) obtained with the DynaFit software package (*cf.* manuscript and Figure S2).

Run	Factors				Responses			
	A: conc. / g L ⁻¹	B: time / min	C: dose / kGy	D: enzyme	V_{max} / $\mu\text{M s}^{-1}$	K_m / μM	V/K / 10^{-3} s^{-1}	D / $\mu\text{M s}^{-1}$
1	1.0	5.1	125	FE-01	0.04	94.3	0.5	-0.0048
2	8.2	2.1	80	FE-01	1.71	86.4	19.8	-0.0603
3	8.2	8.0	80	FE-01	1.97	84.9	23.2	-0.0288
4	2.8	2.1	80	FE-01	0.42	61.9	6.8	-0.0141
5	5.5	5.1	125	EL-01	0.85	31.2	27.1	-0.0297
6	1.0	5.1	125	EL-01	0.06	45.9	1.4	-0.0056
7	5.5	5.1	125	EL-01	0.59	28.1	21.0	-0.0297
8	2.8	8.0	170	EL-01	0.05	56.3	0.9	-0.0047
9	2.8	2.1	50	EL-01	0.50	61.5	8.2	-0.0306
10	5.5	0.1	125	FE-01	0.19	58.6	3.2	-0.0186
11	2.8	8.0	50	FE-01	0.45	69.4	6.5	-0.0220
12	2.8	8.0	80	EL-01	1.45	129.0	11.2	-0.0399
13	2.8	2.1	170	EL-01	0.05	28.7	1.8	-0.0043
14	8.2	8.0	170	EL-01	0.48	10.4	45.7	-0.0194
15	8.2	8.0	80	EL-01	3.03	70.7	42.9	-0.0399
16	8.2	2.1	170	EL-01	0.38	22.6	17.0	-0.0155
17	2.8	2.1	170	FE-01	0.03	68.9	0.5	-0.0032
18	5.5	5.1	125	FE-01	1.06	55.3	19.1	-0.0411
19	8.2	8.0	80	FE-01	1.80	83.0	21.7	-0.0795
20	8.2	2.1	50	EL-01	0.49	9.9	49.2	-0.0260
21	5.5	5.1	80	EL-01	1.83	49.0	37.3	-0.0536
22	8.2	2.1	170	FE-01	0.78	44.3	17.5	-0.0277
23	5.5	5.1	125	EL-01	0.85	44.4	19.1	-0.0384
24	5.5	5.1	200	EL-01	0.04	46.5	0.8	-0.0043
25	2.8	8.0	170	FE-01	0.04	46.5	1.0	-0.0040
26	5.5	5.1	200	FE-01	0.15	52.7	2.9	-0.0187
27	5.5	0.1	125	EL-01	0.08	68.3	1.2	-0.0043
28	5.5	5.1	125	EL-01	0.60	37.6	16.0	-0.0312
29	5.5	10.0	125	FE-01	1.72	71.5	24.1	-0.0499
30	5.5	5.1	125	FE-01	0.55	31.0	17.6	-0.0226
31	5.5	10.0	125	EL-01	0.94	31.5	29.9	-0.0268
32	10.0	5.1	80	FE-01	2.22	104.6	21.2	-0.0479
33	5.5	5.1	50	FE-01	1.20	25.7	46.7	-0.0558
34	10.0	5.1	125	EL-01	1.33	30.3	44.0	-0.0330
35	5.5	5.1	125	FE-01	1.03	47.3	21.8	-0.0335
36	5.5	5.1	125	FE-01	0.91	55.2	16.4	-0.0361
37	8.2	5.1	50	EL-01	1.34	37.2	36.0	-0.0384
38	10.0	0.1	200	FE-01	0.26	35.8	7.4	-0.0106
39	10.0	10.0	200	FE-01	0.53	47.6	11.2	-0.0324
40	5.5	10.0	50	EL-01	0.92	74.4	12.3	-0.0655
41	8.2	5.1	80	EL-01	1.39	19.3	71.9	-0.0439
42	10.0	10.0	170	FE-01	0.57	29.4	19.5	-0.0272
43	1.0	0.1	125	EL-01	0.05	158.8	0.3	-0.0035
44	1.0	10.0	125	EL-01	0.07	82.8	0.8	-0.0058
45	10.0	0.1	125	FE-01	0.31	17.7	17.6	-0.0205
46	8.2	5.1	170	EL-01	0.32	20.2	15.7	-0.0219
47	8.2	5.1	170	EL-01	0.28	26.2	10.8	-0.0414
48	10.0	2.1	80	EL-01	1.75	28.4	61.5	-0.0418

Table S2. XPS data of fouled samples. Given are the data of the top site *before* and *after* the first fouling and self-cleaning cycle.

sample	elemental composition / at%						elemental ratio / %			
	C	F	O	N	S	Si	F/C	O/C	N/C	S/C
PVDF-Ref (before)	59.18 ±0.57	37.21 ±1.05	3.13 ±0.40	0.00 ±0.00	0.00 ±0.00	0.49 ±0.10	62.89 ±2.38	5.29 ±0.62	0.00 ±0.00	0.00 ±0.00
PVDF-Ref (after)	81.69 ±1.20	4.22 ±0.64	12.07 ±0.60	0.04 ±0.08	0.06 ±0.13	1.94 ±0.35	5.17 ±0.83	14.78 ±0.90	0.04 ±0.09	0.08 ±0.15
PVDF- γ -EL (before)	61.51 ±0.47	32.27 ±1.32	5.03 ±0.67	0.58 ±0.10	0.00 ±0.00	0.62 ±0.36	52.47 ±2.50	8.17 ±1.04	0.93 ±0.15	0.00 ±0.00
PVDF- γ -EL (after)	70.98 ±1.05	20.43 ±1.73	6.65 ±0.81	0.66 ±0.05	0.07 ±0.10	1.22 ±0.19	28.82 ±2.87	9.36 ±1.04	0.92 ±0.08	0.09 ±0.14