Supporting Information

Deep eutectic solvents as modulators of *Yarrowia lipolytica* lipase activity

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Table S1: Effect of HBA/HBD DES at 20 wt% on the YlLip2 activity [a].

HBA	HBD	YlLip2 activity (U L^{-1})	pH
ChCl	-	19.48 ± 0.56	
	Hexanoic acid	17.69 ± 2.66	7.09 ± 0.09
	Octanoic acid	3.57 ± 0.58	7.14 ± 0.10
	Decanoic acid	1.87 ± 0.33	7.09 ± 0.11
$[N_{4444}]Cl$	-	29.34 ± 3.17	
	Hexanoic acid	19.75 ± 2.64	7.11 ± 0.07
	Octanoic acid	6.48 ± 0.36	7.14 ± 0.08
	Decanoic acid	2.91 ± 0.27	7.13 ± 0.07
$[N_{8881}]Cl$	-	73.79 ± 4.45	
	Hexanoic acid	44.57 ± 1.29	7.08 ± 0.09
	Octanoic acid	24.79 ± 0.27	7.19 ± 0.11
	Decanoic acid	12.50 ± 0.29	7.12 ± 0.05
$[N_{4444}]Br$	-	13.80 ± 0.08	
	Hexanoic acid	8.25 ± 0.41	7.11 ± 0.11
	Octanoic acid	2.15 ± 0.11	7.12 ± 0.12
	Decanoic acid	1.77 ± 0.28	7.10 ± 0.09
$[N_{8881}]Br$	-	25.10 ± 0.44	
	Hexanoic acid	9.78 ± 0.33	7.13 ± 0.10
	Octanoic acid	3.45 ± 0.15	7.08 ± 0.08
	Decanoic acid	0.99 ± 0.12	7.08 ± 0.09
$[N_{8888}]Br$	-	9.45 ± 0.44	
	Hexanoic acid	5.48 ± 0.26	7.11 ± 0.08
	Octanoic acid	1.69 ± 0.15	7.14 ± 0.07
	Decanoic acid	0.49 ± 0.12	7.12 ± 0.09

[a] Control exhibited an enzymatic activity of 45.00 ± 4.57 U L^{-1} and pH of 7.2 ± 0.11

Table S2: Catalytic and allosteric site amino acids of YlLip2 and their probabilities.

Catalytic site	Allosteric site		
	1 (29.22%)	2 (15.48%)	3 (15.35%)
Ser162	Asp11	Ile191	Pro40
Asp230	Glu13	Arg224	Phe41
His289	Ser14	Pro233	Asn42
	Phe17	Gln234	Cys47
	Lys20	Tyr241	Ala48
	Tyr21	Gln242	Phe50
	Gln80	His243	Pro51
	Gln155	Glu247	Asn52
	Leu183	Gln268	Val53
	Val216	Ser269	Glu54
	Ser217	Asn270	His76
	Lys218	Lys271	
	Arg220	Ser274	
	Lys221	Ala275	
	Tyr223		

Table S3: Docking affinity energy and interacting atoms predicted by AutoDock vinna between cation- and anion-based HBA (ligand) with amino acids (AA).

Ligands	Affinity (kcal mol^{-1})	Amino acids (AA)	Distance (Å)	Binding types	From	To
$[Ch]^+$	-3.2	Ser214	2.73	Hydrogen Bond	AA	Ligand
		Lys215	3.56	Hydrogen Bond	Ligand	AA
		Ser217	3.58	Hydrogen Bond	Ligand	AA
		Ser217	3.57	Hydrogen Bond	Ligand	AA
		Asp212	3.57	Hydrogen Bond	Ligand	AA
		Val213	-	Van der Waals	-	-
		Arg220	-	Van der Waals	-	-
$[N_{4444}]^+$	-4.7	Phe17	4.12	Electrostatic	Ligand	AA
		Val216	5.01	Hydrophobic	Ligand	AA
		Glu13	-	Van der Waals	-	-
		Ser14	-	Van der Waals	-	-
		Asn16	-	Van der Waals	-	-
		Ly20	-	Van der Waals	-	-
		Tyr21	-	Van der Waals	-	-
		Gln80	-	Van der Waals	-	-
		Gln155	-	Van der Waals	-	-
		Leu183	-	Van der Waals	-	-
		Ser217	-	Van der Waals	-	-
		Lys218	-	Van der Waals	-	-
		Arg220	-	Van der Waals	-	-
		Lys221	-	Van der Waals	-	-
		Tyr223	-	Van der Waals	-	-
$[N_{8881}]^+$	-5.5	Lys20	3.62	Hydrophobic	AA	Ligand
		Lys218	5.46	Hydrophobic	AA	Ligand
		Leu183	4.52	Hydrophobic	Ligand	AA
		Phe17	4.74	Hydrophobic	AA	Ligand
		Phe17	4.60	Hydrophobic	AA	Ligand
		Phe17	4.17	Hydrophobic	AA	Ligand
		His49	4.90	Hydrophobic	AA	Ligand
		Phe50	5.32	Hydrophobic	AA	Ligand
		Phe50	4.62	Hydrophobic	AA	Ligand
		Glu13	-	Van der Waals	-	-
		Ser14	-	Van der Waals	-	-
		Asn16	-	Van der Waals	-	-
		Tyr21	-	Van der Waals	-	-
		Arg23	-	Van der Waals	-	-
		Gln80	-	Van der Waals	-	-
		Gln155	-	Van der Waals	-	-
		Val216	-	Van der Waals	-	-

		Ser217	-	Van der Waals	-	-
		Arg220	-	Van der Waals	-	-
		Tyr223	-	Van der Waals	-	-
$[N_{8888}]^+$	-5.3	Lys20	3.96	Hydrophobic	AA	Ligand
		Lys20	5.46	Hydrophobic	AA	Ligand
		Leu183	5.48	Hydrophobic	AA	Ligand
		Lys20	4.18	Hydrophobic	Ligand	AA
		Lys218	5.11	Hydrophobic	Ligand	AA
		Phe17	4.76	Hydrophobic	AA	Ligand
		Phe17	4.21	Hydrophobic	AA	Ligand
		Glu13	-	Van der Waals	-	-
		Ser14	-	Van der Waals	-	-
		Asn16	-	Van der Waals	-	-
		Arg23	-	Van der Waals	-	-
		Asp75	-	Van der Waals	-	-
		Ser78	-	Van der Waals	-	-
		Gln80	-	Van der Waals	-	-
		Tyr82	-	Van der Waals	-	-
		Gln155	-	Van der Waals	-	-
		Val216	-	Van der Waals	-	-
		Ser217	-	Van der Waals	-	-
		Arg220	-	Van der Waals	-	-
		Lys221	-	Van der Waals	-	-
		Tyr223	-	Van der Waals	-	-
Br^-	-1.1	-	-	-	-	-
Cl^-	-1.0	Phe109	-	Van der Waals		
		Ile114	-	Van der Waals		
		Ala118	-	Van der Waals		
		Thr119	-	Van der Waals		
		Ile173	-	Van der Waals		
		Val177	-	Van der Waals		
		Trp200	-	Van der Waals		

Table S4: Docking affinity energy and interacting atoms predicted by AutoDock vinna between fatty acids (HBD) (ligand) with amino acids (AA).

Ligands	Affinity (kcal mol^{-1})	Amino acids (AA)	Distance (Å)	Binding types	From	To
Hexanoic	-4.2	Tyr223	2.35	Hydrogen Bond	AA	Ligand
		Ser217	2.51	Hydrogen Bond	Ligand	AA
		Arg220	2.51	Hydrogen Bond	Ligand	AA
		Val216	5.26	Hydrophobic	AA	Ligand
		Phe17	4.70	Hydrophobic	AA	Ligand
		Phe17	4.05	Hydrophobic	AA	Ligand
		Ser14	-	Van der Waals	-	-
		Glu13	-	Van der Waals	-	-
		Leu183	-	Van der Waals	-	-
		Lys221	-	Van der Waals	-	-
		Lys218	-	Van der Waals	-	-
Octanoic	-4.4	Ser14	2.45	Hydrogen Bond	AA	Ligand
		Leu183	4.31	Hydrophobic	Ligand	AA
		Phe17	5.24	Hydrophobic	AA	Ligand
		Phe17	4.20	Hydrophobic	AA	Ligand
		Asp11	-	Van der Waals	-	-
		Glu13	-	Van der Waals	-	-
		Gln155	-	Van der Waals	-	-
		Val216	-	Van der Waals	-	-
		Ser217	-	Van der Waals	-	-
		Lys218	-	Van der Waals	-	-
		Tyr223	-	Van der Waals	-	-
Decanoic	-4.6	Arg224	2.15	Hydrogen Bond	AA	Ligand
		Arg224	2.13	Hydrogen Bond	AA	Ligand
		Gln268	2.24	Hydrogen Bond	Ligand	AA
		Val1	4.04	Hydrophobic	Ligand	AA
		Ile191	5.03	Hydrophobic	Ligand	AA
		His243	4.68	Hydrophobic	AA	Ligand
		Thr226	-	Van der Waals	-	-
		Pro233	-	Van der Waals	-	-
		Gln234	-	Van der Waals	-	-
		Gln242	-	Van der Waals	-	-
		Glu247	-	Van der Waals	-	-
		Ser269	-	Van der Waals	-	-
		Asn270	-	Van der Waals	-	-
		Ser274	-	Van der Waals	-	-
		Ala275	-	Van der Waals	-	-

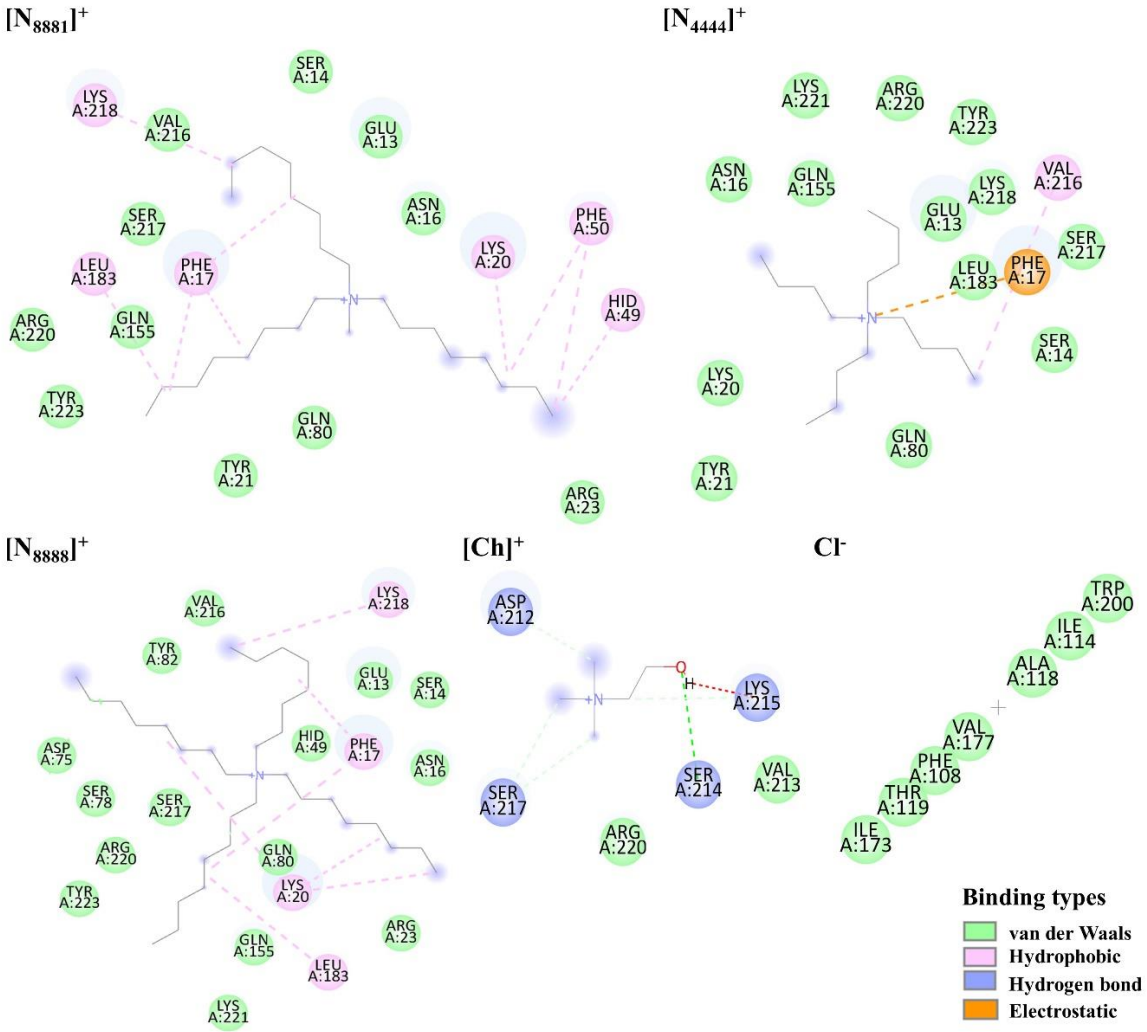

Figure S1: Molecular interaction diagrams between receptor (lipase from *Yarrowia lipolytica* – YlLip2) and ammonium-based HBA DES.

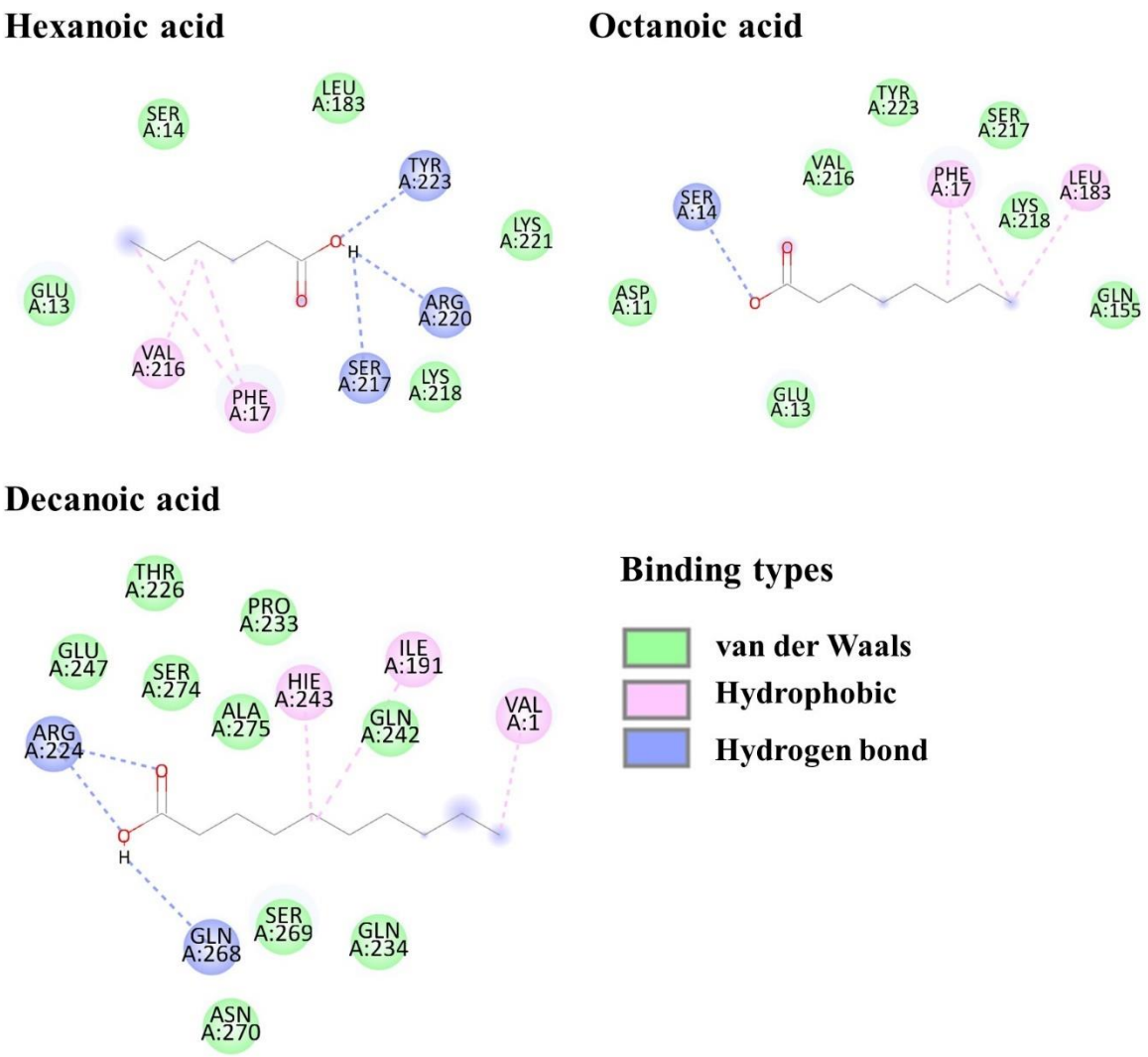

Figure S2: Molecular interaction diagrams between receptor (lipase from *Yarrowia lipolytica* – YlLip2) and fatty-acid-based HBD DES.