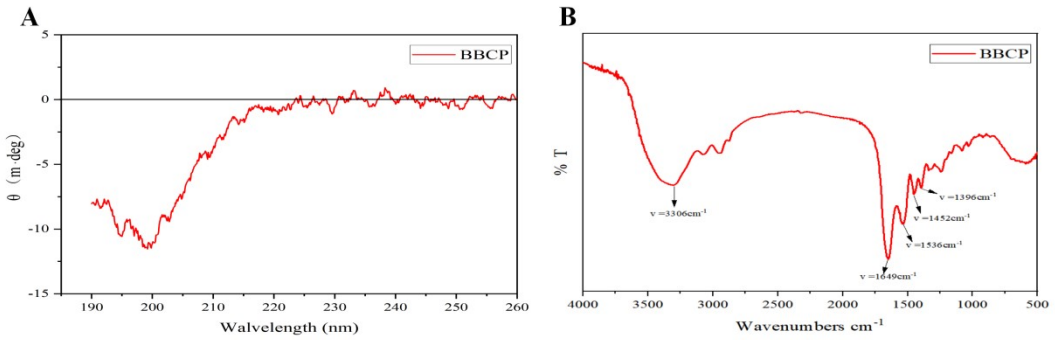

Figure S1 Structural characterization of BBCP. (A) CD spectra analysis of APS. (B) Fourier transform infrared spectroscopy of BBCP.

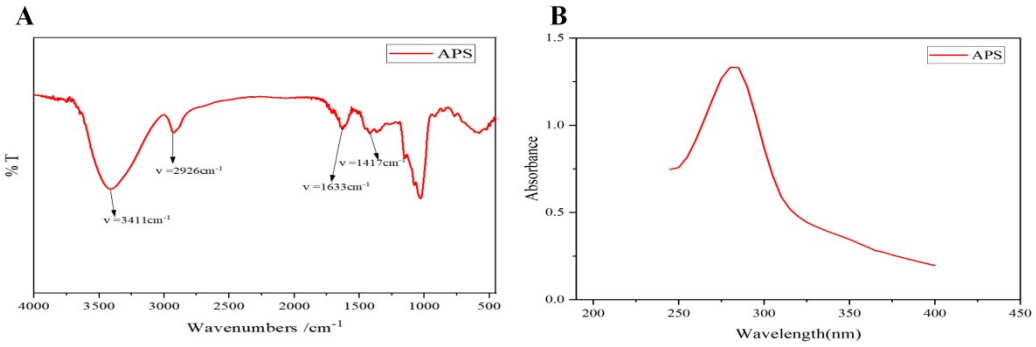

Figure S2 Structural characterization of APS. (A) Fourier transform infrared spectroscopy of APS. (B) Ultraviolet spectrum of APS.

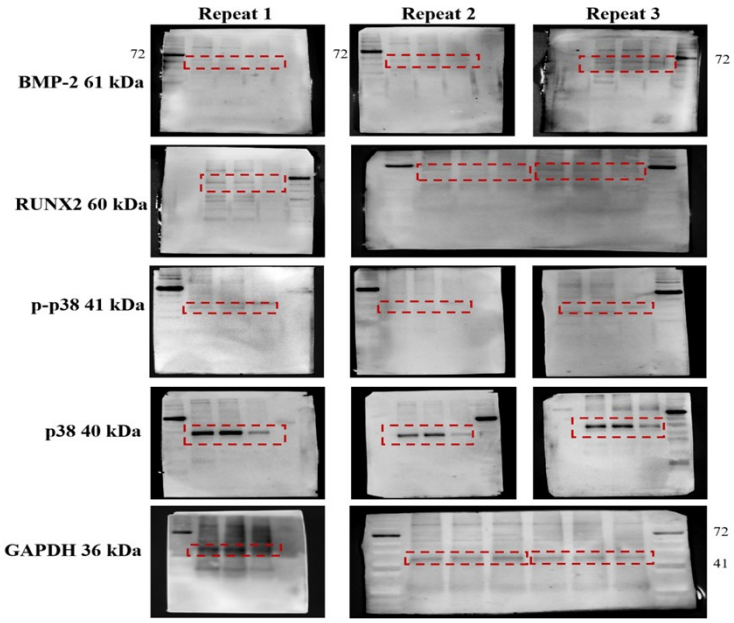

Figure S3 Western blot analysis

Figure S3 shows the whole blot membrane at molecular weights of 72 kDa, 52 kDa, 41 kDa, and 10~31 kDa for BMP-2 (61 kDa), RUNX2 (60 kDa), p-p38 (41 kDa), p38 (40 kDa), and GAPDH (36 kDa). As shown in **Figure S3**, the western blot lanes within the red box represent the following groups in this order from left to right: Control, BBCP/APS, and BBCP/APS + SB203580.

Table S1 Component in BBCP

Types of amino acids	Residues/1000 residues	Content (%)
Asp	63.40 ± 0.10	4.97
Thr	21.90 ± 0.30	1.7
Ser	37.63 ± 0.21	2.97
Glu	115.57 ± 0.40	9.05
Gly	264.03 ± 0.31	20.71
Ala	88.13 ± 0.58	6.91
Cys	1.43 ± 0.12	0.1
Val	22.47 ± 1.00	1.67
Met	7.17 ± 1.20	0.66
Ile	12.77 ± 0.70	0.94
Leu	32.93 ± 0.30	2.57
Tyr	1.97 ± 0.40	0.13
Phe	20.13 ± 0.06	1.58
His	13.37 ± 0.50	1.08
Lys	50.60 ± 0.40	3.94
Arg	98.90 ± 0.20	7.77
Pro	149.37 ± 1.00	11.78

Table S2 Component in APS

Types of monosaccharides	Content (%)

Man	0.201
GlcN	0.135
Rha	0.000
GlcA	0.000
GalA	0.000
GalN	0.000
Glc	99.009
Gal	0.221
Xyl	0.000
Ara	0.433
Fuc	0.000

Table S3 Target genes for each amino acid component in BBCP

Component	Content (mg/g)	Target	Common name
Asp	5.063	Egl nine homolog 1	EGLN1
Thr	1.753	GABA-B receptor	GABBR2
		Gamma-amino-N-butyrate transaminase (by homology)	ABAT
		Excitatory amino acid transporter 3	SLC1A1
Ser	2.999	NO[a]	NO[a]
Glu	9.239	Glutamate receptor ionotropic kainate 1	GRIK1
		Glutamate receptor ionotropic, AMPA 1	GRIA1
		Adenosine A3 receptor	ADORA3

Component	Content (mg/g)	Target	Common name
		Glutamate receptor ionotropic kainate 5	GRIK5
		Excitatory amino acid transporter 3	SLC1A1
		Metabotropic glutamate receptor 4	GRM4
		Metabotropic glutamate receptor 3	GRM3
		Glutamate receptor ionotropic, AMPA 4	GRIA4
		Metabotropic glutamate receptor 5	GRM5
		Metabotropic glutamate receptor 8	GRM8
		Glutamate receptor ionotropic kainate 2	GRIK2
		Glutamate receptor ionotropic kainate 3	GRIK3
		Metabotropic glutamate receptor 1	GRM1
		Metabotropic glutamate receptor 7	GRM7
		Glutamate receptor ionotropic, AMPA 2	GRIA2
		Metabotropic glutamate receptor 6	GRM6
		Metabotropic glutamate receptor 2	GRM2
		Metabotropic glutamate receptor 1	GRM1

Component	Content (mg/g)	Target	Common name
		Metabotropic glutamate receptor 7	GRM7
		Glutamate receptor ionotropic, AMPA 2	GRIA2
		Metabotropic glutamate receptor 6	GRM6
		Metabotropic glutamate receptor 2	GRM2
Gly	21.041	NO[a]	NO[a]
Ala	6.85	Gamma-amino-N-butyrate transaminase (by homology)	ABAT
Cys	0.12	GABA-B receptor	GABBR2
		Gamma-amino-N-butyrate transaminase (by homology)	ABAT
Val	1.81	GABA-B receptor	GABBR2
		GABA transporter 1	SLC6A1
		GABA A receptor alpha-3/beta-2/gamma-2	GABRA3
		GABA A receptor alpha-2/beta-2/gamma-2	GABRA2
		GABA receptor rho-1 subunit	GABRR1
		GABA transporter 3	SLC6A11
		GABA transporter 2 (by homology)	SLC6A13

Component	Content (mg/g)	Target	Common name
		Ornithine aminotransferase, mitochondrial	OAT
		GABA-B receptor (by homology)	GABBR1
		Histone deacetylase 3	HDAC3
		Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		Adenosine A3 receptor	ADORA3
		Metabotropic glutamate receptor 4	GRM4
		Metabotropic glutamate receptor 5	GRM5
		Metabotropic glutamate receptor 8	GRM8
		Metabotropic glutamate receptor 7	GRM7
Met	0.48	Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		GABA-B receptor	GABBR2 GABBR1
		GABA-B receptor (by homology)	GABBR1
		Aminopeptidase B	RNPEP
		Ornithine aminotransferase,	OAT

Component	Content (mg/g)	Target	Common name
		mitochondrial	
		Tyrosine 3-hydroxylase	TH
		Kynurenine 3-monooxygenase	KMO
		Xaa-Pro dipeptidase	PEPD
		Kynureninase	KYNU
		Tyrosine-protein kinase FYN	FYN
		Epidermal growth factor receptor erbB1	EGFR
		Tyrosine-protein kinase LCK	LCK
		Glutamate receptor ionotropic, AMPA 1	GRIA1
		Glutamate receptor ionotropic kainate 5	GRIK5
		Glutamate receptor ionotropic, AMPA 4	GRIA4
		Glutamate receptor ionotropic, AMPA 2	GRIA2
		GABA transporter 1 (by homology)	SLC6A1
		S-methylmethionine--homocysteine S-methyltransferase BHMT2	BHMT2

Component	Content (mg/g)	Target	Common name
Ile	1.02	Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		Adenosine A3 receptor	ADORA3
		Excitatory amino acid transporter 3	SLC1A1
		Metabotropic glutamate receptor 4	GRM4
		Metabotropic glutamate receptor 5	GRM5
		Metabotropic glutamate receptor 8	GRM8
		Metabotropic glutamate receptor 1	GRM1
		Metabotropic glutamate receptor 7	GRM7
		GABA-B receptor	GABBR2
			GABBR1
		Glutamate receptor ionotropic kainate 1	GRIK1
		Leukotriene A4 hydrolase	LTA4H
		Glutamate receptor ionotropic kainate 2	GRIK2
		GABA receptor rho-1 subunit	GABRR1
		Glutamate receptor ionotropic, AMPA 1	GRIA1

Component	Content (mg/g)	Target	Common name
		GABA-A receptor; alpha-1/beta-2/gamma-2	GABRA1 GABRB2 GABRG2
		GABA transporter 3	SLC6A11
		GABA transporter 2 (by homology)	SLC6A13
		Ornithine aminotransferase, mitochondrial	OAT
		Metabotropic glutamate receptor 3	GRM3
		Glutamate receptor ionotropic, AMPA 4	GRIA4
		Metabotropic glutamate receptor 6	GRM6
		Metabotropic glutamate receptor 2	GRM2
		Excitatory amino acid transporter 2	SLC1A2
		Plasminogen	PLG
		Glutamate receptor ionotropic kainate 5	GRIK5
		Glutamate receptor ionotropic kainate 3	GRIK3
		Glutamate receptor ionotropic, AMPA 2	GRIA2

Component	Content (mg/g)	Target	Common name
Leu	2.57	Kynurenine 3-monooxygenase	KMO
		Gamma-butyrobetaine dioxygenase	BBOX1
		Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		Adenosine A3 receptor	ADORA3
		Excitatory amino acid transporter 3	SLC1A1
		Metabotropic glutamate receptor 4	GRM4
		Metabotropic glutamate receptor 5	GRM5
		Metabotropic glutamate receptor 8	GRM8
		Metabotropic glutamate receptor 1	GRM1
		Metabotropic glutamate receptor 7	GRM7
		GABA-B receptor	GABBR2
		Glutamate receptor ionotropic kainate 1	GRIK1
		Leukotriene A4 hydrolase	LTA4H
		Glutamate receptor ionotropic kainate 2	GRIK2
		Ornithine aminotransferase, mitochondrial	OAT

Component	Content (mg/g)	Target	Common name
		Glutamate receptor ionotropic, AMPA 1	GRIA1
		GABA receptor rho-1 subunit	GABRR1
		Metabotropic glutamate receptor 3	GRM3
		Metabotropic glutamate receptor 6	GRM6
		Metabotropic glutamate receptor 2	GRM2
		Glutamate receptor ionotropic, AMPA 4	GRIA4
		GABA-A receptor; alpha-1/beta-2/gamma-2	GABRA1
		GABA transporter 3	SLC6A11
		GABA transporter 2 (by homology)	SLC6A13
		Excitatory amino acid transporter 2	SLC1A2
		Plasminogen	PLG
		Glutamate receptor ionotropic kainate 3	GRIK3
		Glutamate receptor ionotropic, AMPA 2	GRIA2
		Betaine transporter	SLC6A12
		Glutamate receptor ionotropic	GRIK5

Component	Content (mg/g)	Target	Common name
		kainate 5	
		Gamma-butyrobetaine dioxygenase	BBOX1
Tyr	0.14	Lysine-specific demethylase 4D-like	KDM4E
		Tyrosine-protein kinase FYN	FYN
		Epidermal growth factor receptor erbB1	EGFR
		Tyrosine-protein kinase LCK	LCK
		Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		Tyrosine 3-hydroxylase	TH
		L-type amino acid transporter 1	SLC7A5
		Thyroid hormone receptor alpha	THRA
		Thyroid hormone receptor beta-1	THRB
		Receptor-type tyrosine-protein phosphatase alpha	PTPRA
		Bile acid receptor FXR	NR1H4
		DNA-(apurinic or apyrimidinic site) lyase	APEX1

Component	Content (mg/g)	Target	Common name
		Trace amine-associated receptor 1 (by homology)	TAAR1
		Kynurenine 3-monooxygenase	KMO
		Lysine-specific demethylase 4C	KDM4C
		GABA-B receptor	GABBR2
		GABA-B receptor (by homology)	GABBR1
		MAP kinase-activated protein kinase 2	MAPKAPK2
		Kinesin-like protein 1	KIF11
		Estrogen receptor alpha	ESR1
		Estrogen receptor beta	ESR2
		Carboxypeptidase B	CPB1
		Growth factor receptor-bound protein 2	GRB2
Phe	1.58	Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		L-type amino acid transporter 1	SLC7A5
		GABA-B receptor	GABBR2
		Adenosine A3 receptor	ADORA3

Component	Content (mg/g)	Target	Common name
		Lysine-specific demethylase 4D-like	KDM4E
		Tyrosine-protein kinase FYN	FYN
		Epidermal growth factor receptor erbB1	EGFR
		GABA-B receptor (by homology)	GABBR1
		Neurokinin 1 receptor (by homology)	TACR1
		Tyrosine 3-hydroxylase	TH
		Tyrosine-protein kinase LCK	LCK
		Lysine-specific demethylase 4C	KDM4C
		Alpha-2a adrenergic receptor	ADRA2A
		Alpha-2b adrenergic receptor (by homology)	ADRA2B
		Alpha-1a adrenergic receptor (by homology)	ADRA1A
		GABA receptor rho-1 subunit	GABRR1
		Carboxypeptidase B2 isoform A	CPB2
		Lysine-specific histone demethylase 1	KDM1A

Component	Content (mg/g)	Target	Common name
		Aminopeptidase N	ANPEP
		Aminopeptidase A	ENPEP
		Mast cell carboxypeptidase A	CPA3
		Norepinephrine transporter	SLC6A2
		Serotonin transporter	SLC6A4
		Trace amine-associated receptor 1	TAAR1
		Oligopeptide transporter small intestine isoform	SLC15A1
		Xaa-Pro dipeptidase	PEPD
His	1.05	Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		Histamine H3 receptor	HRH3
		Histamine H4 receptor	HRH4
		Carboxypeptidase B2 isoform A	CPB2
		Glutamate receptor ionotropic, AMPA 1	GRIA1
		Glutamate receptor ionotropic, AMPA 4	GRIA4
		Glutamate receptor ionotropic,	GRIA2

Component	Content (mg/g)	Target	Common name
		AMPA 2	
		Glutamate receptor ionotropic kainate 5	GRIK5
		Glucosamine--fructose-6-phosphate aminotransferase [isomerizing] 1	GFPT1
		GABA-B receptor	GABBR2
		GABA-B receptor (by homology)	GABBR1
		Histamine H2 receptor	HRH2
		Histamine H1 receptor	HRH1
		Aminopeptidase A	ENPEP
		Kynureninase	KYNU
		Ornithine decarboxylase	ODC1
		Kynurenine 3-monooxygenase (by homology)	KMO
		GABA transporter 1 (by homology)	SLC6A1
Lys	3.95	Leukotriene A4 hydrolase	LTA4H
		Metabotropic glutamate receptor 5	GRM5
		Plasminogen	PLG
		Glutamate receptor ionotropic kainate 1	GRIK1

Component	Content (mg/g)	Target	Common name
		Glutamate receptor ionotropic kainate 2	GRIK2
		Metabotropic glutamate receptor 2 (by homology)	GRM2
		Testis-specific androgen-binding protein	SHBG
		Androgen Receptor	AR
		Metabotropic glutamate receptor 1	GRM1
		Voltage-gated calcium channel alpha2/delta subunit 1 (by homology)	CACNA2D1
		Metabotropic glutamate receptor 3	GRM3
		Metabotropic glutamate receptor 6	GRM6
		Ornithine decarboxylase	ODC1
		Metabotropic glutamate receptor 8	GRM8
		Carboxypeptidase B2 isoform A	CPB2
		Xaa-Pro dipeptidase	PEPD
		Excitatory amino acid transporter 3	SLC1A1
		Solute carrier family 22 member 6 (by homology)	SLC22A6

Component	Content (mg/g)	Target	Common name
		Glutamate receptor ionotropic, AMPA 1	GRIA1
		Glutamate receptor ionotropic kainate 5	GRIK5
		Metabotropic glutamate receptor 4	GRM4
		Glutamate receptor ionotropic, AMPA 4	GRIA4
		Glutamate receptor ionotropic kainate 3	GRIK3
		Metabotropic glutamate receptor 7	GRM7
		Glutamate receptor ionotropic, AMPA 2	GRIA2
Arg	7.54	Nitric oxide synthase, inducible	NOS2
		Nitric-oxide synthase, brain	NOS1
Pro	11.948	GABA A receptor alpha-3/beta-2/gamma-2	GABRA3
		GABA A receptor alpha-2/beta-2/gamma-2	GABRA2
		GABA transporter 1	SLC6A1
		Angiotensin-converting enzyme	ACE

Component	Content (mg/g)	Target	Common name
		Renin	REN
		GABA receptor rho-1 subunit	GABRR1
		Egl nine homolog 1	EGLN1
		Aminopeptidase N	ANPEP
		GABA-B receptor	GABBR2
		Thrombin	F2
		Leukotriene A4 hydrolase	LTA4H

Note: The subscript "a" in Table S1 indicates that there is no possibility of the amino acid being greater than 0 in related genes.

Table S4 Target genes for each monosaccharide component in APS

Component	Content (mg/g)	Target	Common name
Glucose	99.082	Beta-glucocerebrosidase	GBA
		Heat shock protein HSP 90-alpha	HSP90AA1
		Vascular endothelial growth factor A	VEGFA
		Gamma-secretase	PSEN2
		Acidic fibroblast growth factor	FGF1
		Basic fibroblast growth factor	FGF2
		Heparanase	HPSE
		Cyclin-dependent kinase 1	CDK1
		Galectin-4	LGALS4
		Galectin-3	LGALS3
		Galectin-8	LGALS8
		Brain glycogen phosphorylase	PYGB
D-Mannose	0.202	Heat shock protein HSP 90-alpha	HSP90AA1

Component	Content (mg/g)	Target	Common name
		Beta-glucocerebrosidase	GBA
		Vascular endothelial growth factor A	VEGFA
		Gamma-secretase	PSEN2
		Acidic fibroblast growth factor	FGF1
		Basic fibroblast growth factor	FGF2
		Heparanase	HPSE
		Cyclin-dependent kinase 1	CDK1
		Galectin-4	LGALS4
		Galectin-3	LGALS3
		Galectin-8	LGALS8
Galactose	0.221	Beta-glucocerebrosidase	GBA
		Heat shock protein HSP 90-alpha	HSP90AA1
		Vascular endothelial growth factor A	VEGFA
		Gamma-secretase	PSEN2
		Acidic fibroblast	FGF1

Component	Content (mg/g)	Target	Common name
		growth factor	
		Basic fibroblast growth factor	FGF2
		Heparanase	HPSE
		Cyclin-dependent kinase 1	CDK1
		Galectin-4	LGALS4
		Galectin-3	LGALS3
		Galectin-8	LGALS8
		Brain glycogen phosphorylase	PYGB
Glucosamine Hydrochloride	0.135	Beta-glucocerebrosidase	GBA
L-Arabinose	0.361	Vanilloid receptor	GBA
		Maltase-glucoamylase	HSP90AA1
		Sucrase-isomaltase	VEGFA
		Beta-glucocerebrosidase	PSEN2
		Heat shock protein HSP 90-alpha	FGF1
		Vascular endothelial growth factor A	FGF2

Component	Content (mg/g)	Target	Common name
		Gamma-secretase	HPSE
		Acidic fibroblast growth factor	CDK1
		Basic fibroblast growth factor	GBA
		Heparanase	HSP90AA1
		Cyclin-dependent kinase 1	VEGFA
Dextran	-	NO[a]	NO[a]

Note: The subscript “a” in Table S2 indicates that there is no possibility of the amino acid being greater than 0 in related genes.

Table S5 GO terms

Category	Term	Count	PValue
BP	GO:0007188	adenylate cyclase-modulating G protein-coupled receptor signaling pathway	5	1.18745108829952 43E-8
	GO:0071880	adenylate cyclase-activating adrenergic receptor signaling pathway	4	3.32652331090583 3E-7
	GO:0007186	G protein-coupled receptor signaling pathway	7	4.40284878980839 6E-6
	GO:0045907	positive regulation of vasoconstriction	3	1.30198847517708 67E-4
	GO:0043410	positive regulation of MAPK cascade	4	1.32719902317559 08E-4
	GO:0030168	platelet activation	3	5.41539280584928 9E-4
	GO:0007266	Rho protein signal transduction	3	5.41539280584928 9E-4
	GO:0008217	regulation of blood pressure	3	8.07891386575680 7E-4
	GO:0007188	receptor transactivation	2	0.00222796005157 45773

CC	GO:0005834	heterotrimeric G-protein complex	4	2.10724716281984 58E-7
	GO:0005886	plasma membrane	3	3.56267061874176 1E-4
	GO:0045202	synapse	4	9.19294552924458 4E-4
	GO:0043005	neuron projection	2	0.00113936497110 16962
	GO:0031526	brush border membrane	4	0.00135334743545 2095
	GO:0001750	photoreceptor outer segment	2	0.00170860479002 15712
	GO:0009986	cell surface	2	0.00227754968137 48223
	GO:0005737	cytoplasm	2	0.00398261616450 8609
	GO:0005834	intracellular membrane-bounded organelle	2	0.03753247265599 574
	GO:0005886	metal ion binding	5	0.06336328552070 175
	GO:0031683	G-protein beta/gamma-subunit complex binding	4	2.10724716281984 58E-7

	GO:0003925	G protein activity	3	3.56267061874176 1E-4
	GO:0003924	GTPase activity	4	9.19294552924458 4E-4
	GO:0031752	D5 dopamine receptor binding	2	0.00113936497110 16962
	GO:0005525	GTP binding	4	0.00135334743545 2095
MF	GO:0004938	alpha2-adrenergic receptor activity	2	0.00170860479002 15712
	GO:0004937	alpha1-adrenergic receptor activity	2	0.00227754968137 48223
	GO:0051379	epinephrine binding	2	0.00398261616450 8609
	GO:0001664	G protein-coupled receptor binding	2	0.03753247265599 574
	GO:0046872	metal ion binding	5	0.06336328552070 175

Table S6 Molecular docking energy

Target	Ligand	Affinity (kcal/moL)

ADRA1A	Ala	-3.7
	Cys	-3.8
	Asp	-4.4
	Glu	-4.8
	Phe	-5.4
	Gly	-3.4
	His	-4.9
	Ile	-4.4
	Lys	-4.5
	Leu	-4.6
	Met	-4.1
	Asn	-4.4
	Pro	-4.4
	Gln	-4.8
	Arg	-5.4
	Ser	-4
	Thr	-4.4
	Val	-4.4
	Trp	-6.3
	Tyr	-5.5
	dextran	-6.6
	D-Mannose	-5.7

ADRA2A	Galactose	-5.6
	Glucosamine	-5.3
	Glucose	-5.4
	L-Arabinose	-5.4
	Ala	-3.8
	Cys	-3.8
	Asp	-4.9
	Glu	-5
	Phe	-6.6
	Gly	-3.3
	His	-5.2
	Ile	-5.1
	Lys	-4.8
	Leu	-5
	Met	-4.5
	Asn	-5
	Pro	-4.8
	Gln	-5
	Arg	-5.6
	Ser	-3.8
	Thr	-4.5
	Val	-4.7

	Trp	-7.5
	Tyr	-6.7
	dextran	-7.5
	D-Mannose	-5.6
	Galactose	-5.6
	Glucosamine	-5.8
	Glucose	-5.8
	L-Arabinose	-5.2