(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 August 2017 (17.08.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/139689 A1

(51) International Patent Classification:
C07F 5/02 (2006.01)

(21) International Application Number:
PCT/US2017/017542

(22) International Filing Date:
10 February 2017 (10.02.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/294,624 12 February 2016 (12.02.2016) US

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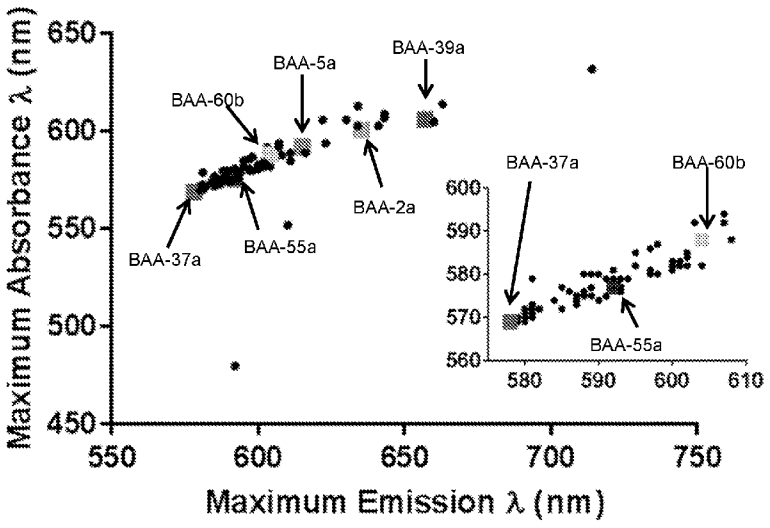
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: DERIVATIVES OF BODIPY

FIG. 1A



(57) Abstract: Derivatives of BODIPY with improved properties (such as longer Stokes shift relative to existing fluorophores) are disclosed.

WO 2017/139689 A1

Published:

— *with international search report (Art. 21(3))*

DERIVATIVES OF BODIPY

CROSS-REFERENCE TO RELATED APPLICATION

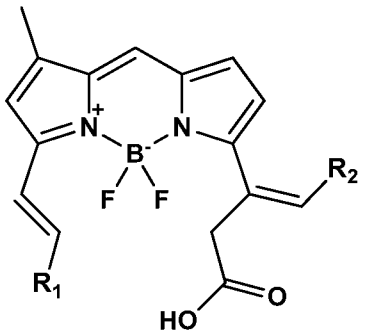
[0001]This application claims the benefit of US Provisional Patent Application 62/294,624, filed February 12, 2016, and entitled DERIVATIVES OF BODIPY, the entire disclosure of which is incorporated by reference herein.

BACKGROUND OF THE DISCLOSURE

[0002]Single-molecule localization microscopy (SMLM) utilizes photoswitchable fluorophores to detect biological entities with 10-20 nm resolution. Multispectral superresolution microscopy (MSSRM) extends SMLM functionality by improving its spectral resolution up to 5 fold facilitating imaging of multicomponent cellular structures or signaling pathways. Current commercial fluorophores are not ideal for MSSRM as they are not designed to photoswitch and do not adequately cover the visible and far-red spectral regions required for MSSRM imaging. To obtain optimal MSSRM spatial and spectral resolution, fluorophores with narrow emission spectra and controllable photoswitching properties are necessary.

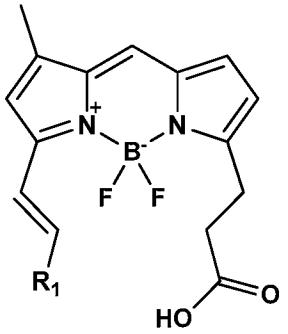
SUMMARY OF THE DISCLOSURE

[0003]Disclosed are compounds with the structure:



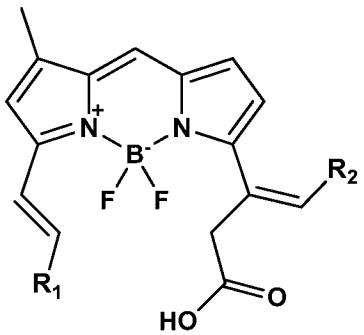
where R_1 is an aryl, a substituted aryl, an aromatic heterocycle, or a substituted aromatic heterocycle and R_2 is H, an aryl, a substituted aryl, an aromatic heterocycle, or a substituted aromatic heterocycle. In examples, R_2 is H, a substituted aryl, or a substituted aromatic heterocycle.

[0004]In further examples, the compounds have the structure:



where R_1 is an aryl, a substituted aryl, an aromatic heterocycle, or substituted aromatic heterocycle. In examples, R_1 is a substituted aryl or a substituted aromatic heterocycle. In examples, R_1 is a substituted or unsubstituted quinolinyl, indolyl, benzyl, naphthyl, pyrimidinyl, thiophenyl, pyrazolyl, thiazolyl, pyridinyl, or furanyl. In further examples R_1 is a substituted quinolinyl, indolyl, benzyl, naphthyl, pyrimidinyl, thiophenyl, pyrazolyl, thiazolyl, pyridinyl, or furanyl.

[0005]In still further examples, the compounds have the structure:



where R_1 and R_2 are independently substituted or unsubstituted quinolinyl, isoquinolinyl, indolyl, benzyl, naphthyl, pyrimidinyl, thiophenyl, pyrazolyl, thiazolyl, pyridinyl, or furanyl. In other examples, R_1 and R_2 are both substituted or unsubstituted quinolinyl, isoquinolinyl, indolyl, benzyl, naphthyl, pyrimidinyl, thiophenyl, pyrazolyl, thiazolyl, pyridinyl, or furanyl. In still other examples, R_1 is the same structure as R_2. Specific examples of R_1 and R_2groups are shown in Table 1 herein.

[0006]It is an object of the invention to provide fluorophores with narrow emission spectra and controllable photoswitching properties.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[007]Some of the drawings are better understood when presented in color. Applicants consider the color drawings to be part of the original disclosure and reserve the right to present color versions of the drawings in later proceedings.

[008]FIG. 1A is a plot showing the maximum absorbance vs maximum emission wavelength for

all of the compounds in the BAA library. Particular compounds are indicated by arrows. The inset is a higher resolution view with three indicated compounds.

[009]FIG. 1B is a plot showing the quantum yield vs maximum emission wavelength for all of the compounds in the BAA library. Particular compounds are indicated by arrows.

[0010]FIG. 1C is a plot showing the full width at half max vs maximum emission wavelength for all of the compounds in the BAA library. Particular compounds are indicated by arrows.

[0011]FIG. 2A is a plot of the absorbance spectra of the indicated compounds.

[0012]FIG. 2B is a plot of the emission spectra of the indicated compounds.

[0013]FIG. 3 is a set of images showing the organelle specificity of the indicated compounds in fixed U2OS cells.

[0014]FIG. 4 is a set of images showing the organelle specificity of the indicated compounds in fixed U2OS cells.

[0015]FIG. 5 is a set of images showing the organelle specificity of the indicated compounds in fixed U2OS cells.

[0016]FIG. 6 is a set of images showing the organelle specificity of the indicated compounds in fixed U2OS cells.

[0017]FIG. 7A shows the molecular orbitals of BAA-37a.

[0018]FIG. 7B shows the molecular orbitals of BAA-55a

[0019]FIG. 7C shows the molecular orbitals of BAA-60b

[0020]FIG. 7D shows the molecular orbitals of BAA-5a

[0021]FIG. 7E shows the molecular orbitals of BAA-2a

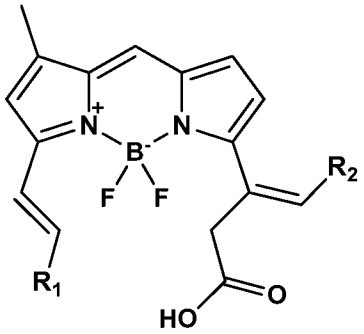
[0022]FIG. 7F shows the molecular orbitals of BAA-39a.

DETAILED DESCRIPTION

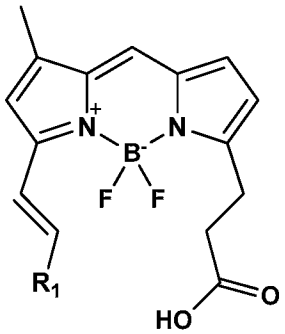
[0023]Herein, a library of BODIPY-based fluorophores was synthesized and characterized to create optimal photoswitchable fluorophores for MSSRM. BODIPY was chosen as the core structure as it is photostable, has high quantum yield, and controllable photoswitching. The BODIPY core was modified through the addition of various aromatic moieties, resulting in a spectrally diverse library. Photoswitching properties were characterized using a novel polyvinyl alcohol (PVA) based film methodology to isolate single molecules. The PVA film methodology enabled photoswitching assessment without the need for protein conjugation, greatly improving screening efficiency of the BODIPY library. Additionally, image buffer conditions were optimized for the BODIPY-based fluorophores through systematic testing of oxygen scavenger systems, redox components, and additives. Through screening the photoswitching properties of BODIPY-

based compounds in PVA films with optimized imaging buffer we identified novel fluorophores well suited for SMLM and MSSRM. Such compounds have longer Stokes shifts than commercial fluorophores.

[0024]The disclosed compounds have the structure:

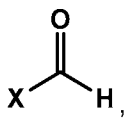


where R_1 is an aryl, a substituted aryl, an aromatic heterocycle, or a substituted aromatic heterocycle and R_2 is H, an aryl, a substituted aryl, an aromatic heterocycle, or a substituted aromatic heterocycle. In examples, R_2 is H, a substituted aryl, or a substituted aromatic heterocycle. In further examples, the compounds have the structure:

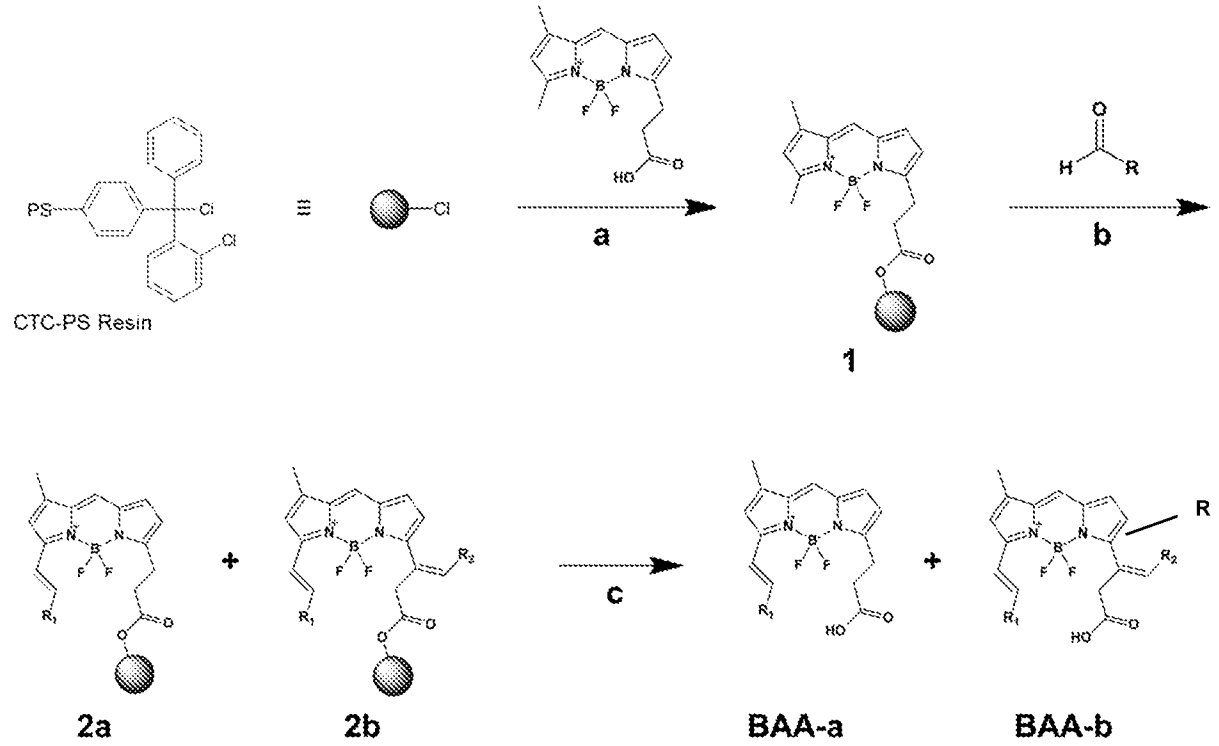


where R_1 is an aryl, a substituted aryl, an aromatic heterocycle, or a substituted aromatic heterocycle. In examples, R_1 is a substituted aryl or a substituted aromatic heterocycle. In examples, R_1 is a substituted or unsubstituted quinolinyl, indolyl, benzyl, naphthyl, pyrimidinyl, thiophenyl, pyrazolyl, thiazolyl, pyridinyl, or furanyl. In further examples, R_1 is a substituted quinolinyl, indolyl, benzyl, naphthyl, pyrimidinyl, thiophenyl, pyrazolyl, thiazolyl, pyridinyl, or furanyl.

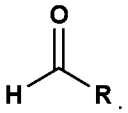
[0025]The compounds are synthesized by attaching an aromatic aldehyde of general structure:



where X is a substituted aryl, aromatic heterocycle or substituted aromatic heterocycle to BODIPY via the following scheme.



where the aromatic aldehyde is indicated in the scheme by the following structure:



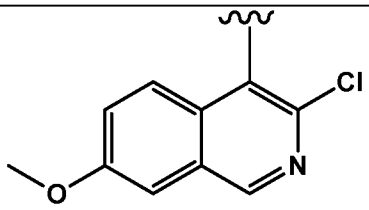
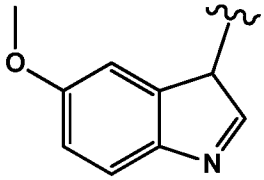
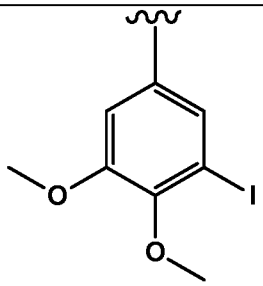
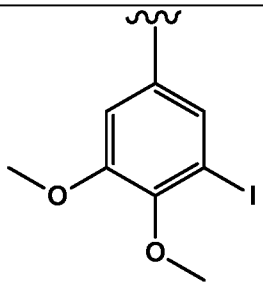
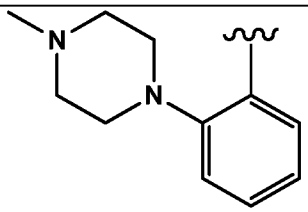
[0026]Reaction (a) is performed in the presence of DCM and DIEA, at room temperature for 20 h. In reaction (b) R-CHO are added in the presence of DMSO-ACN (1:1), pyrrolidine, acetic acid, at 85°C for 15 min; (c) TFA-DCM (0.5:99.5), rt, 2 x 10 min.

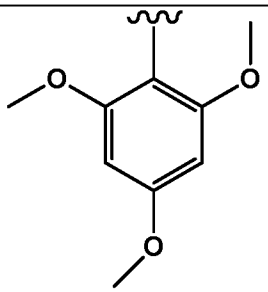
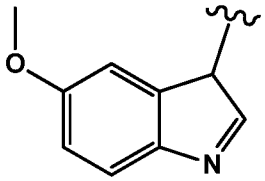
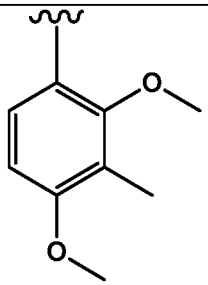
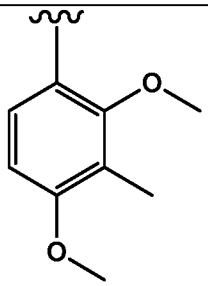
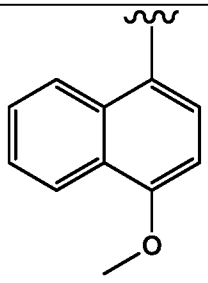
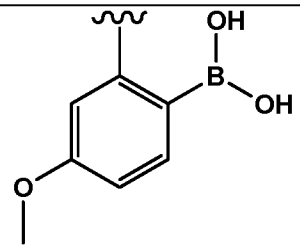
[0027]More specifically, BODIPY FL was loaded onto CTC-PS resin in the following increments: 500 mg of BODIPY FL in 17.2 ml of DCM was added to 5 g of CTC-PS resin in 14.9 ml of DIEA, protected from light, and placed on the shaker overnight. This was washed 3 times in dichloromethane (DCM), 3 times in dimethylformamide (DMF), 3 times in methanol, 3 additional times in DMF, 3 x DCM and dried with ethyl ether, resulting in 90% BODIPY FL retained on the resin.

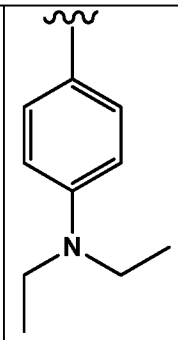
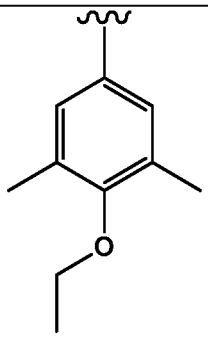
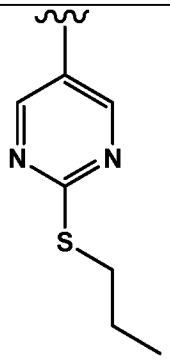
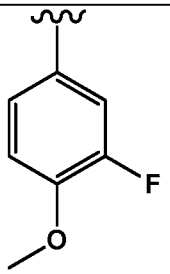
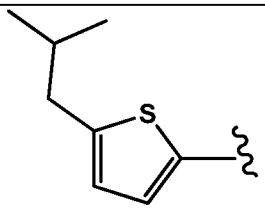
[0028]The BODIPY FL loaded CTC-PS resin (100 mg in 3 ml of a 1:1 mixture of dimethylsulfoxide (DMSO) and acetonitrile (ACN)) and 15 equivalents of aldehyde solution (0.45 mmol in 1 ml of a 1:1 mixture of DMSO and ACN) were mixed with 65 equivalents of acetic acid (105 µl, 2 mmol) and 65 equivalents of pyrrolidine (150 µl, 2 mmol) at 85°C for 15 min. The resin was washed 3 times in DCM and 3 times in DMF – and this cycle (3x in DCM, 3x in DMF) was repeated three times. The resin was then washed 3x in ethyl ether before cleaving the formed BAA compound

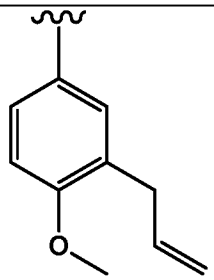
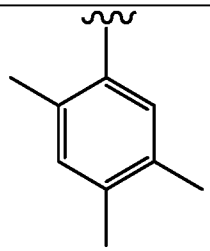
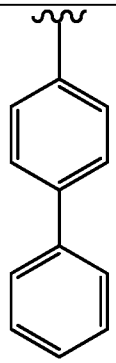
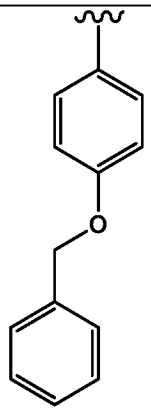
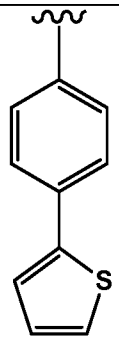
with 0.5% TFA in DCM. The BAA compounds were purified via HPLC and dried using a Labconco freeze dryer.

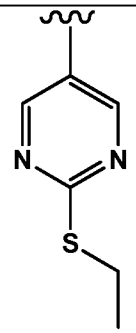
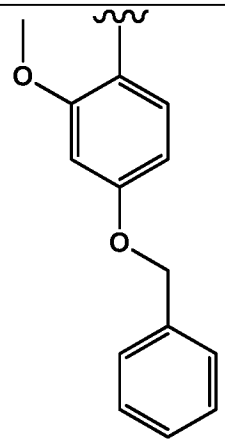
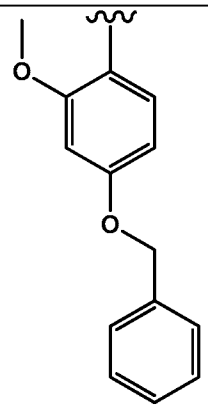
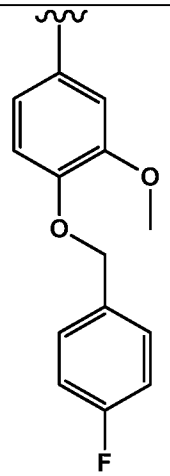
[0029]Specific structures and purity data are as follows:

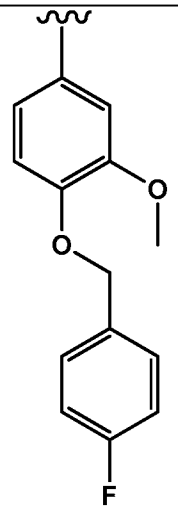
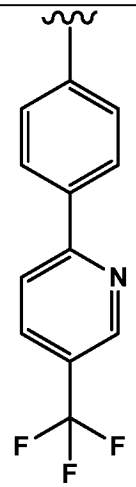
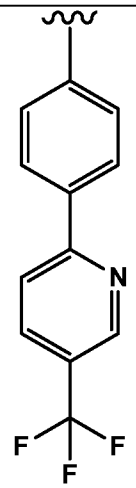
Product	R_1	R_2	m/z calc	m/z exp	RT (min)	Purity (%)
BAA-1b		= R_1	698.15	699.15	7.83	92
BAA-2a		H	419.16	400.16[a]	7.66	> 99
BAA-3a		H	566.07	567.95	8.07	98
BAA-3b		= R_1	840.02	863.25[b]	8.21	97
BAA-4a		H	478.24	479.24	6.02	> 99

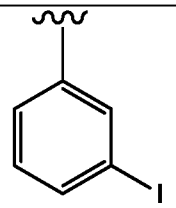
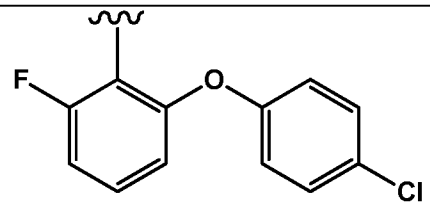
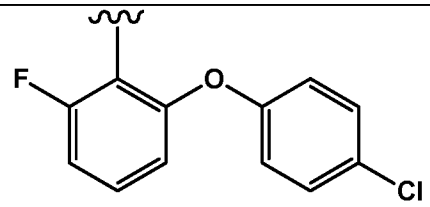
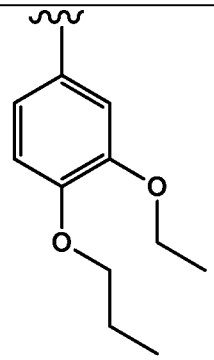
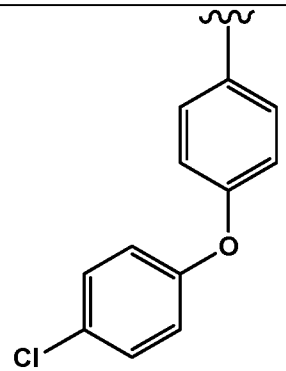
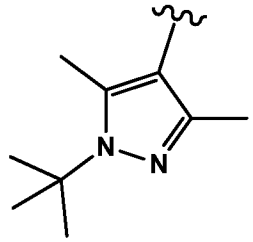
BAA-5a		H	470.18	471.19	8.26	> 99
BAA-6a		H	449.17	472.18[b]	7.69	82
BAA-7a		H	454.19	477.27[b]	8.64	83
BAA-7b		= R_1	616.26	617.26	7.32	88
BAA-8a		H	460.18	461.19	8.31	80
BAA-9a		H	454.17	455.13	8.15	92

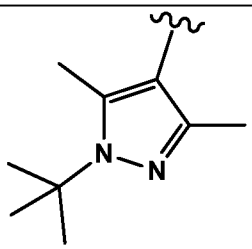
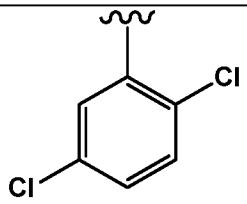
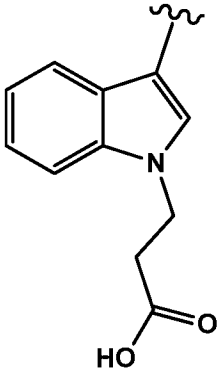
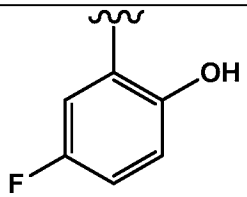
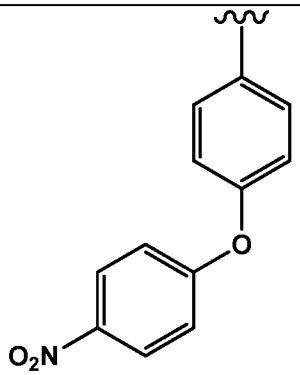
BAA-10b		= R_1	610.33	611.35	9.45	> 99
BAA-11a		H	514.22	515.22	8.98	91
BAA-12a		H	456.16	474.19[c]	7.69	88
BAA-13a		H	428.15	429.15	7.28	90
BAA-14a		H	442.17	465.16[b]	9.15	83

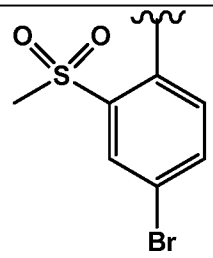
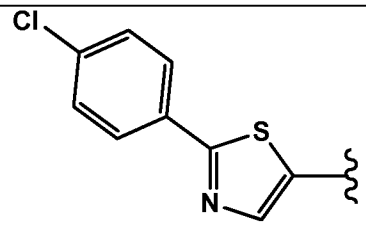
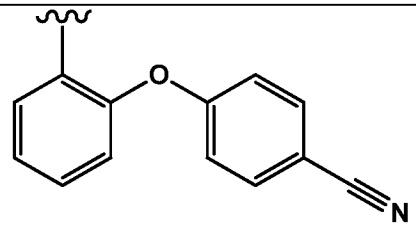
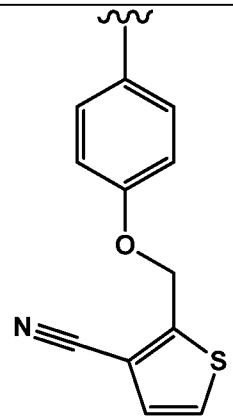
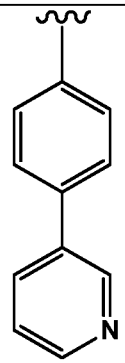
BAA-15a		H	450.19	451.19	8.83	96
BAA-16a		H	422.2	445.19[b]	9.08	98
BAA-17a		H	456.18	479.17[b]	9.09	85
BAA-18a		H	486.19	509.18[b]	8.94	92
BAA-19a		H	462.14	485.13	8.94	96

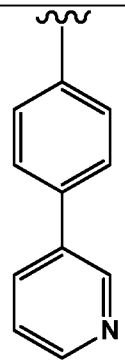
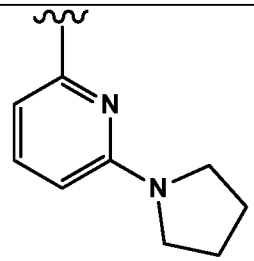
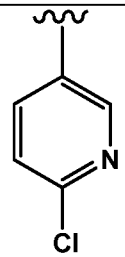
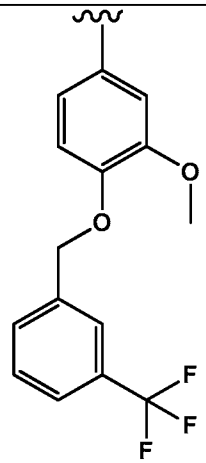
BAA-20a		H	442.14	443.15	8.07	98
BAA-21a		H	516.2	497.21[a]	9.13	95
BAA-21b		= R_1	740.29	741.29	7.82	92
BAA-22a		H	534.19	515.20[a]	8.65	94

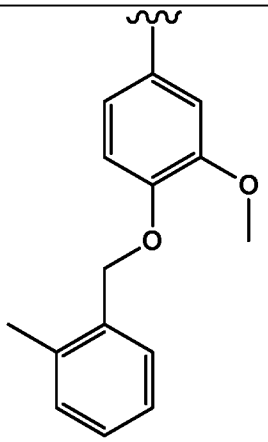
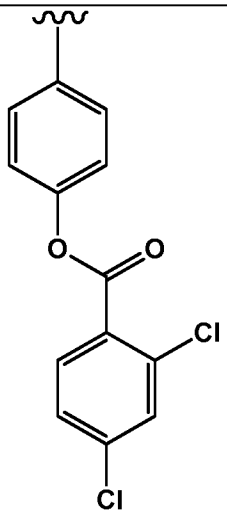
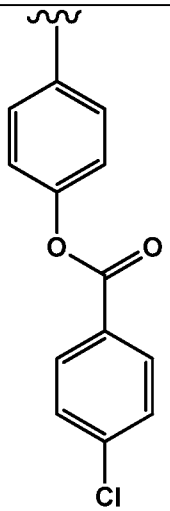
BAA-22b		= R_1	776.27	777.28	7.51	90
BAA-23a		H	525.16	526.18	9.05	> 99
BAA-23b		= R_1	758.21	739.13	7.93	89

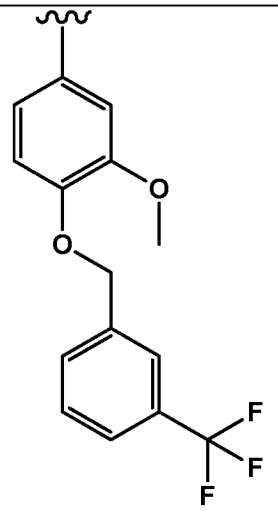
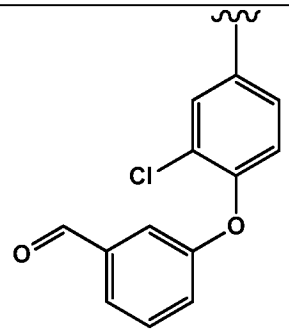
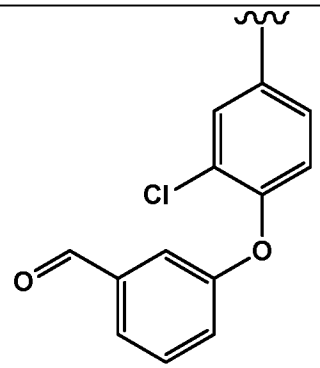
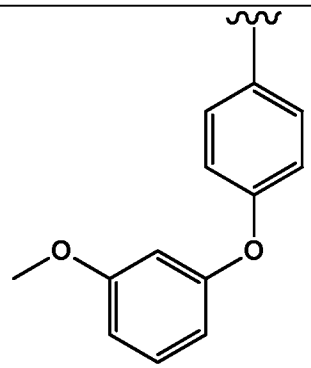
BAA-24b		= R_1	719.98	700.98[a]	7.46	94
BAA-25a		H	524.73	547.12[b]	9.30	93
BAA-25b		= R_1	756.14	757.15	7.88	95
BAA-26b		= R_1	672.32	673.33	7.56	98
BAA-27b		= R_1	720.16	683.22	7.19	97
BAA-28a		H	454.24	435.28	6.69	88

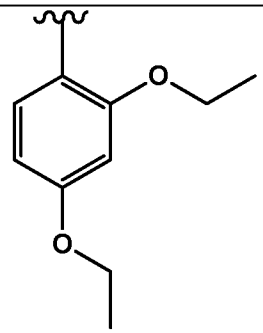
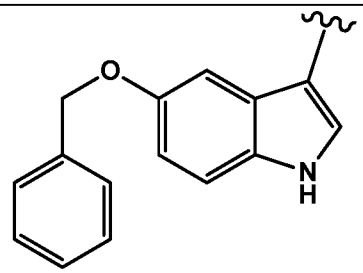
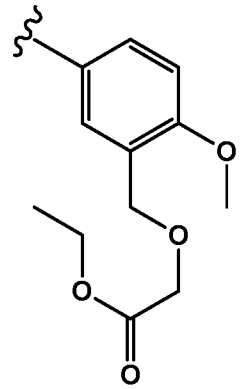
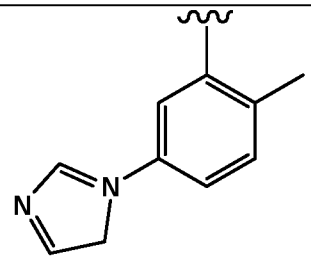
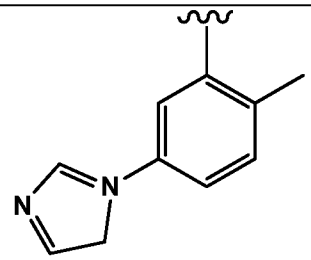
BAA-28b		= R_1	616.35	617.37	6.99	97
BAA-29b		= R_1	604.03	605.03	8.14	86
BAA-30a		H	491.18	492.19	7.41	96
BAA-31b		= R_1	536.28	497.15[d]	6.34	94
BAA-32a		H	517.16	478.15[d]	8.77	> 99

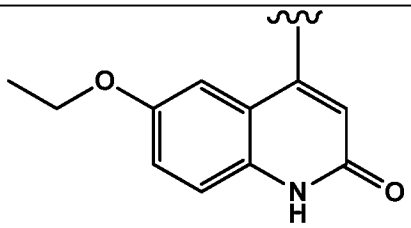
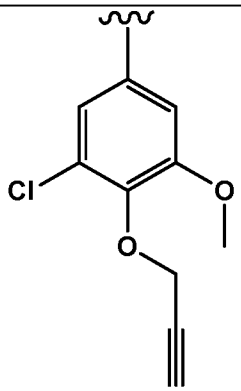
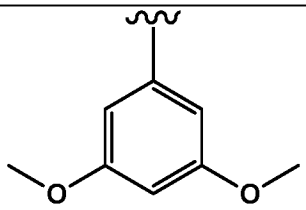
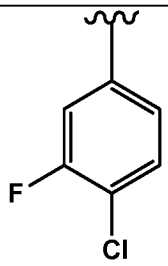
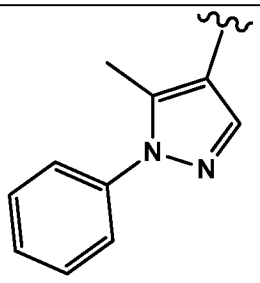
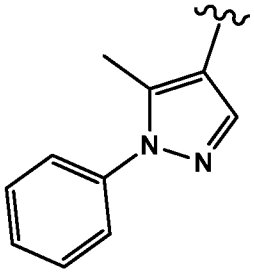
BAA-33a		H	536.04	559.02[b]	7.94	98
BAA-34b		= R_1	702.07	683.06[a]	7.69	94
BAA-35b		= R_1	702.22	703.15	8.49	86
BAA-36b		= R_1	742.17	743.18	8.16	94
BAA-37a		H	457.18	438.18[a]	5.75	88

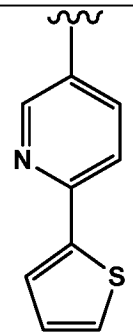
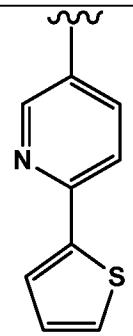
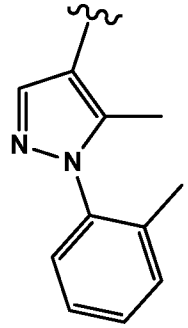
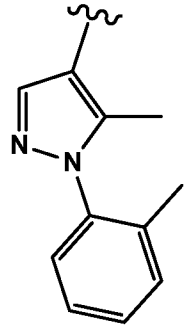
BAA-37b		= R_1	622.24	623.24	5.78	> 99
BAA-38a		H	450.2	451.21	6.28	99
BAA-39a		H	415.11	451.21[g]	5.99	94
BAA-40b		= R_1	876.26	877.27	7.96	89

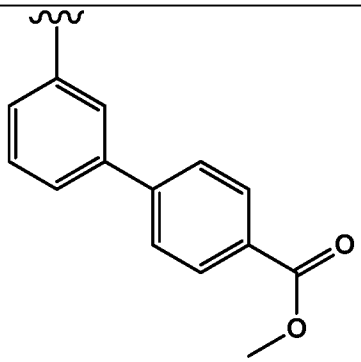
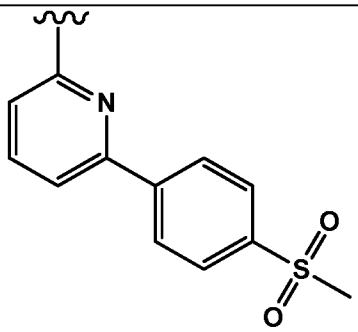
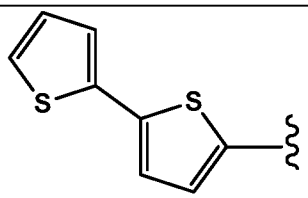
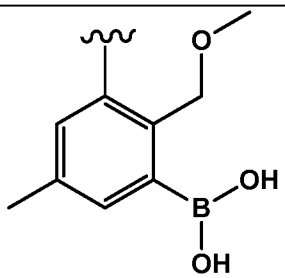
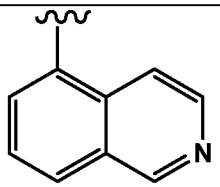
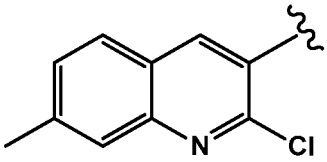
BAA-41b		= R_1	768.32	769.33	7.61	94
BAA-42a		H	568.09	501.17[a]	6.17	82
BAA-43a		H	534.13	501.17[f]	6.13	94

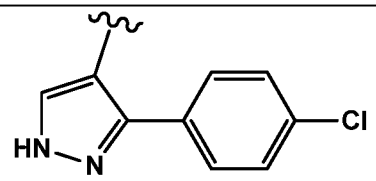
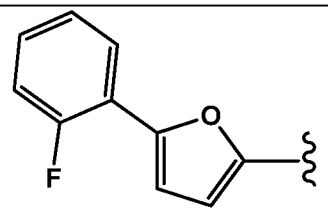
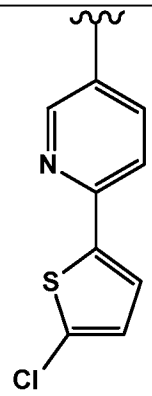
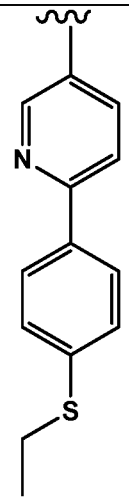
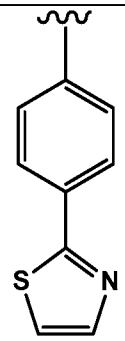
BAA-44b		= R_1	876.26	877.27	8.15	92
BAA-45a		H	538.75	562.14[b]	9.29	>99
BAA-45b		= R_1	784.17	785.17	8.24	96
BAA-46b		= R_1	740.29	741.28	7.69	94

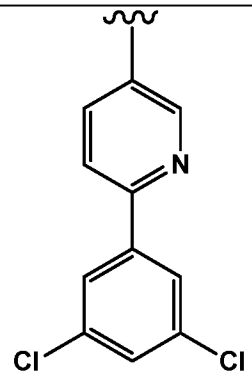
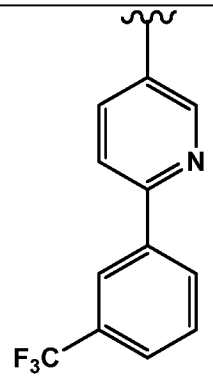
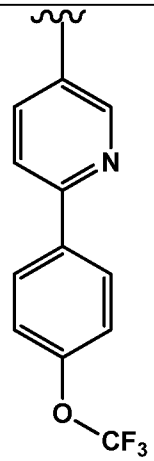
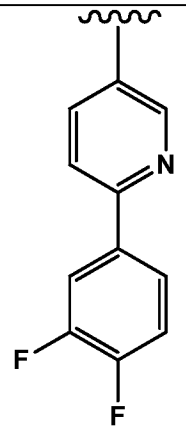
BAA-47a		H	468.2	491.20[b]	8.62	94
BAA-48a		H	525.2	548.19[b]	8.24	> 99
BAA-49b		= R_1	638.21	619.21[a]	6.58	> 99
BAA-50a		H	460.19	483.18[b]	8.07	> 99
BAA-50b		= R_1	628.26	629.25	6.94	> 99

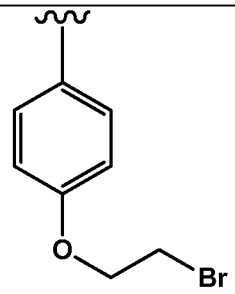
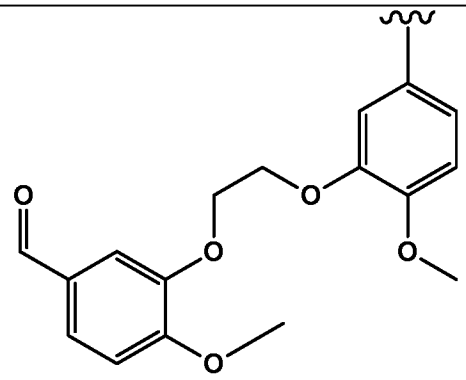
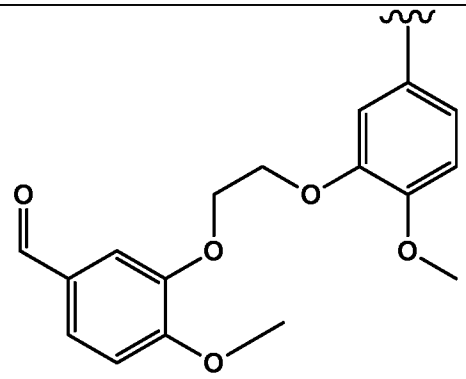
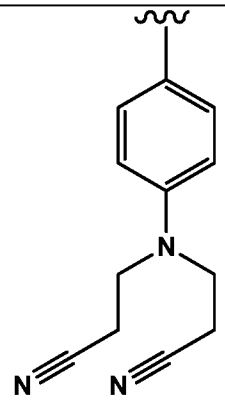
BAA-51a		H	491.18	514.16[b]	7.59	89
BAA-52a		H	498.13	499.12	7.86	83
BAA-53a		H	440.17	441.17	7.57	> 99
BAA-54a		H	432.1	433.09	7.98	89
BAA-55a		H	460.19	461.18	7.30	> 99
BAA-55b		= R_1	628.26	629.26	6.89	89

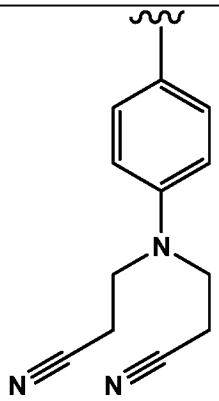
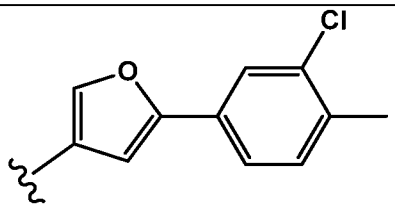
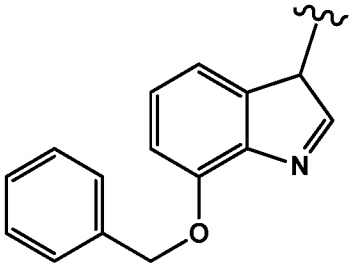
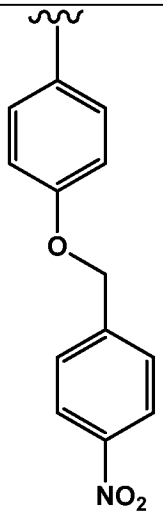
BAA-56a		H	463.13	464.13	5.87	> 99
BAA-56b		= R_1	634.15	635.15	7.84	84
BAA-57a		H	474.2	475.21	6.10	85
BAA-57b		= R_1	656.29	657.30	8.01	> 99

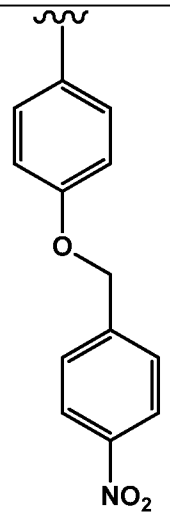
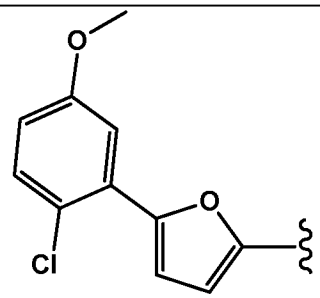
BAA-58a		H	514.19	515.18	8.20	> 99
BAA-59a		H	535.15	553.16	7.37	96
BAA-60b		= R_1	644.07	645.08	8.11	99
BAA-61a		H	496.22	497.21	7.32	98
BAA-62a		H	431.16	449.16[c]	6.81	> 99
BAA-63a		H	479.14	502.15[b]	7.05	93

BAA-64a		H	480.13	481.11	7.50	91
BAA-65a		H	464.15	427.14[d]	8.82	88
BAA-66a		H	497.09	498.10	9.09	93
BAA-67a		H	517.18	518.18	9.02	92
BAA-68a		H	463.13	464.14	8.27	> 99

BAA-69a		H	525.1	526.09	9.08	> 99
BAA-70a		H	525.16	526.18	8.95	99
BAA-71a		H	541.16	542.17	9.06	> 99
BAA-72a		H	493.16	511.17[c]	8.13	98

BAA-73a		H	502.09	503.08	7.95	> 99
BAA-74a		H	604.22	627.21[b]	8.02	92
BAA-74b		=R_1	916.32	897.32[c]	7.01	94
BAA-75a		H	501.21	482.22	10.99	> 99

BAA-75b		= R_1	710.31	711.32	6.38	94
BAA-76a		H	510.13	491.13[a]	90.31	98
BAA-77a		H	525.2	506.21[a]	8.52	99
BAA-78a		H	531.18	512.18[a]	8.72	> 99

BAA-78b		= R_1	770.24	771.24	7.73	98
BAA-79a		H	494.14	457.13[d]	9.421	91

LC/MS Conditions: A: H_2O-CH_2O_2: 99.9:0.1. B: ACN-CH_2O_2: 99.9:0.1; gradient 5% B to 30% B (1 min), gradient 30% B to 95% B (4.5 min), isocratic 95% B (4.5 min), flowrate: 0.4 ml/min. ESI (+) m/z signal found correspond to (M+H) except a: (M-F), b: (M+Na), c: (M+NH4), d: (M-2F+H), e: (M-2Cl+H), and f: (M-Cl); g: Cl replaced by pyrrolidine during synthesis reaction. Purity was determined by integration of the LC/MS absorbance peaks at 254 nm.

= R_1 indicates that R_2 is the same structure as R_1.

[0030]Table 2 shows the spectroscopic properties of the BAA library:

Product	λmax ABS (nm)	λmax EM (nm)	Stokes Shift (nm)	Φ_{fl}	FWHM
BAA-1b	580	597	17	0.62	40
BAA-2a	601	635	34	0.62	57
BAA-3a	569	579	10	0.61	31
BAA-3b	574	587	13	0.70	34
BAA-4a	581	600	19	0.43	56
BAA-5a	592	615	23	0.83	47
BAA-6a	609	643	34	0.18	64
BAA-7a	582	600	18	0.29	63
BAA-7b	581	600	19	0.43	56
BAA-8a	594	623	29	0.50	61
BAA-9a	569	579	10	0.35	32
BAA-10b	632	714	82	0.01	102
BAA-11a	575	589	14	0.86	33
BAA-12a	589	616	27	0.10	88
BAA-13a	576	586	10	0.19	44
BAA-14a	594	607	13	0.44	70
BAA-15a	581	597	16	0.42	39
BAA-16a	552	610	58	0.22	78
BAA-17a	579	591	12	0.59	42
BAA-18a	577	593	16	0.65	37
BAA-19a	582	595	13	0.64	35
BAA-20a	577	585	8	0.15	31
BAA-21a	585	611	26	0.51	46
BAA-21b	588	608	20	0.54	50
BAA-22a	585	602	17	0.39	49
BAA-22b	582	601	19	0.27	46
BAA-23a	592	603	11	0.23	30
BAA-23b	580	588	8	0.19	32
BAA-24b	570	579	9	0.29	32
BAA-25a	571	580	9	0.19	32
BAA-25b	572	580	8	0.18	32
BAA-26b	582	604	22	0.30	51
BAA-27b	575	588	13	0.33	35
BAA-28a	480	592	112	0.04	52
BAA-28b	580	598	18	0.58	43
BAA-29b	569	580	11	0.13	37
BAA-30a	607	643	36	0.43	58

Product	λmax ABS (nm)	λmax EM (nm)	Stokes Shift (nm)	Φ_{fl}	FWHM
BAA-31b	576	588	12	0.28	34
BAA-32a	574	584	10	0.23	32
BAA-33a	575	587	12	0.15	35
BAA-34b	570	581	11	0.96	31
BAA-35b	571	580	9	0.25	32
BAA-36b	579	592	13	0.35	37
BAA-37a	568	578	10	0.54	55
BAA-37b	569	578	9	0.55	30
BAA-38a	579	581	2	0.07	33
BAA-39a	606	657	51	0.19	79
BAA-40b	583	601	18	0.26	45
BAA-41b	582	602	20	0.36	47
BAA-42a	570	580	10	0.36	30
BAA-43a	569	579	10	0.45	31
BAA-44b	582	600	18	0.28	43
BAA-45b	570	579	9	0.50	30
BAA-45a	571	580	9	0.22	31
BAA-46b	572	585	13	0.61	33
BAA-47a	589	611	22	0.33	47
BAA-48a	603	641	38	0.45	60
BAA-49b	571	580	9	0.14	33
BAA-50a	571	581	10	0.28	33
BAA-50b	572	581	9	0.12	34
BAA-51a	594	607	13	0.06	42
BAA-52a	577	585	8	0.04	51
BAA-53a	570	581	11	0.44	30
BAA-54a	573	581	8	0.04	46
BAA-55a	576	592	16	0.75	35
BAA-55b	575	591	16	0.75	38
BAA-56a	585	595	10	0.91	32
BAA-56b	586	597	11	0.15	35
BAA-57a	574	590	16	0.75	45
BAA-57b	575	591	16	0.75	38
BAA-58a	572	582	10	0.70	30
BAA-59a	571	581	10	0.53	30
BAA-60b	588	604	16	0.47	37
BAA-61a	573	587	14	1.00	35
BAA-62a	579	594	15	0.68	33
BAA-63a	592	607	15	0.43	39

Product	λmax ABS (nm)	λmax EM (nm)	Stokes Shift (nm)	Φ_{fl}	FWHM
BAA-64a	576	593	17	0.80	37
BAA-65a	606	622	16	0.21	54
BAA-66a	587	598	11	0.28	34
BAA-67a	587	598	11	0.15	61
BAA-68a	585	595	10	0.17	30
BAA-69a	577	589	12	0.85	30
BAA-70a	580	588	8	0.17	33
BAA-71a	580	589	9	0.19	32
BAA-72a	580	590	10	0.40	31
BAA-73a	579	593	14	0.55	46
BAA-74a	584	602	18	0.15	59
BAA-74b	583	600	17	0.22	51
BAA-75a	614	663	49	0.08	91
BAA-75b	605	660	55	0.18	91
BAA-76a	613	634	21	0.21	55
BAA-77a	603	634	31	0.50	61
BAA-78a	581	592	11	0.19	46
BAA-78b	579	593	14	0.37	39
BAA-79a	606	630	24	0.63	49

[0031]Terms:

[0032]Alkyl: a branched or unbranched saturated or unsaturated hydrocarbon group, such as, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, t-butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, tetradecyl, hexadecyl, eicosyl, tetracosyl and the like. A lower alkyl group is a saturated branched or unbranched hydrocarbon having from 1 to 6 carbon atoms (C_{1-6} alkyl). Similarly, a C_2 or greater alkyl, a C_3 or greater alkyl, a C_4 or greater alkyl, etc. refers to a branched or unbranched saturated or unsaturated hydrocarbon group of two or more, three or more, four or more, etc. carbons. The term alkyl also encompasses cycloalkyls. Alkyl also encompasses substituted alkyls which are alkyl groups wherein one or more hydrogen atoms are replaced with a substituent such as, alkyl, alkynyl, alkenyl, aryl, halide, nitro, amino, ester, ether, ketone, aldehyde, hydroxyl, carboxyl, cyano, amido, haloalkyl, haloalkoxy, or alkoxy. The term alkyl also encompasses heteroalkyls. A heteroalkyl contains at least one heteroatom such as nitrogen, oxygen, sulfur, or phosphorus replacing one or more of the carbons. Substituted heteroalkyls are also encompassed by the term alkyl.

[0033]Amino: a saturated or unsaturated nitrogen group. An amino group includes an unsubstituted amino (-NH_2 or –NH_3^+) or substituted amino. A substituted amino generally has the

structure -NQ_1Q_2 or –$NQ_1Q_2Q_3^+$ where at least one of Q_1, Q_2 and Q_3 are selected from an alkyl (including a substituted alkyl) as described above or any other substituent including, for example, alkynyl, alkenyl, aryl, halide, nitro, amino, ester, ether, ketone, aldehyde, hydroxyl, carboxyl, cyano, amido, haloalkyl, haloalkoxy, or alkoxy. Examples of substituted amino groups include the following structures: --$NHCH_3$, --$N(CH_3)_2$ --$NH(CH_3)_2^+$--$N(CH3)_3^+$, $NHCH_2CH_3$, $NH_2CH_2CH_3^+$, $NCH_3CH_2CH_3$, $N(CH_2CH_3)_2$, $NHCH_3CH_2CH_3^+$. Amino groups also include cyclic structures and structures including other heteroatoms such as oxygen, sulfur or phosphorus. Cyclic amino structures include 4-member single nitrogen (azetidinyl), 5-member single nitrogen (pyrrolidinyl), or 6-member single nitrogen (piperidinyl) structures as well as double nitrogen structures, as well as substituted cyclic amino structures.

[0034]Aryl: any carbon-based aromatic group including, benzyl, naphthyl, and phenyl. The term aryl also contemplates substituted aryls in which one or more of the hydrogens is substituted with one or more groups including alkyl, alkynyl, alkenyl, aryl, halide, nitro, amino, ester, ether, ketone, aldehyde, hydroxy, carboxylic acid, cyano, amido, haloalkyl, haloalkoxy, or alkoxy. The term aryl also contemplates heteroaryls in which one or more of the carbons is replaced by a heteroatom. Examples of heteroatoms include, nitrogen, oxygen, sulfur, and phosphorous. Substituted heteroaryls are also encompassed by the term aryl.

[0035]Cycloalkyl: a non-aromatic carbon-based ring composed of at least three carbon atoms. Examples of cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, and cyclohexyl. Cycloalkyls also encompass substituted cycloalkyls and heterocycloalkyls where at least one of the carbon atoms is replaced with a heteroatom such as nitrogen, sulfur or phosphorus. A heterocycloalkyl wherein one or more of the carbons is replaced with nitrogen is also termed a cycloalkylamino herein. The term also encompasses substituted heterocycloalkyls.

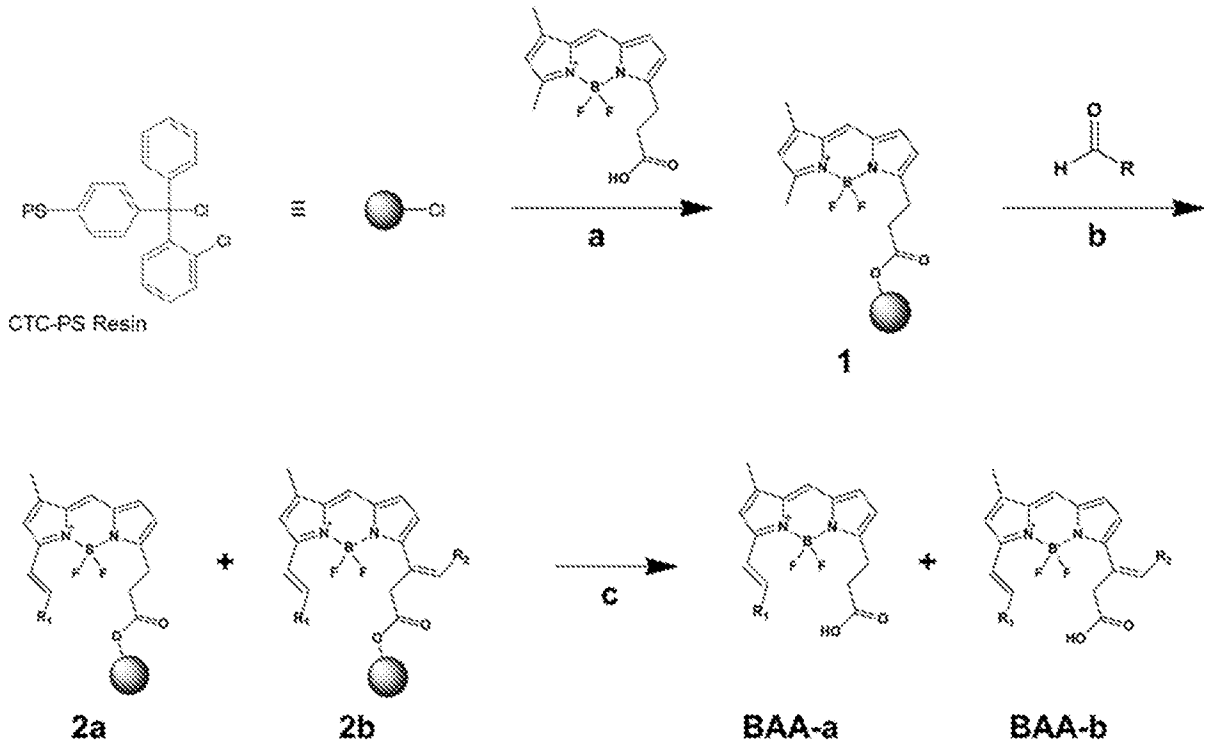
[0036]Heterocycle: A group that encompasses both heteroaryls and heterocycloalkyls. Heteroaryls can also be termed aromatic heterocycles. Heterocycles may be monocyclic or polycyclic rings. Exemplary heterocycles include azepinyl, aziridinyl, azetyl, azetidinyl, diazepinyl, dithiadiazinyl, dioxazepinyl, dioxolanyl, dithiazolyl, furanyl, isooxazolyl, isothiazolyl, imidazolyl, morpholinyl, oxetanyl, oxadiazolyl, oxiranyl, oxazinyl, oxazolyl, piperazinyl, pyrazinyl, pyridazinyl, pyrimidinyl, piperidyl, piperidino, pyridyl, pyranyl, pyrazolyl, pyrrolyl, pyrrolidinyl, thiatriazolyl, tetrazolyl, thiadiazolyl, triazolyl, thiazolyl, thienyl, tetrazinyl, thiadiazinyl, triazinyl, thiazinyl, thiopyranyl, furoisoxazolyl, imidazothiazolyl, thienoisothiazolyl, thienothiazolyl, imidazopyrazolyl, cyclopentapyrazolyl, pyrrolopyrrolyl, thienothienyl, thiadiazolopyrimidinyl, thiazolothiazinyl, thiazolopyrimidinyl, thiazolopyridinyl, oxazolopyrimidinyl, oxazolopyridyl, benzoxazolyl, benzisothiazolyl, benzothiazolyl, imidazopyrazinyl, purinyl, pyrazolopyrimidinyl, imidazopyridinyl,

benzimidazolyl, indazolyl, benzoxathiolyl, benzodioxolyl, benzodithiolyl, indolizinyl, indolinyl, isoindolinyl, furopyrimidinyl, furopyridyl, benzofuranyl, isobenzofuranyl, thienopyrimidinyl, thienopyridyl, benzothienyl, cyclopentaoxazinyl, cyclopentafuranyl, benzoxazinyl, benzothiazinyl, quinazolinyl, naphthyridinyl, quinolinyl, isoquinolinyl, benzopyranyl, pyridopyridazinyl and pyridopyrimidinyl groups. The term also contemplates substituted heterocycles, including substituted forms of all the species listed above.

[0037]Fluorescent Dye: a small molecule that absorbs light at one wavelength and then emits light at a second wavelength. Dyes of different structure emit at different wavelengths and, as a result, multiple fluorescent dyes can be distinguishable from one another and can label multiple targets simultaneously. The compositions disclosed herein can be used as fluorescent dyes.

[0038]Scheme 1

[0039]Synthesis of BAA Library



[0040]Reagents and Conditions: (a) DCM, DIEA, rt, 20 h; (b) R-CHO (79 aromatic aldehydes shown in the tables herein), DMSO-ACN (1:1), pyrrolidine, acetic acid, 85°C, 15 min; (c) TFA-DCM (0.5:99.5), rt, 2 x 10 min.

[0041]Experimentals:

[0042]Materials. All commercially available starting materials were used without further purification unless otherwise stated. 4,4-Difluoro-5,7-Dimethyl-4-Bora-3a,4a-Diaza-s-Indacene-3-Propionic Acid (BODIPY FL) was obtained from Thermo Fisher Scientific. Aromatic aldehydes

were purchased from Thermo Fisher Scientific and Sigma-Aldrich. 2-Chlorotrityl chloride polystyrene (CTC-PS) 100-200 mesh resin was purchased from EMD-Millipore. ACN and water for HPLC and LC/MS were purchased from Thermo Fisher Scientific at LC/MS purity grade.

[0043]General Instruments. Synthesized sample purification was performed with an Agilent 1260 Infinity HPLC utilizing a C18 column (150mm x 21.2 mm). MS (HRMS, ESI) spectra data was collected with an Agilent 6244 TOF LC/MS with diode array detector VL+ and C18 column (4.6 mm x 50 mm). Absorbance and fluorescence data were measured on a SpectraMax M5 Microplate reader. NMR spectra, ^{1}H and ^{13}C, were recorded on a Bruker ARK400 spectrometer. BAA microscopy screening in cells for organelle specificity and signal-to-background ratio was completed with an Axio Zeiss Light Microscope and 63x oil immersion objective.

[0044]General Procedure for the Synthesis of BAA Fluorophore Library BODIPY FL was loaded onto CTC-PS resin in the following increments: 500 mg of BODIPY FL in 17.2 ml of DCM added to 5 g of CTC-PS resin in 14.9 ml of DIEA, protected from light on shaker overnight, washed 3 x DCM, 3 x DMF, 3 x MeOH, 3 x DMF, 3 x DMC and dried with ethyl ether, resulting in 90% BODIPY FL retained on resin. BODIPY FL loaded CTC-PS resin (100 mg in 3 ml of 1:1 DMOS:ACN) and 15 equiv aldehyde (0.45 mmol in 1 ml 1:1 DMSO:ACN) were mixed with 65 equivalent acetic acid (105 µl, 2 mmol) and 65 equivalent pyrrolidine (150 µl, 2 mmol) at 85°C for 15 min. The resin was washed 3 x (3 x DMC, 3 x DMF), 3 x ethyl ether before cleaving the formed BAA compound with 0.5% TFA in DCM. The BAA compounds were purified via HPLC and dried with Labconco freeze dryer.

[0045]Characterization of BAA Library. All BAA compounds were characterized by LC/MS for m/z ratio and purity. Marvin Sketch was used for chemical characterization of structures. Molecular orbital calculations were performed using the density functional theory (DFT) at B3LYP/6-31G level. The six BAA compounds selected for CLSM imaging were characterized further by ^{1}H and ^{13}C NMR (See Supporting Information).

[0046]Fluorescence Properties and Quantum Yield Measurements. Spectroscopic characterizations were performed in anhydrous DMSO in polystyrene 96 well plate. Analysis included the maximum absorbance wavelength, maximum fluorescence emission wavelength, full-width-at half max, and quantum yield. Quantum yields (Φ_{fl}) were determined by comparing the area under the emission spectrum of the BAA compound to a reference fluorophore solution at three concentrations using equation 1, where *Grad* represents the gradient from the plots of integrated fluorescence intensity vs absorbance at three concentrations and η is the refractive index of the solvent. Fluorescein in 0.1 M NaOH (Φ_{fl} = 0.91)[33] was the reference for samples with a max absorbance up to 510 nm, where an excitation of 470 nm was used with the emission

integrated between 490 to 800 nm. Rhodamine B in ethanol (Φ_{fl} = 0.70) was the reference for samples with a max absorbance between 511 – 595 nm, where an excitation of 525 nm was used with the emission integrated between 545 to 800 nm. Cresyl violet in methanol (Φ_{fl} = 0.54)[4] was the reference for samples with a max absorbance above 595 nm, where an excitation of 570 nm was used with the emission integrated between 590 to 800 nm.

$$\Phi_{fl}^{sample} = \Phi_{fl}^{reference}\left(\frac{Grad^{sample}}{Grad^{reference}}\right)\left(\frac{\eta^{sample}}{\eta^{reference}}\right)^2 \quad (1)$$

[0047]Cell Culture. U2OS cells were cultured in Dulbecco's Modified Eagle Medium without phenol red (Invitrogen) supplemented with 10% fetal bovine serum and 1% Penicillin-Streptomycin-Glutamine at 37° C and 5% CO_2. Cells were plated in a 96-well glass bottom plate and incubated for 3 days to reach 50% confluency.

[0048]Microscopy Screening for Organelle Specificity in Cells. Cells were preextracted with 0.5% Triton X-100 in PBS for 20 s, fixed with 0.4% glutaldehyde (GA, Electron Microscopy Science) and 0.25% Triton X-100 in PBS for 90 s, and washed with PBS before fixing with 3% GA in PBS for 15 min. Cells were washed with PBS (3 x 5 min), reduced with 10 mM sodium borohydride for 10 min, washed again with PBS (3 x 5 min), and blocked with 5% bovine serum albumin (BSA) in PBS for 10 min. BAA compounds were diluted to 10 μM in PBS for organelle screening and incubated with permeabilized fixed cells for 5 min, washed with PBS and imaged at 60x magnification.

[0049]The following are incorporated by reference herein:

a. Demas JN and Crosby GA, *J Phys Chem* 75, 991 (1971);
b. Douglas M and Brannon JH, *J Phys Chem* 83, 696 (1979);
c. Karstens T and Kobs KJ, *J Phys Chem* 84, 1871 (1980).

[0050]As will be understood by one of ordinary skill in the art, each embodiment disclosed herein can comprise, consist essentially of or consist of its particular stated element, step, ingredient or component. Thus, the terms "include" or "including" should be interpreted to recite: "comprise, consist of, or consist essentially of." The transition term "comprise" or "comprises" means includes, but is not limited to, and allows for the inclusion of unspecified elements, steps, ingredients, or components, even in major amounts. The transitional phrase "consisting of" excludes any element, step, ingredient or component not specified. The transition phrase "consisting essentially of" limits the scope of the embodiment to the specified elements, steps, ingredients or components and to those that do not materially affect the embodiment.

[0051]Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as molecular weight, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. When further clarity is required, the term "about" has the meaning reasonably ascribed to it by a person skilled in the art when used in conjunction with a stated numerical value or range, i.e. denoting somewhat more or somewhat less than the stated value or range, to within a range of ±10% of the stated value; ±9% of the stated value; ±8% of the stated value; ±7% of the stated value; ±6% of the stated value; ±5% of the stated value; ±4% of the stated value; ±3% of the stated value; ±2% of the stated value; or ±1% of the stated value.

[0052]Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

[0053]The terms "a," "an," "the" and similar referents used in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Recitation of ranges of values herein is merely intended to serve as a shorthand method of referring individually to each separate value falling within the range. Unless otherwise indicated herein, each individual value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention otherwise claimed. No language in the specification should be construed as indicating any non-claimed element essential to the practice of the invention.

[0054]Groupings of alternative elements or embodiments of the invention disclosed herein are not to be construed as limitations. Each group member may be referred to and claimed

individually or in any combination with other members of the group or other elements found herein. It is anticipated that one or more members of a group may be included in, or deleted from, a group for reasons of convenience and/or patentability. When any such inclusion or deletion occurs, the specification is deemed to contain the group as modified thus fulfilling the written description of all Markush groups used in the appended claims.

[0055]Certain embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Of course, variations on these described embodiments will become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventor expects skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

[0056]In closing, it is to be understood that the embodiments of the invention disclosed herein are illustrative of the principles of the present invention. Other modifications that may be employed are within the scope of the invention. Thus, by way of example, but not of limitation, alternative configurations of the present invention may be utilized in accordance with the teachings herein. Accordingly, the present invention is not limited to that precisely as shown and described.

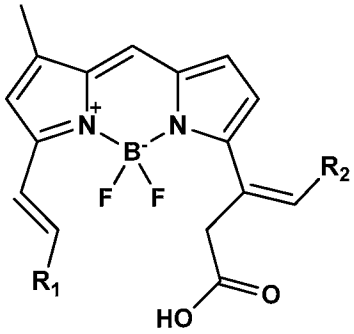
[0057]The particulars shown herein are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of various embodiments of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for the fundamental understanding of the invention, the description taken with the drawings and/or examples making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[0058]Definitions and explanations used in the present disclosure are meant and intended to be controlling in any future construction unless clearly and unambiguously modified in the following examples or when application of the meaning renders any construction meaningless or essentially meaningless. In cases where the construction of the term would render it meaningless or essentially meaningless, the definition should be taken from

Webster's Dictionary, 3rd Edition or a dictionary known to those of ordinary skill in the art, such as the Oxford Dictionary of Biochemistry and Molecular Biology (Ed. Anthony Smith, Oxford University Press, Oxford, 2004).

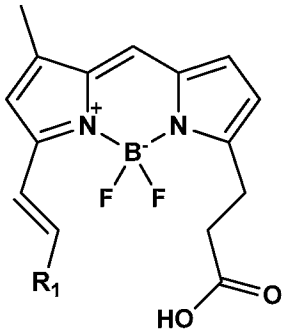
CLAIMS

1. A compound with the structure:



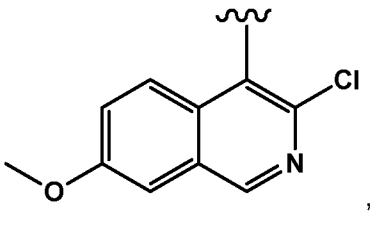
where R_1 is aryl, substituted aryl, aromatic heterocycle, or substituted aromatic heterocycle and where R_2 is H, aryl, substituted aryl, aromatic heterocycle, or substituted aromatic heterocycle.

2. The compound of claim 1 with the structure:

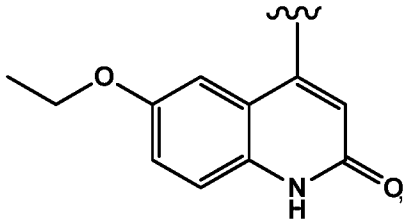


where R_1 is substituted or unsubstituted quinolinyl, substituted or unsubstituted isoquinolinyl, substituted or unsubstituted indolyl, substituted or unsubstituted benzyl, substituted or unsubstituted naphthyl, substituted or unsubstituted pyrimidinyl, substituted or unsubstituted thiophenyl, substituted or unsubstituted pyrazolyl, substituted or unsubstituted thiazolyl, substituted or unsubstituted pyridinyl, or substituted or unsubstituted furanyl.

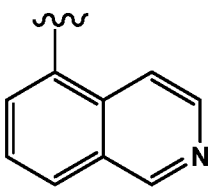
3. The compound of claim 2 where R_1 is selected from:



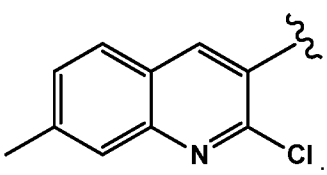
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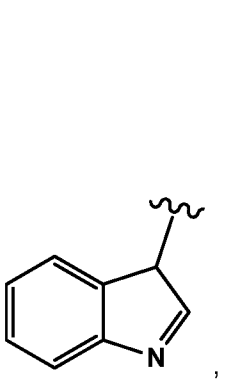
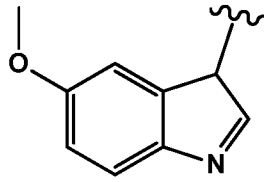
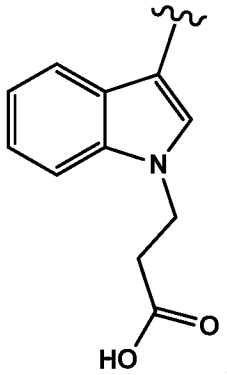
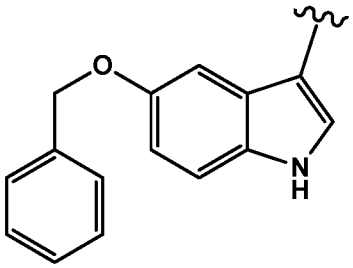
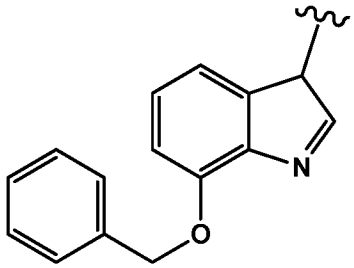


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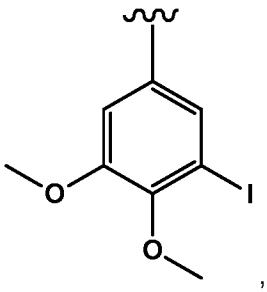
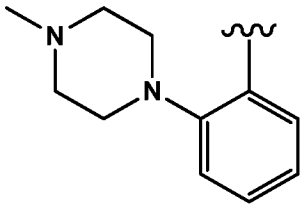
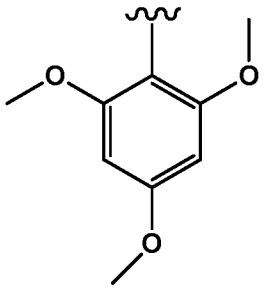
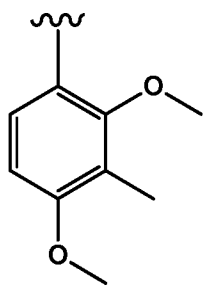
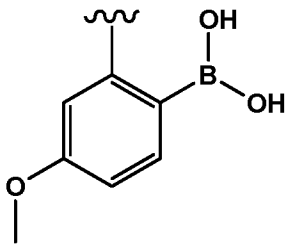
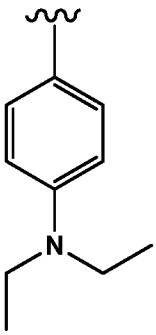
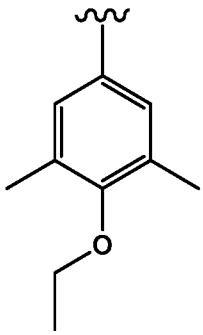
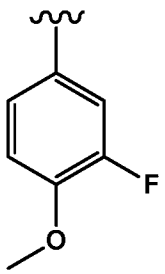
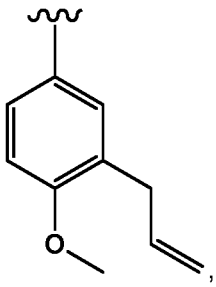


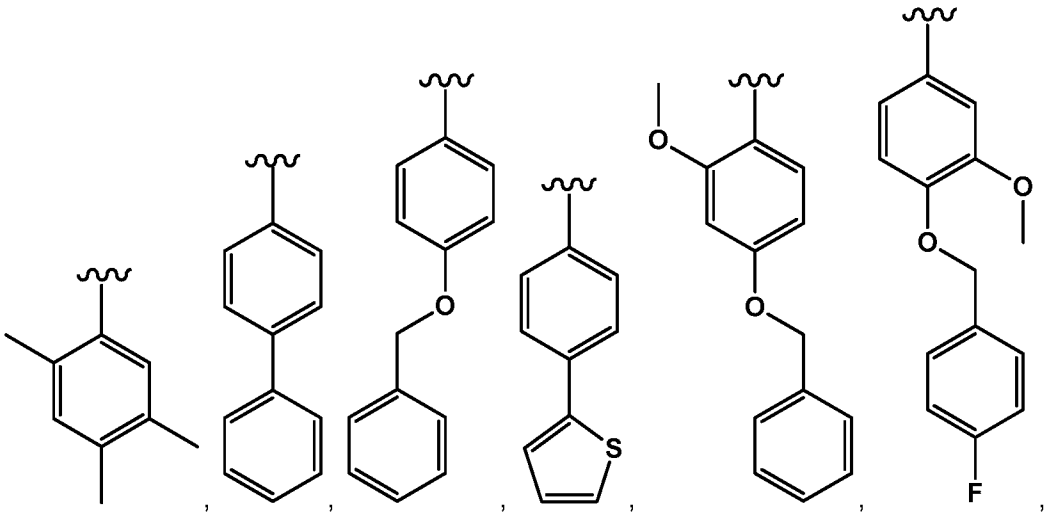
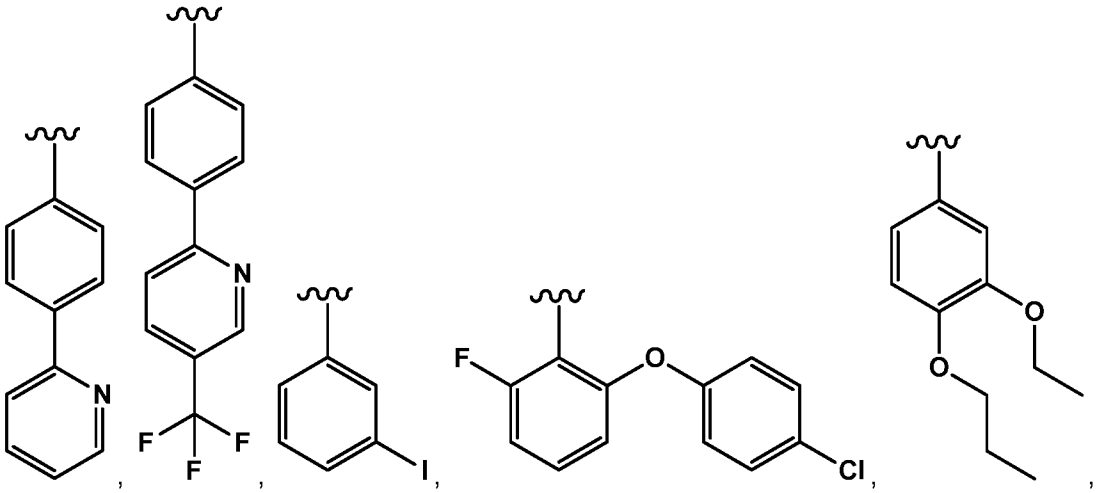
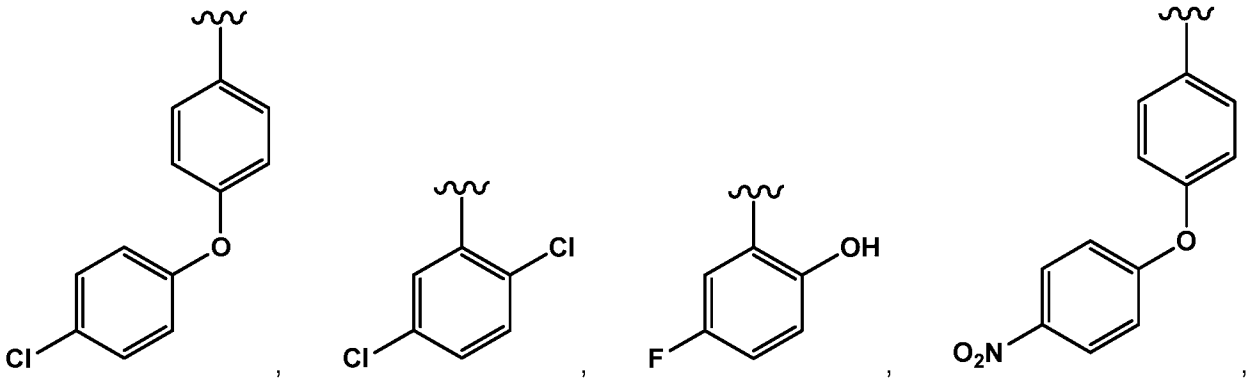
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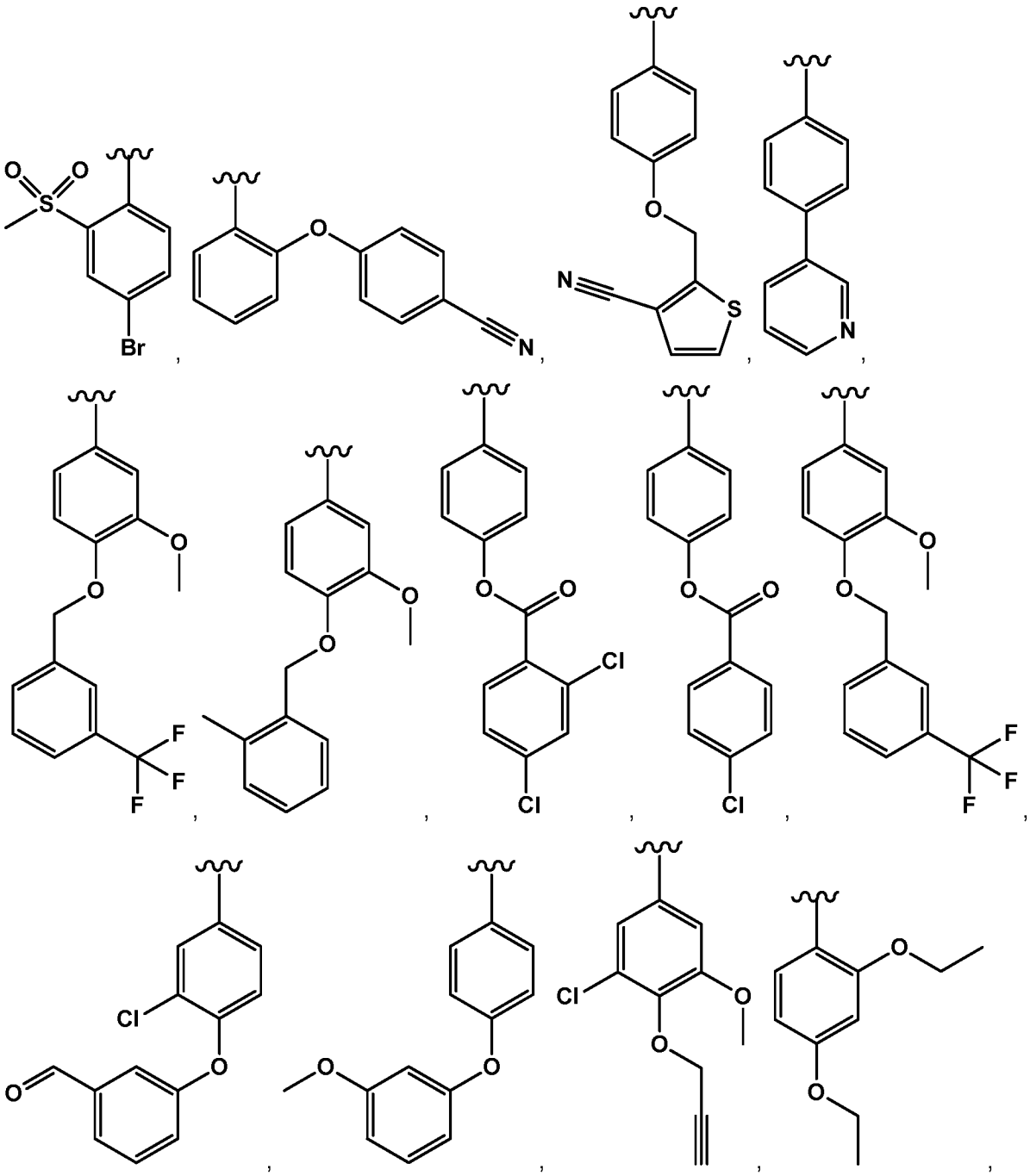
4. The compound of claim 2 where R_1 is selected from:

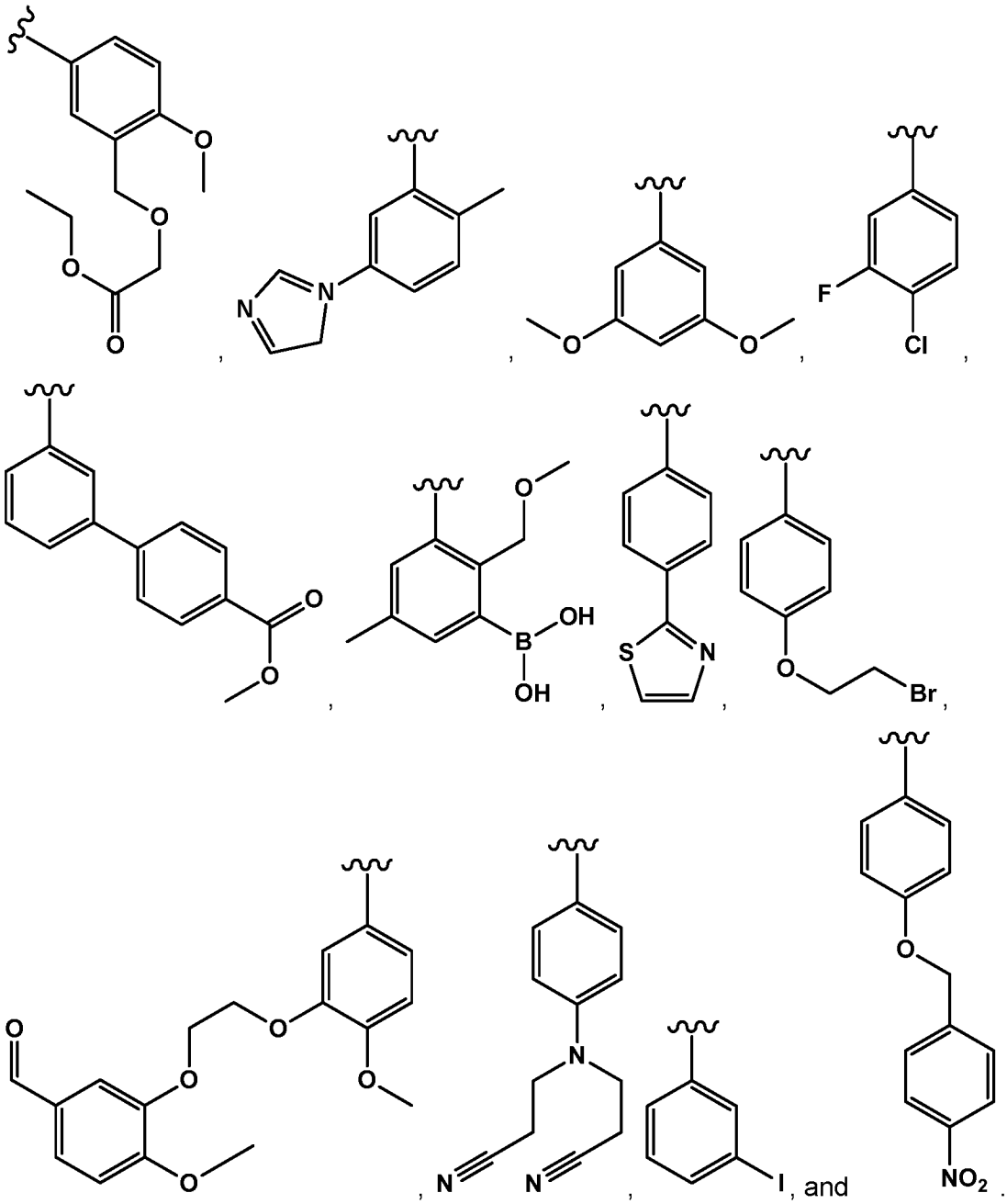

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5. The compound of claim 2 where R_1 is selected from:

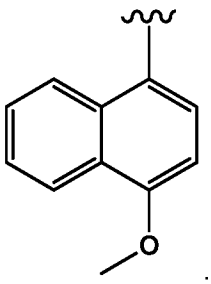

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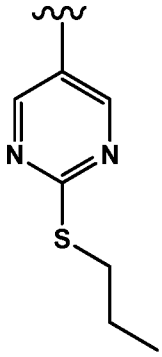
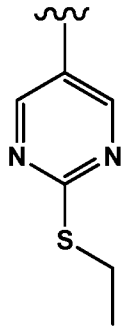


6. The compound of claim 2 where R_1 is

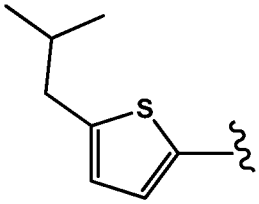
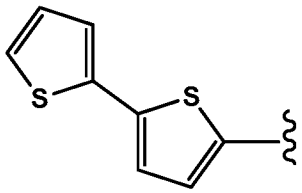


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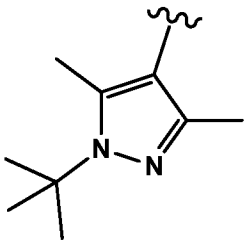
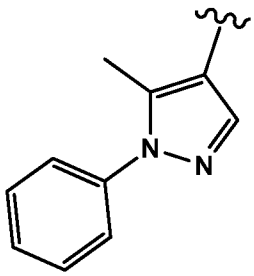
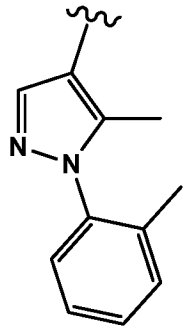
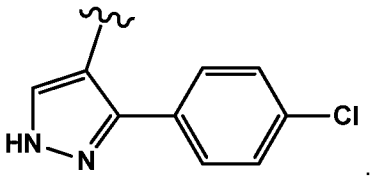
7. The compound of claim 2 where R_1 is selected from


and

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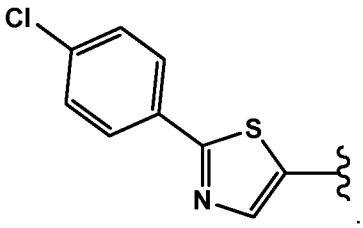
8. The compound of claim 2 where R_1 is selected from


and

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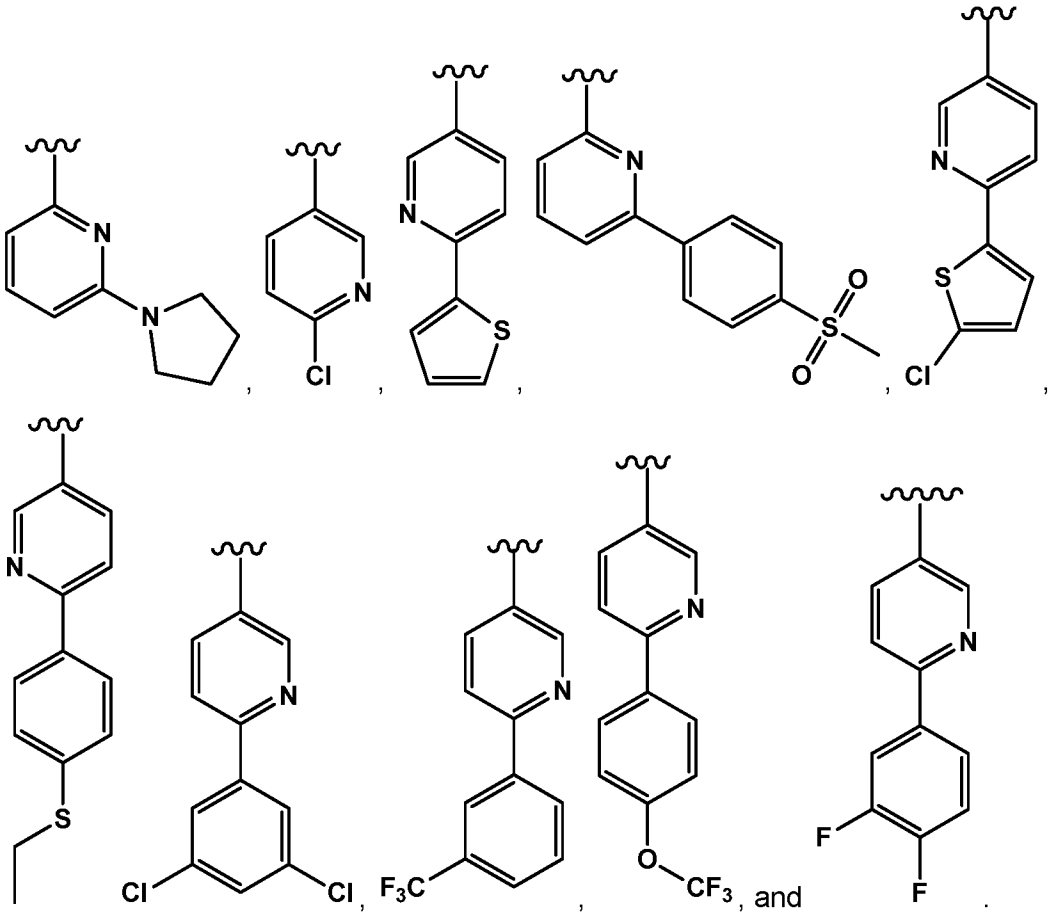
9. The compound of claim 2 where R_1 is selected from


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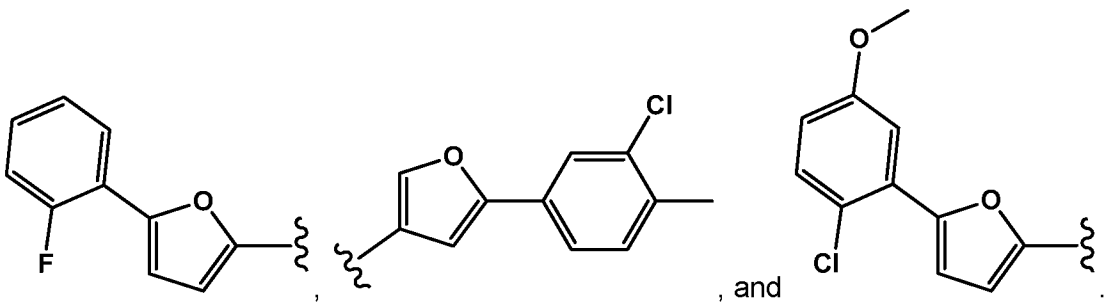
10. The compound of claim 2 where R_1 is:


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11. The compound of claim 2 where R_1 is selected from:



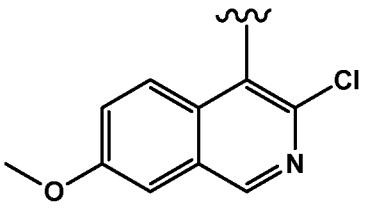
12. The compound of claim 2 where R_1 is selected from:

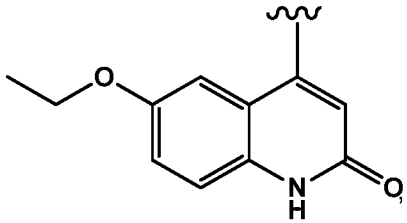


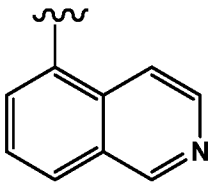
13. The compound of claim 1 where R_1 and R_2 are independently substituted or unsubstituted quinolinyl, substituted or unsubstituted isoquinolinyl, substituted or unsubstituted indolyl, substituted or unsubstituted benzyl, substituted or unsubstituted naphthyl, substituted or unsubstituted pyrimidinyl, substituted or unsubstituted thiophenyl, substituted or unsubstituted pyrazolyl, substituted or unsubstituted thiazolyl, substituted or unsubstituted pyridinyl, or substituted or unsubstituted furanyl.

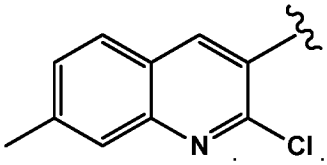
14. The compound of claim 13 where R_1 and R_2 are both substituted or unsubstituted quinolinyl, substituted or unsubstituted isoquinolinyl, substituted or unsubstituted indolyl, substituted or unsubstituted benzyl, substituted or unsubstituted naphthyl, substituted or unsubstituted pyrimidinyl, substituted or unsubstituted thiophenyl, substituted or unsubstituted pyrazolyl, substituted or unsubstituted thiazolyl, substituted or unsubstituted pyridinyl, or substituted or unsubstituted furanyl.

15. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted quinolinyl or isoquinolinyl and selected from:



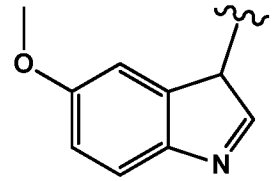
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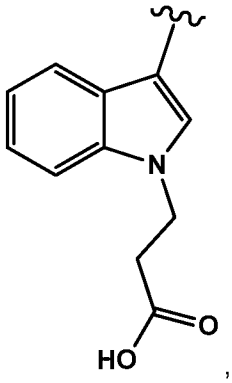
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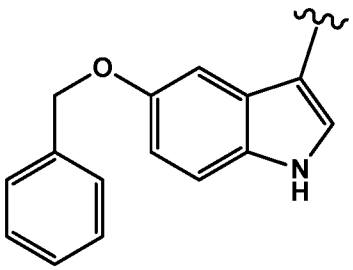
, and


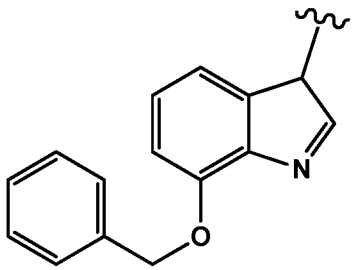
.

16. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted indolyl and are selected from:

b.


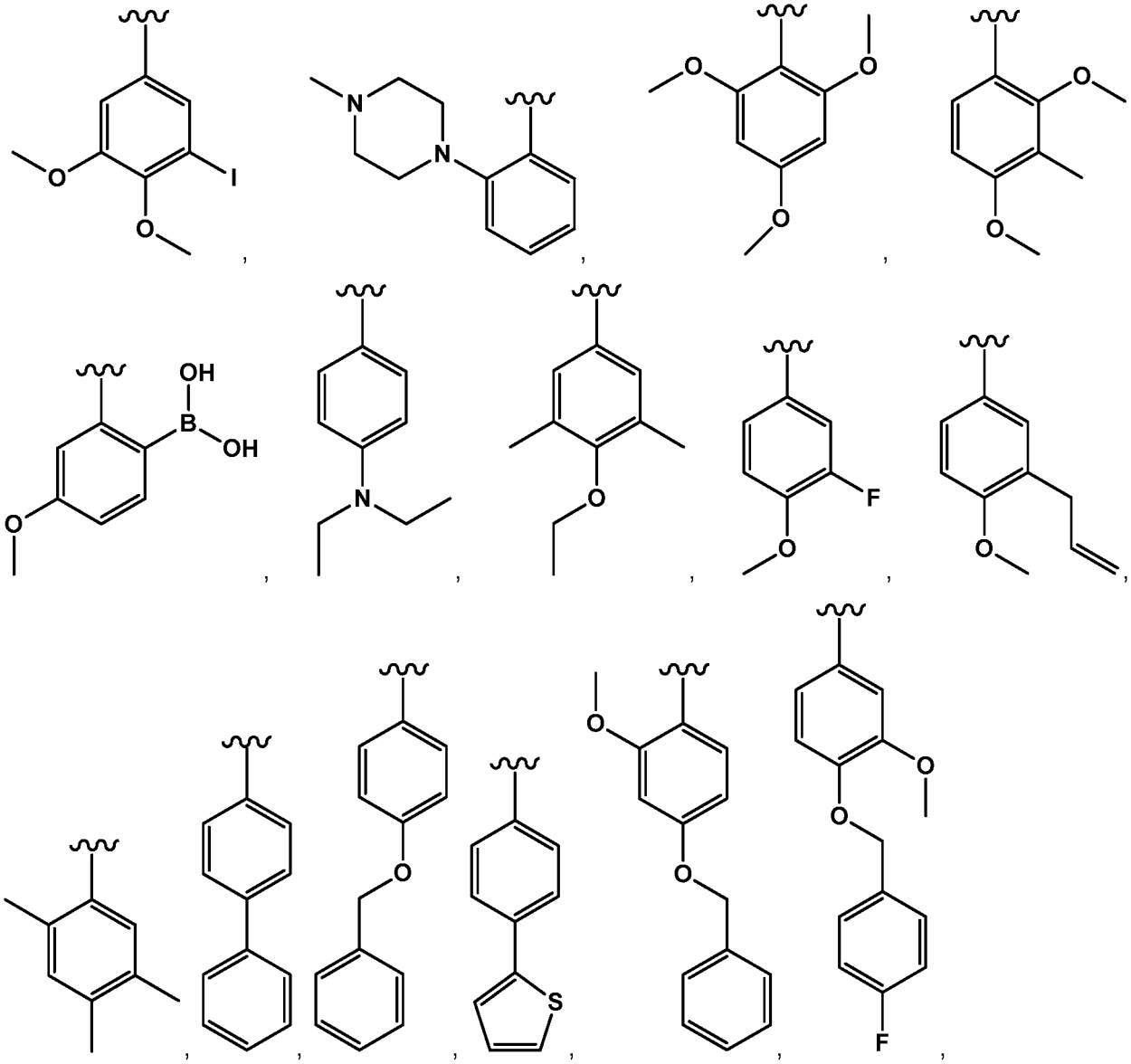
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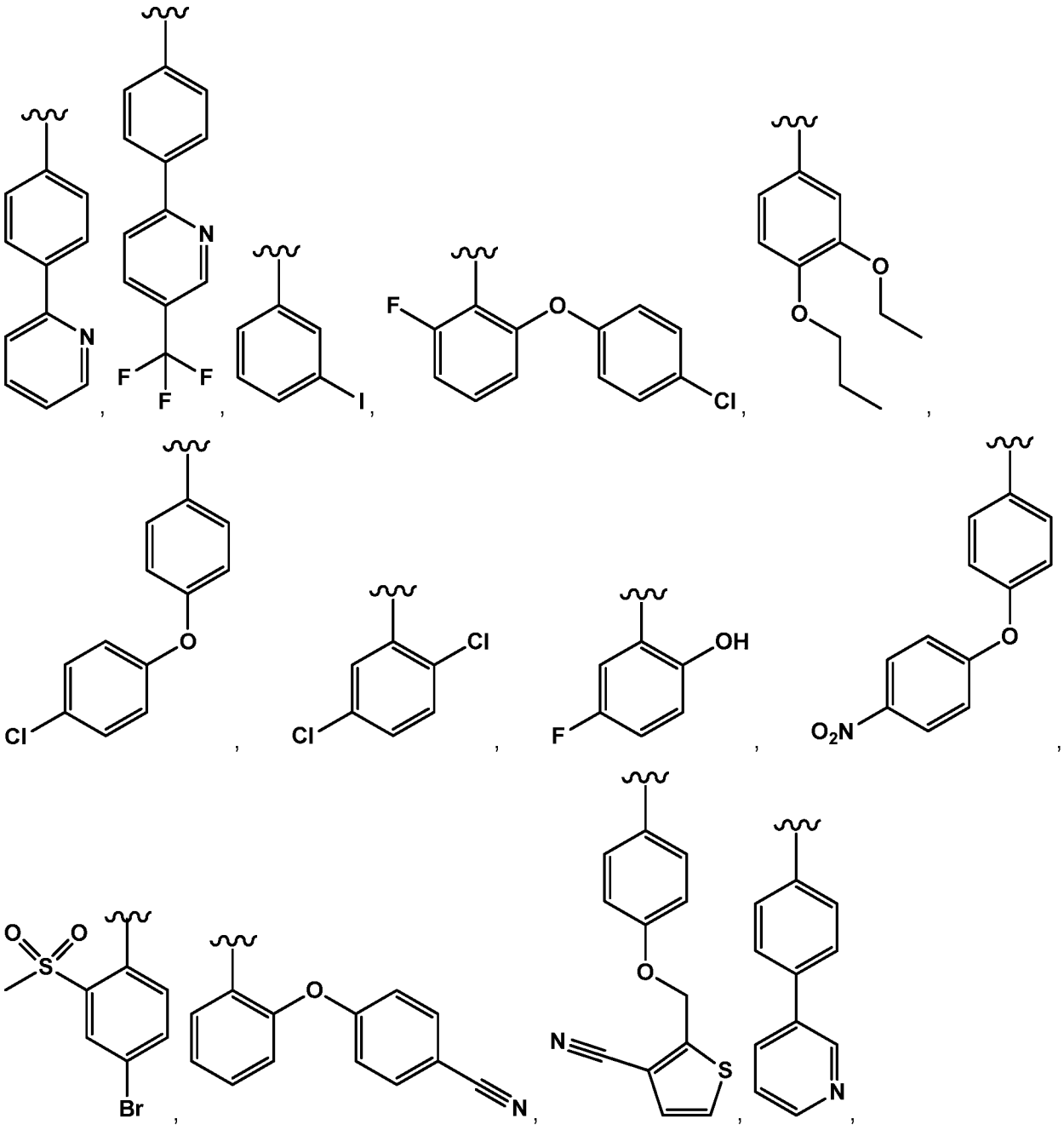
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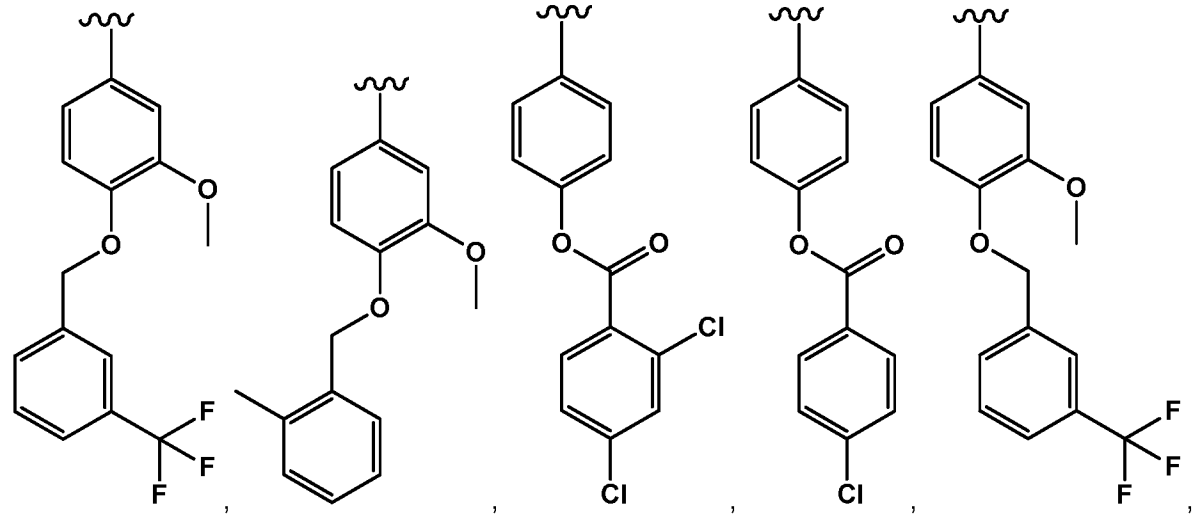
, and


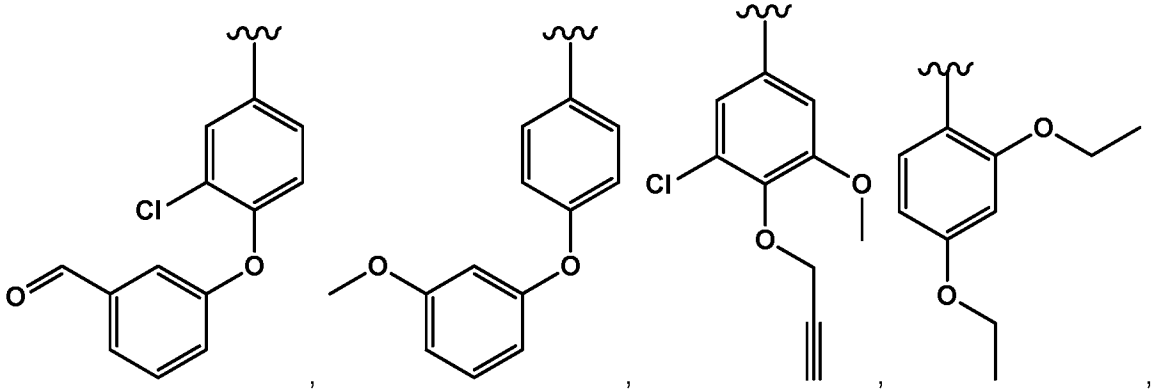
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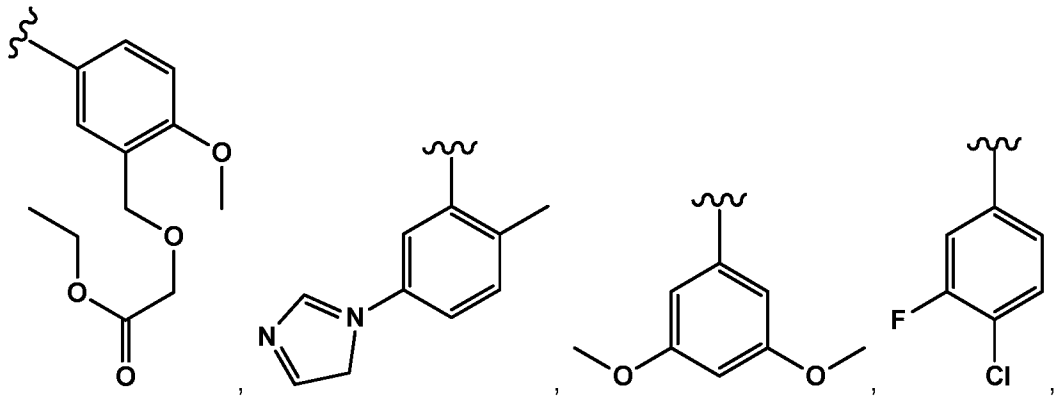
17. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted benzyl and are selected from:

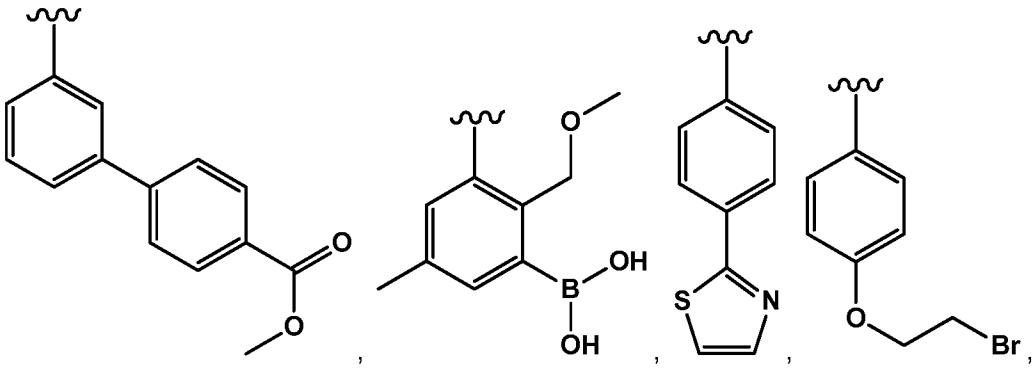


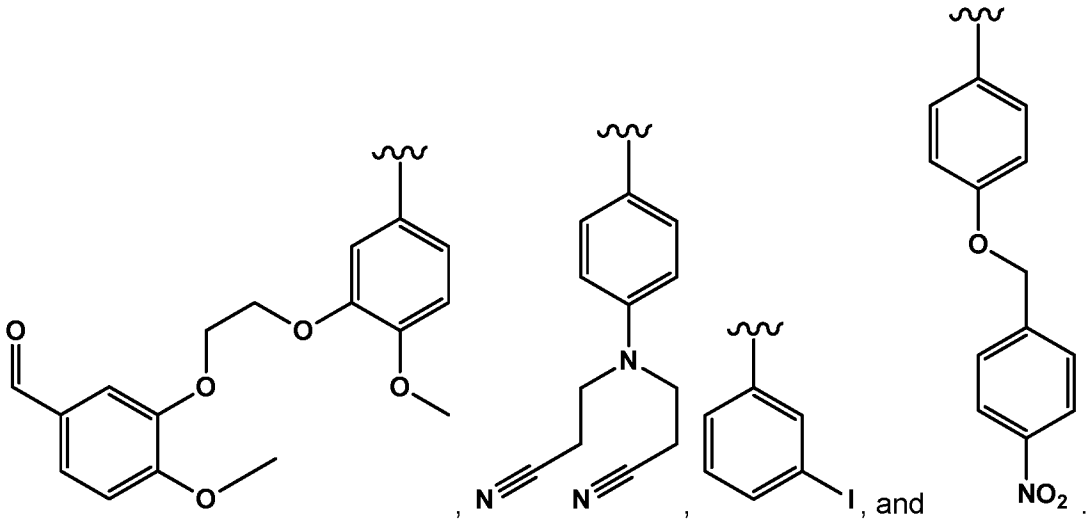




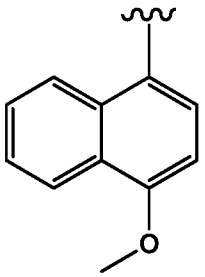




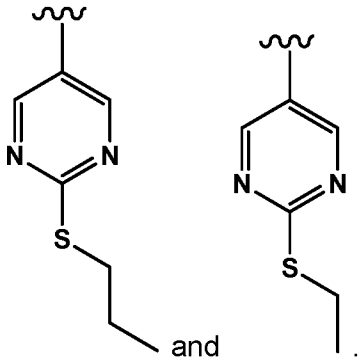




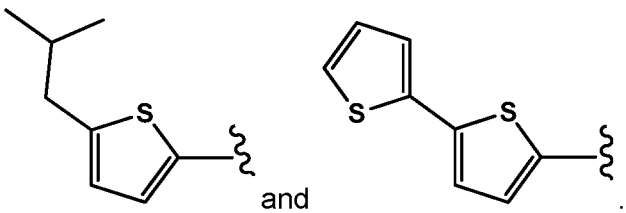
18. The compound of claim 14 where R_1 and R_2 are both



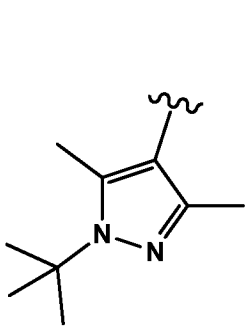
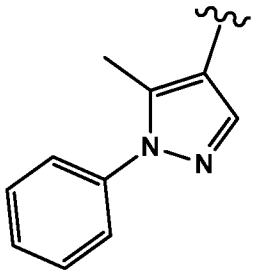
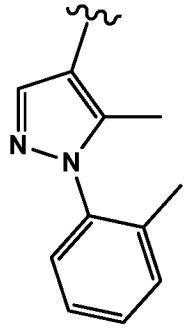
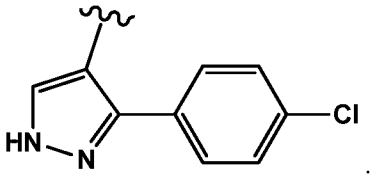
19. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted pyrimidinyl and are selected from:



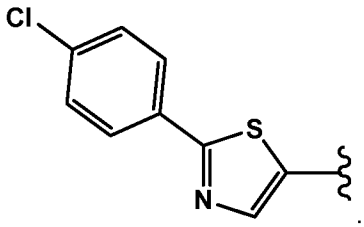
20. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted thiophenyl and are selected from



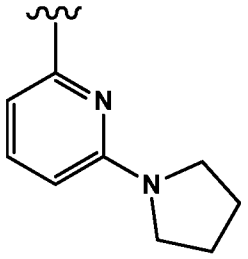
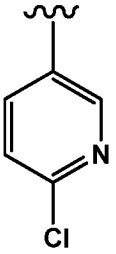
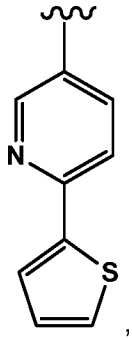
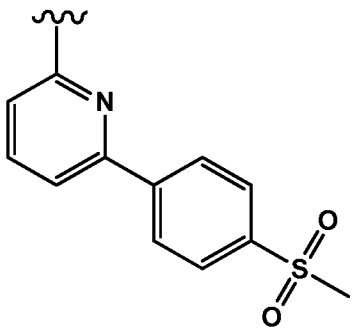
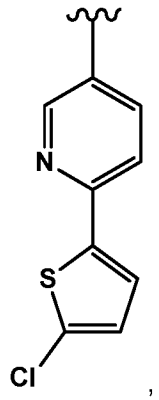
21. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted pyrazolyl and are selected from

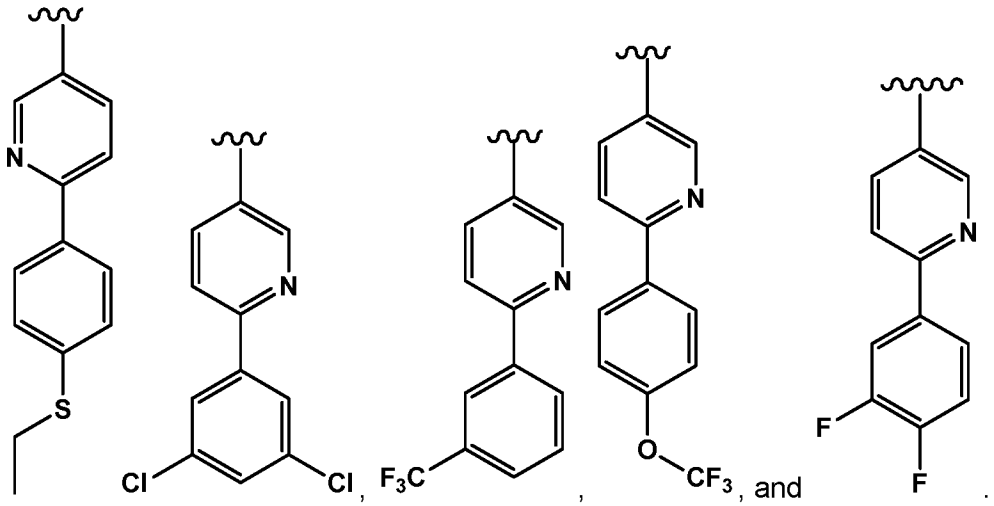



, and

.

22. The compound of claim 14 where R_1 and R_2 are both:

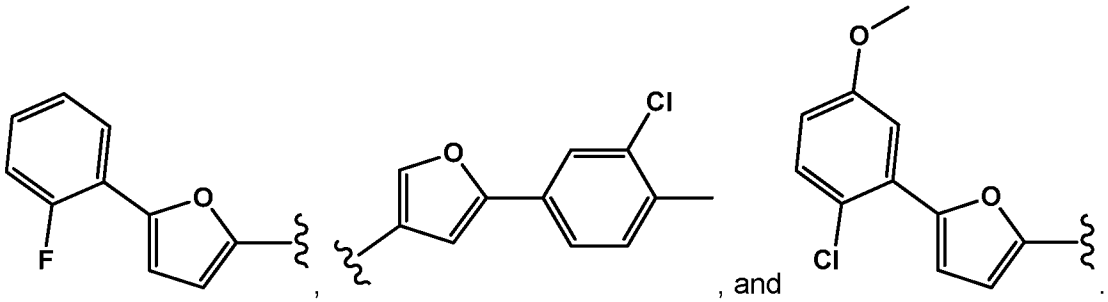

.

23. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted pyridinyl and are selected from:

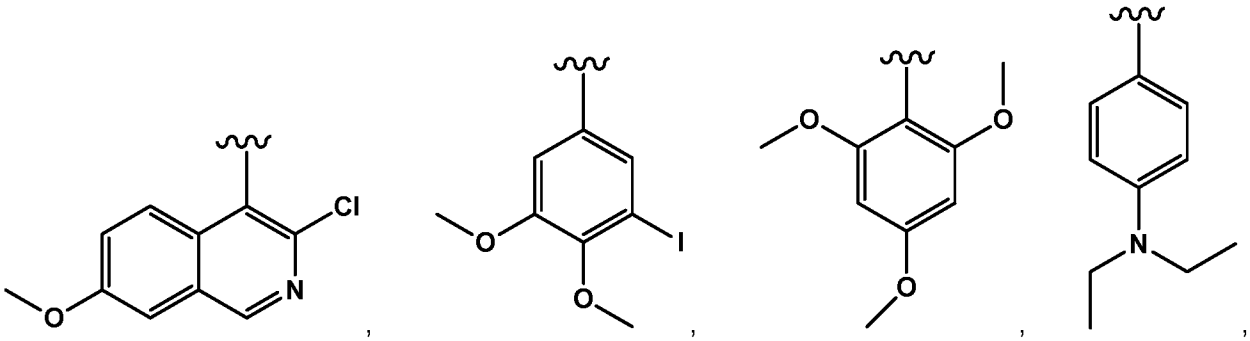





,

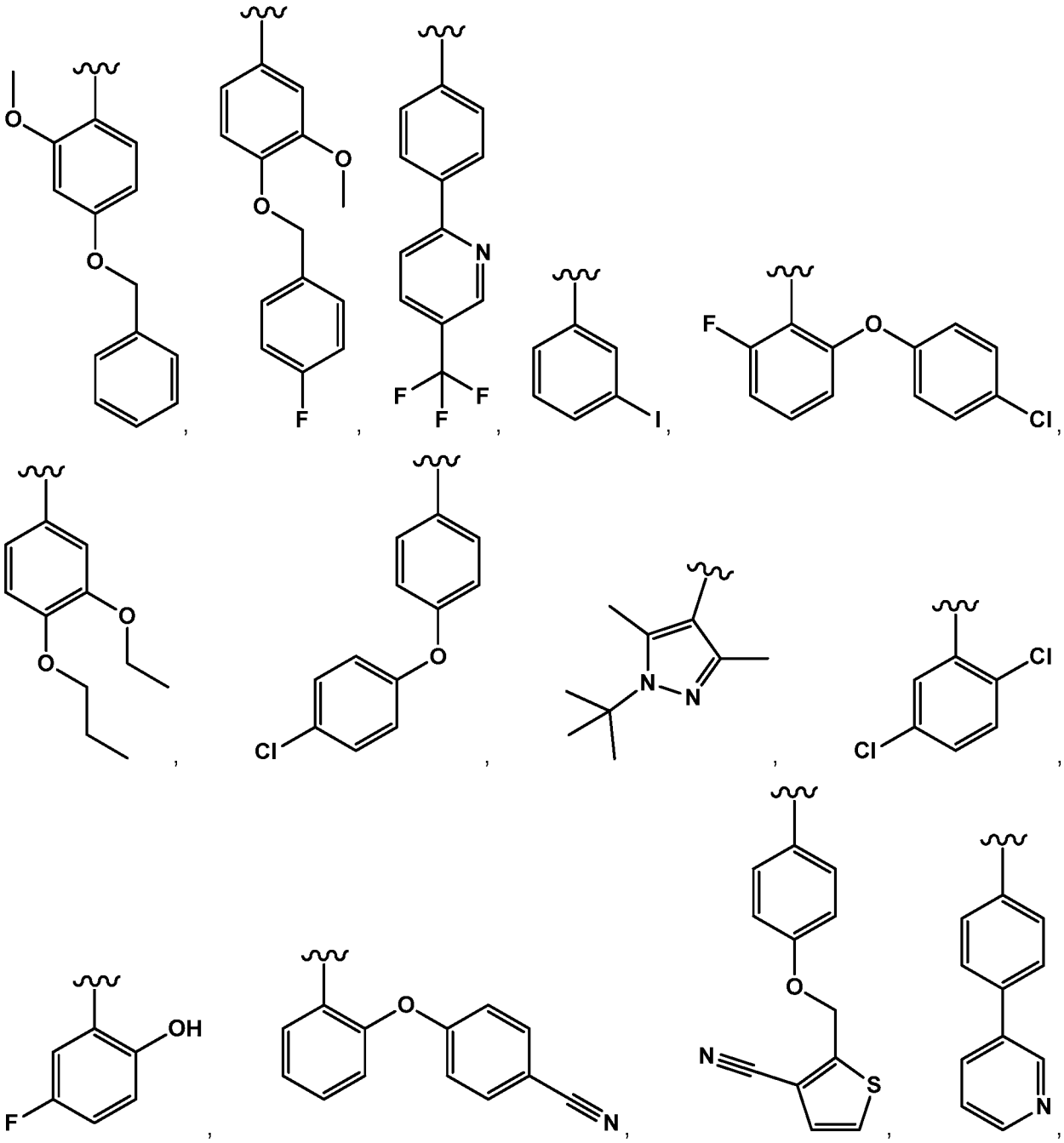


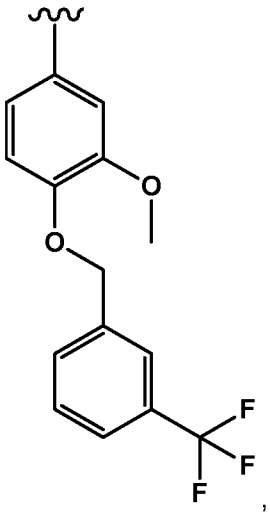
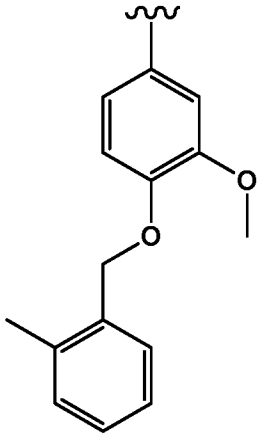
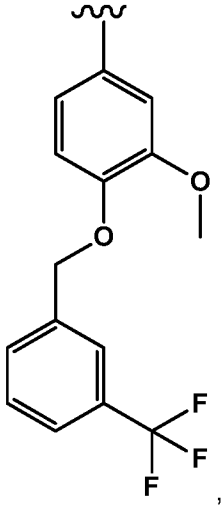
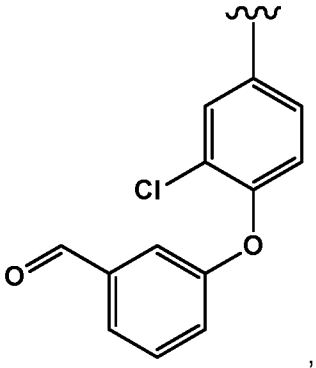
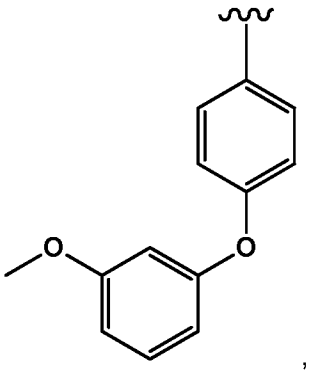
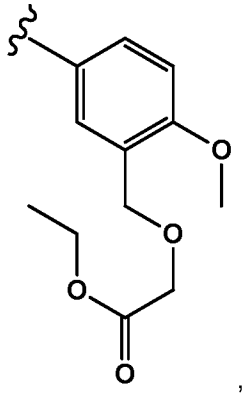
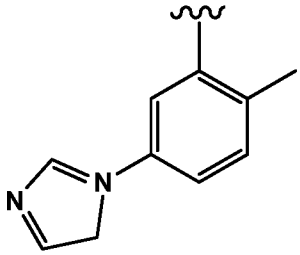
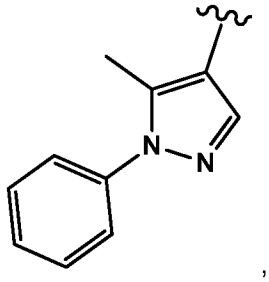
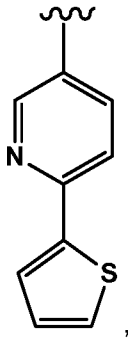
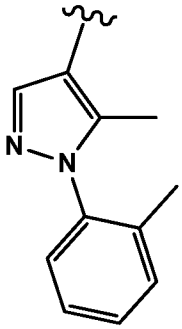
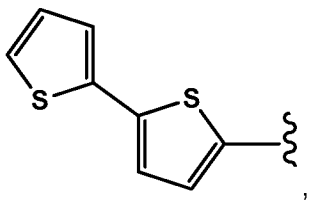
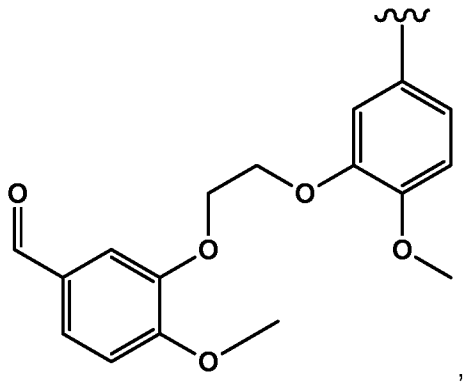
24. The compound of claim 14 where R_1 and R_2 are both substituted or unsubstituted furanyl and are selected from:

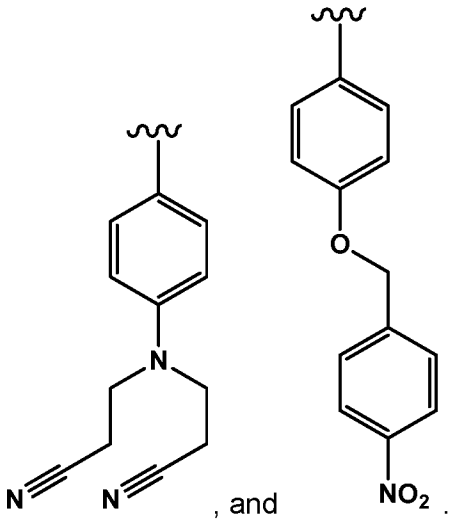


25. The compound of claim 14 where R_1 and R_2 are both selected from:







, and .

FIG. 1A

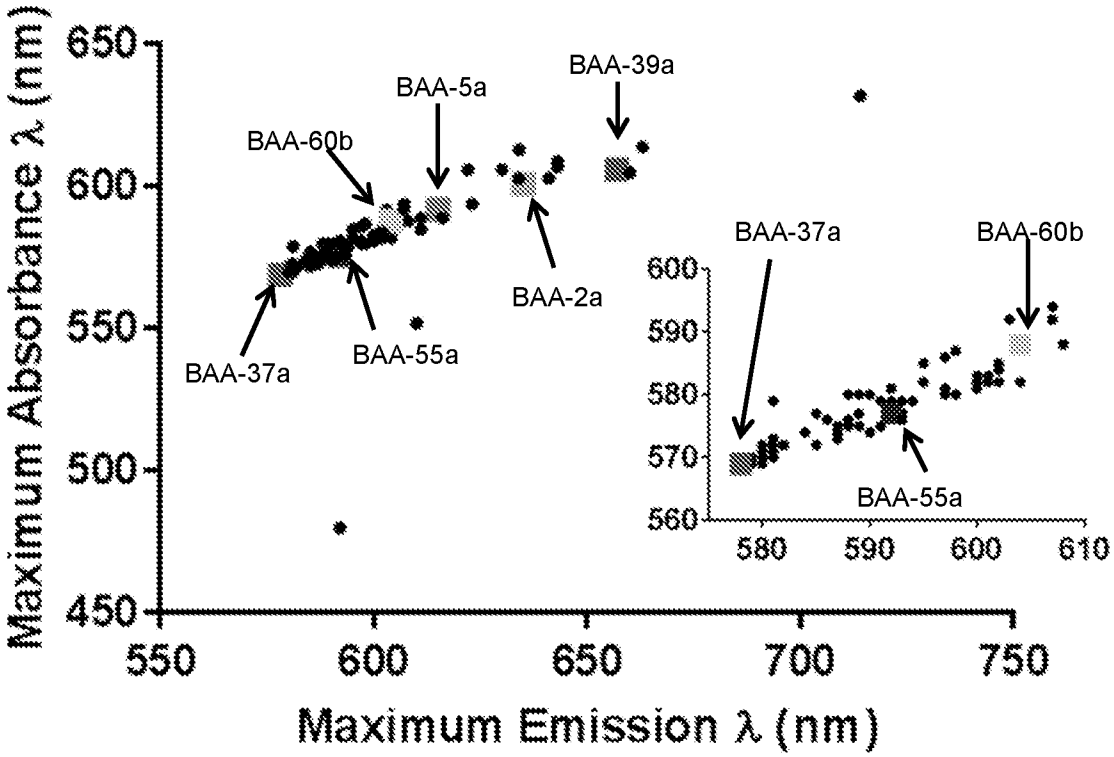

Maximum Absorbance λ (nm)
650
600
550
500
450
550
600
650
700
750
Maximum Emission λ (nm)
BAA-60b
BAA-5a
BAA-39a
BAA-2a
BAA-37a
BAA-55a
600
590
580
570
560
580
590
600
610
BAA-37a
BAA-60b
BAA-55a

FIG. 1B

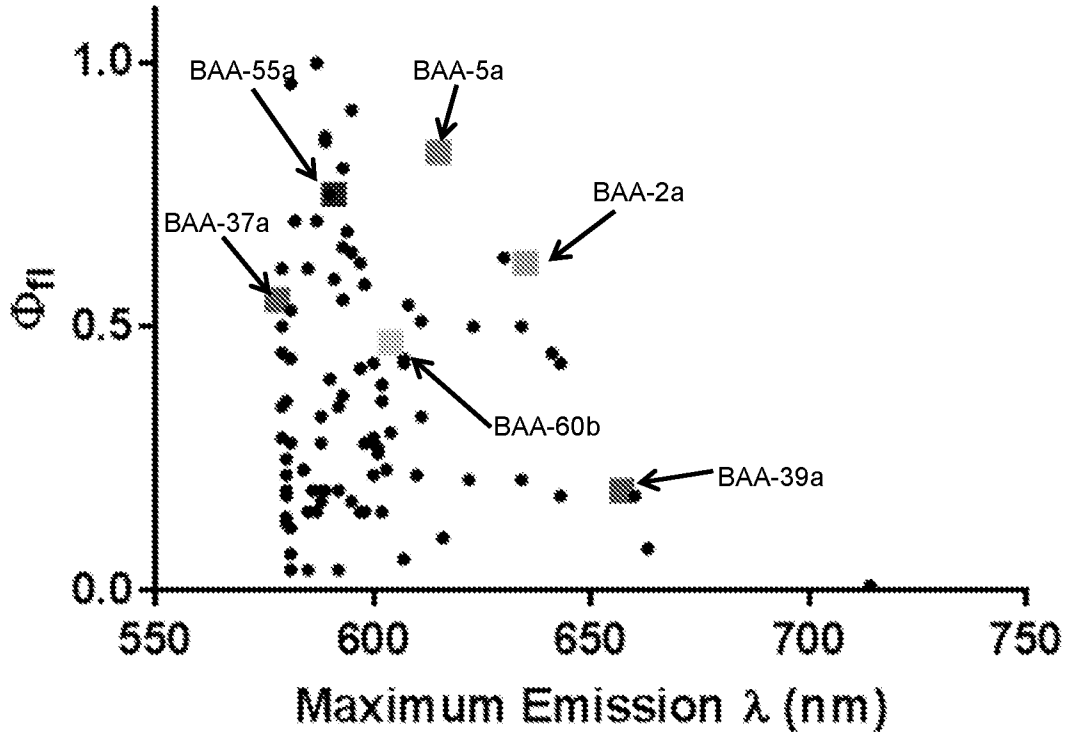

1.0
0.5
0.0
Φ_{fl}
BAA-55a
BAA-5a
BAA-2a
BAA-37a
BAA-60b
BAA-39a
550
600
650
700
750
Maximum Emission λ (nm)

FIG. 1C

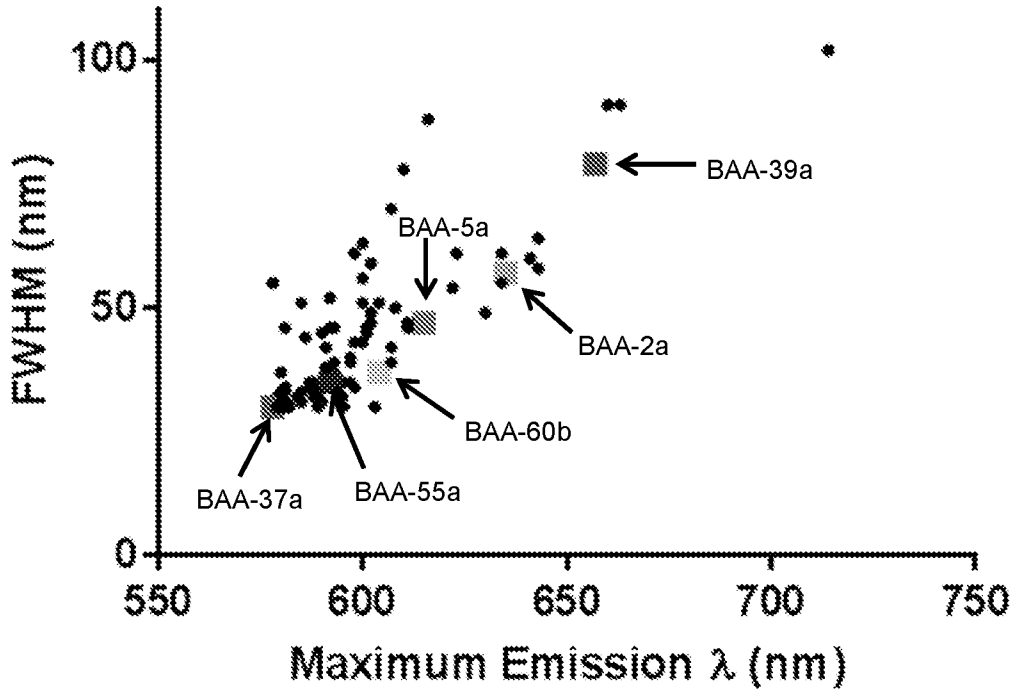

100
50
0
FWHM (nm)
550
600
650
700
750
Maximum Emission λ (nm)
BAA-39a
BAA-5a
BAA-2a
BAA-60b
BAA-37a
BAA-55a

FIG. 2A

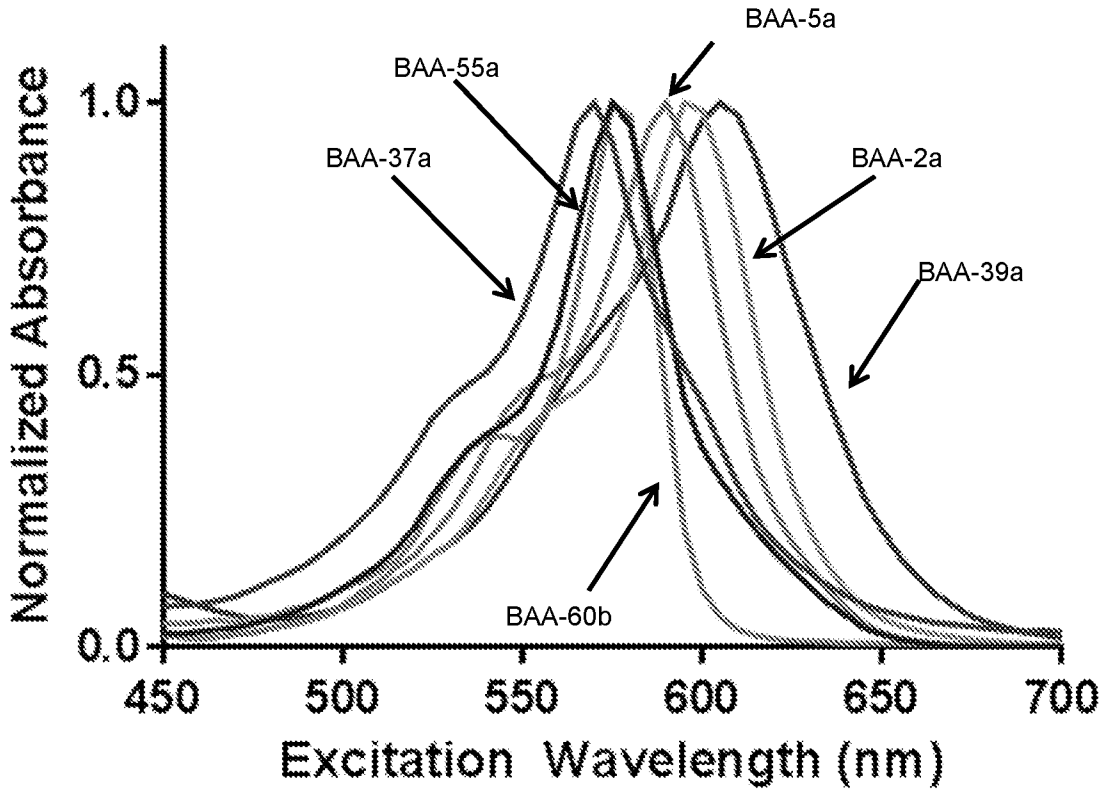

BAA-5a
BAA-55a
BAA-37a
BAA-2a
BAA-39a
BAA-60b
Normalized Absorbance
1.0
0.5
0.0
450
500
550
600
650
700
Excitation Wavelength (nm)

FIG. 2B

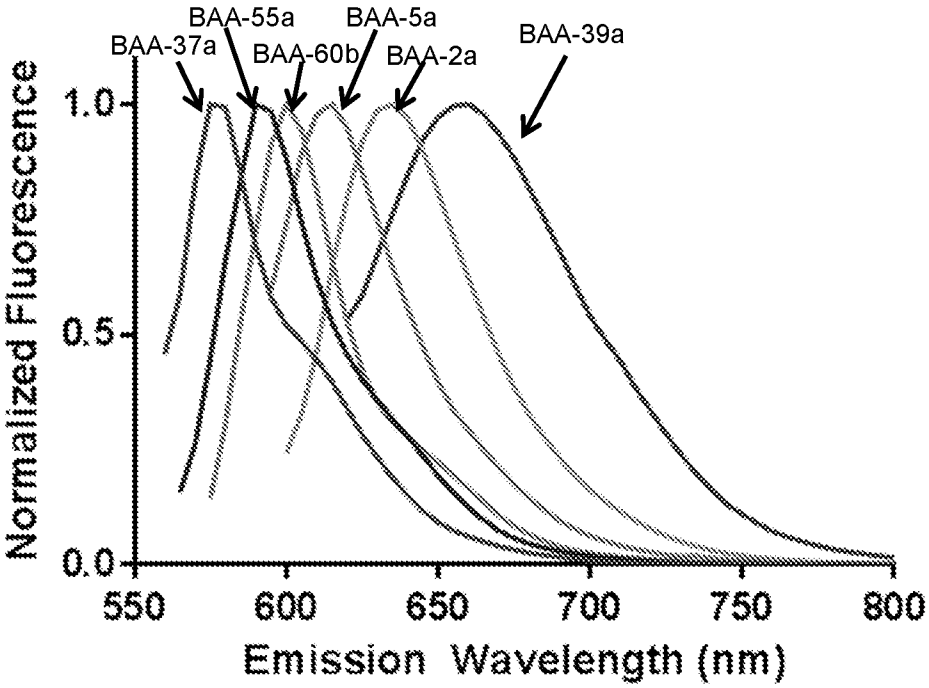

BAA-37a
BAA-55a
BAA-60b
BAA-5a
BAA-2a
BAA-39a
Normalized Fluorescence
1.0
0.5
0.0
550
600
650
700
750
800
Emission Wavelength (nm)

FIG. 3

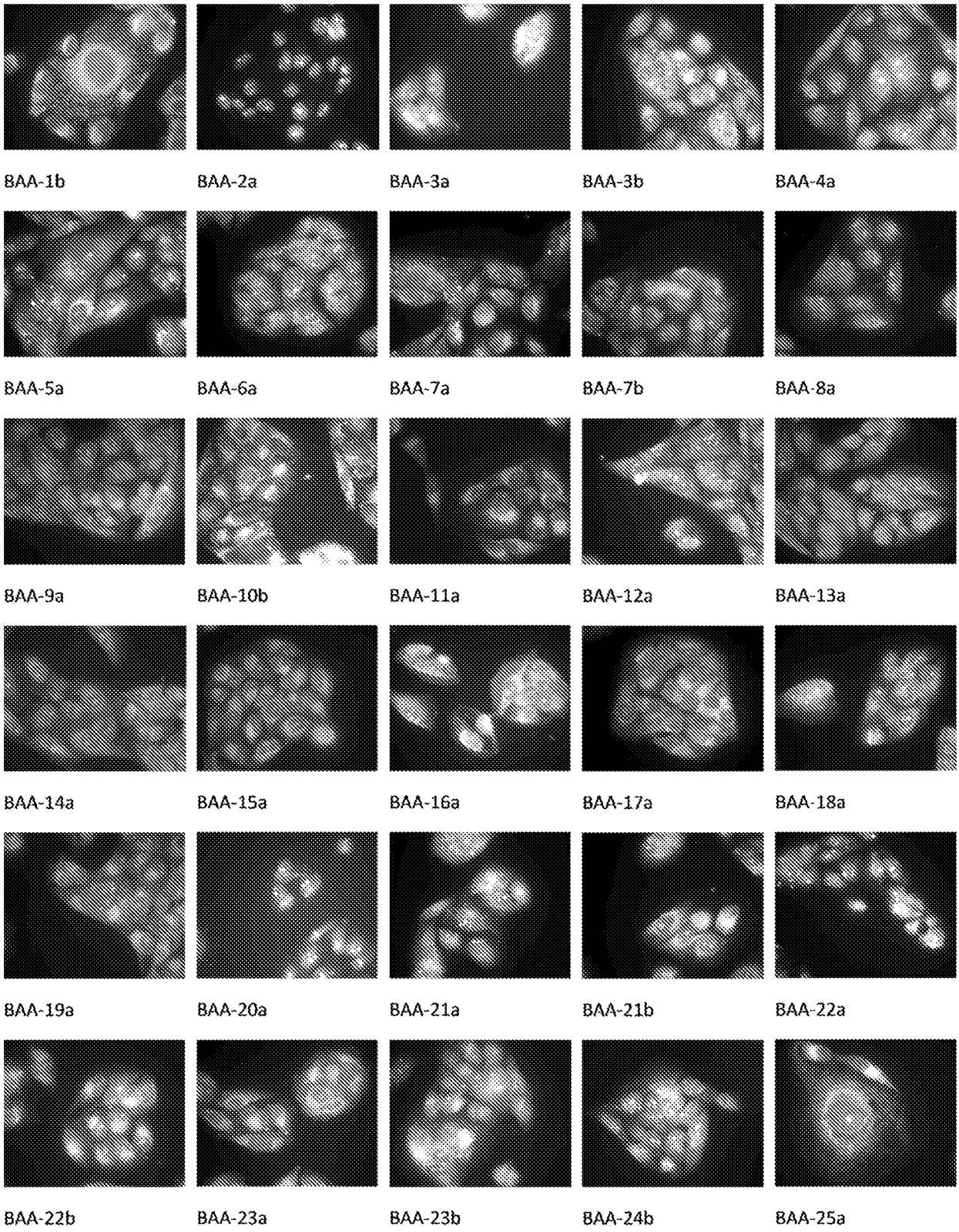

BAA-1b
BAA-2a
BAA-3a
BAA-3b
BAA-4a
BAA-5a
BAA-6a
BAA-7a
BAA-7b
BAA-8a
BAA-9a
BAA-10b
BAA-11a
BAA-12a
BAA-13a
BAA-14a
BAA-15a
BAA-16a
BAA-17a
BAA-18a
BAA-19a
BAA-20a
BAA-21a
BAA-21b
BAA-22a
BAA-22b
BAA-23a
BAA-23b
BAA-24b
BAA-25a

FIG. 4

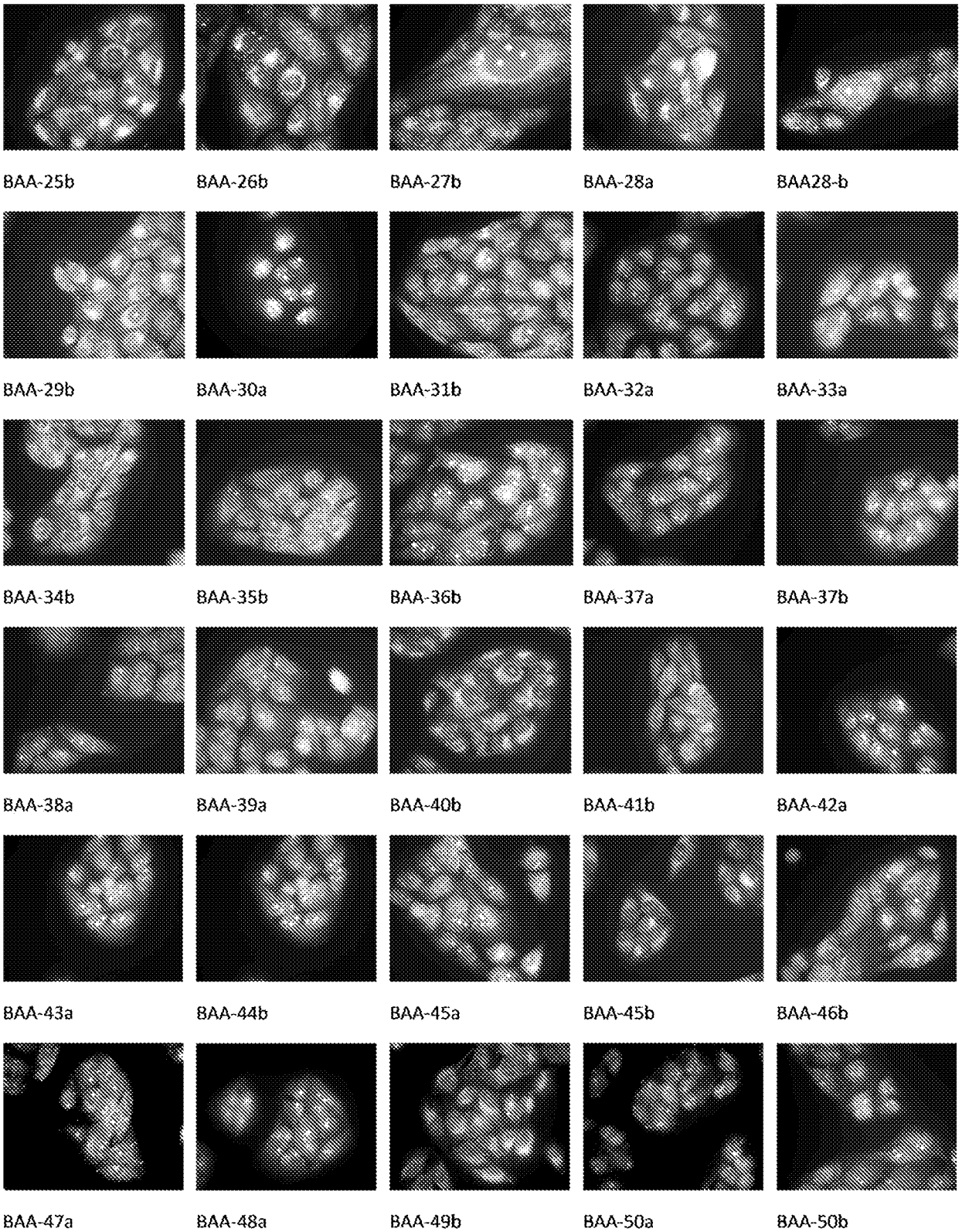

BAA-25b
BAA-26b
BAA-27b
BAA-28a
BAA28-b
BAA-29b
BAA-30a
BAA-31b
BAA-32a
BAA-33a
BAA-34b
BAA-35b
BAA-36b
BAA-37a
BAA-37b
BAA-38a
BAA-39a
BAA-40b
BAA-41b
BAA-42a
BAA-43a
BAA-44b
BAA-45a
BAA-45b
BAA-46b
BAA-47a
BAA-48a
BAA-49b
BAA-50a
BAA-50b

FIG. 5

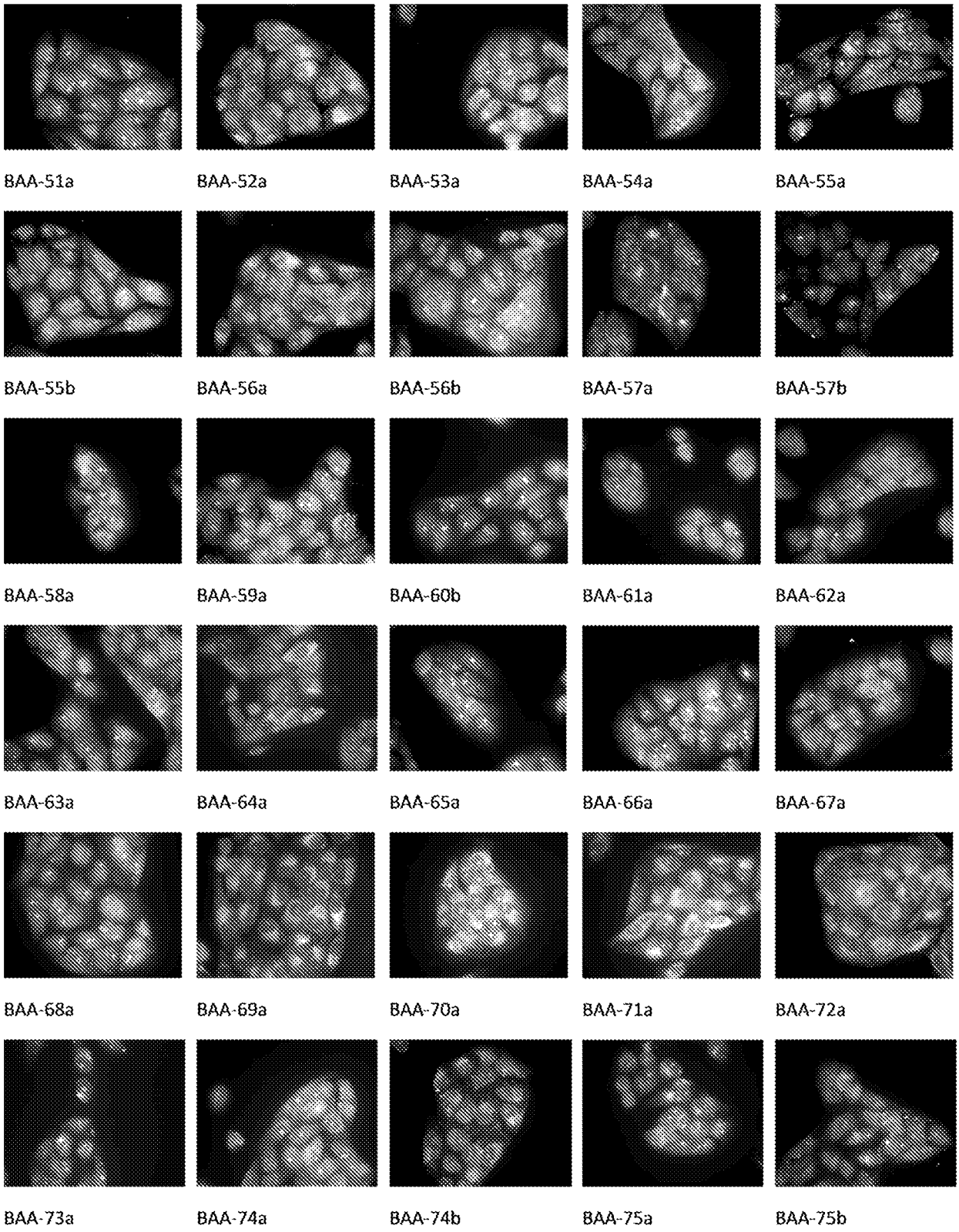
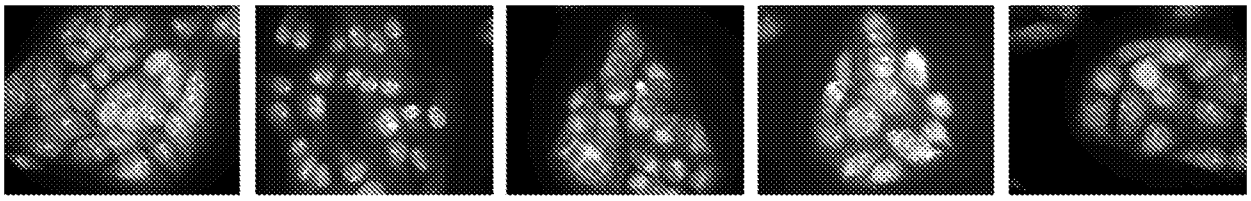

BAA-51a
BAA-52a
BAA-53a
BAA-54a
BAA-55a
BAA-55b
BAA-56a
BAA-56b
BAA-57a
BAA-57b
BAA-58a
BAA-59a
BAA-60b
BAA-61a
BAA-62a
BAA-63a
BAA-64a
BAA-65a
BAA-66a
BAA-67a
BAA-68a
BAA-69a
BAA-70a
BAA-71a
BAA-72a
BAA-73a
BAA-74a
BAA-74b
BAA-75a
BAA-75b

FIG. 6



BAA-76a BAA-77a BAA-78a BAA-78b BAA-79a

FIG. 7A

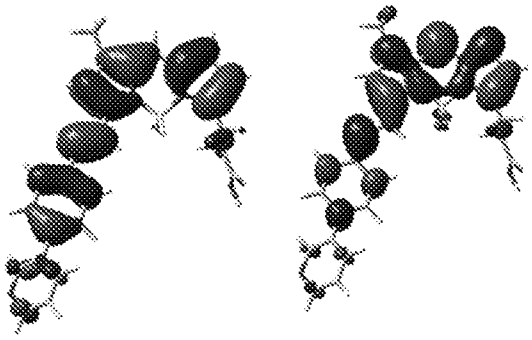


FIG. 7B

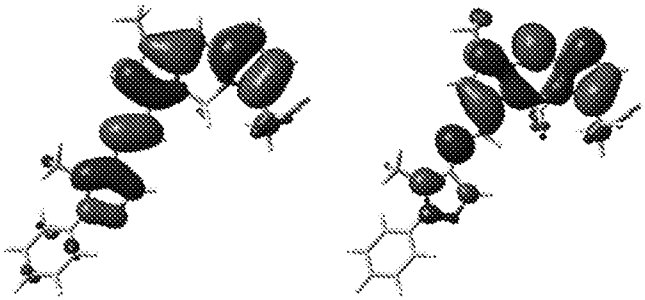


FIG. 7C

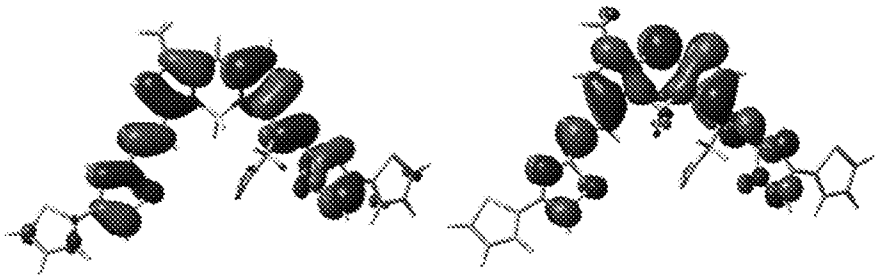


FIG. 7D

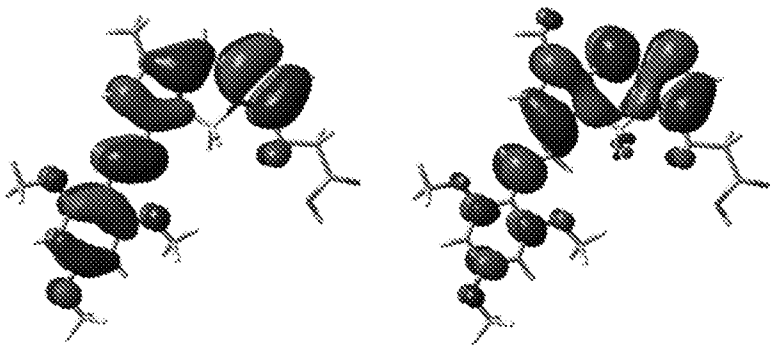


FIG. 7E

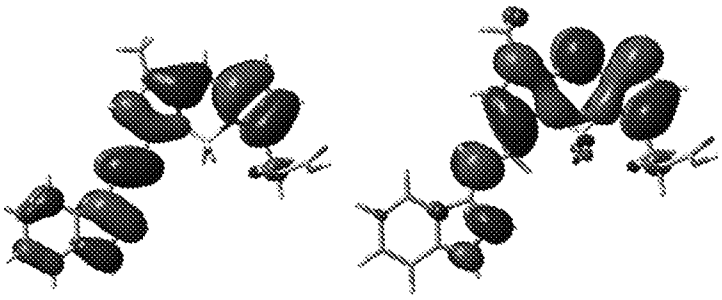
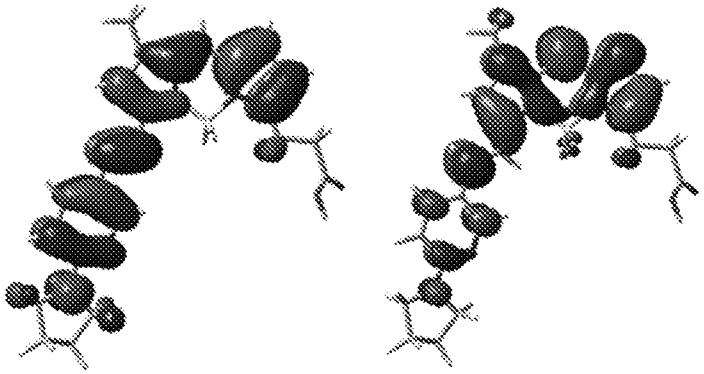


FIG. 7F



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/017542

A. CLASSIFICATION OF SUBJECT MATTER

C07F 5/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07F 5/02; G01N 21/64; C09B 57/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal), STN (Registry, Caplus), Google & Keywords:4,4-difluoro-4-bora-3a,4a-diaza-s-indacene (BODIPY), fluorophore, single molecule localization microscopy (SMLM), multispectral superresolution microscopy (MSSRM)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012-071012 A2 (NATIONAL UNIVERSITY OF SINGAPORE et al.) 31 May 2012 See claim 1; paragraph [0009]; and pages 7-9.	1-25
X	WO 93-09185 A1 (MOLECULAR PROBES, INC.) 13 May 1993 See claim 1; page 1, lines 10-14; and pages 6-9.	1-25
X	MELTOLA, N. J. et al., "Hydrophilic labeling reagents of dipyrrylmethene-BF2 dyes for two-photon excited fluorometry: Syntheses and photophysical characterization", Journal of Fluorescence, 2004, Vol. 14, No. 5, pages 635-647 See page 635; and scheme 1.	1-25
X	WO 2014-088512 A1 (NATIONAL UNIVERSITY OF SINGAPORE et al.) 12 June 2014 See page 10.	1-25
A	Chemical Abstract Compound, STN express. RN 150173-89-0 (22 Sep 1993), RN 749180-51-6 (22 Sep 2004)	1-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 2017 (19.05.2017)	**19 May 2017 (19.05.2017)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/017542

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2012-071012 A2	31/05/2012	CN 103298820 A	11/09/2013
		CN 103298820 B	03/08/2016
		EP 2643328 A2	02/10/2013
		EP 2643328 A4	23/07/2014
		EP 2643328 B1	01/07/2015
		SG 190173 A1	31/07/2013
		US 2013-0244251 A1	19/09/2013
		US 8889883 B2	18/11/2014
		WO 2012-071012 A3	13/12/2012
		WO 2012-071012 A8	26/10/2012
WO 93-09185 A1	13/05/1993	AT 161871 T	15/01/1998
		AT 167511 T	15/07/1998
		CA 2113106 A1	25/11/1993
		CA 2113106 C	24/10/2000
		CA 2122627 A1	13/05/1993
		CA 2122627 C	11/06/2002
		DE 69223985 T2	16/07/1998
		DE 69319205 T2	10/12/1998
		EP 0596098 A1	11/05/1994
		EP 0596098 B1	17/06/1998
		EP 0612336 A1	31/08/1994
		EP 0612336 B1	07/01/1998
		GB 2277096 A	19/10/1994
		GB 2277096 B	11/12/1996
		JP 07-508309 A	14/09/1995
		JP 2004-002851 A	08/01/2004
		JP 3442777 B2	02/09/2003
		JP 3689412 B2	31/08/2005
		US 5227487 A	13/07/1993
		US 5274113 A	28/12/1993
		US 5326692 A	05/07/1994
		US 5326692 B1	30/04/1996
		US 5405975 A	11/04/1995
		US 5433896 A	18/07/1995
		US 5442045 A	15/08/1995
		US 5451663 A	19/09/1995
		US 5453517 A	26/09/1995
		US 5459276 A	17/10/1995
		US 5501980 A	26/03/1996
		US 5516864 A	14/05/1996
		US 5573909 A	12/11/1996
		US 5648270 A	15/07/1997
		US 5723218 A	03/03/1998
		US 6013802 A	11/01/2000
		WO 93-23492 A1	25/11/1993
WO 2014-088512 A1	12/06/2014	None	