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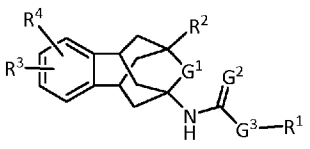

(I)

(57) Abstract: The present invention relates to soluble epoxide hydrolase (sEH) inhibitors of formula (I) to processes for their obtention and to their therapeutic indications.

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POLYCYCLIC COMPOUNDS AS SOLUBLE EPOXIDE HYDROLASE INHIBITORS

The present invention relates to the field of pharmaceutical products for human and veterinary medicine, particularly to soluble epoxide hydrolase (sEH) inhibitors and their therapeutic indications.

BACKGROUND ART

A total of more than 100 patent publications have described multiple classes of sEH inhibitors, based on different chemical structures, such as amides, thioamides, ureas, thioureas, carbamates, acyl hydrazones and chalcone oxides (cf. e.g. H.C. Shen, "Soluble epoxide hydrolase inhibitors: a patent review", *Expert Opin Ther Patents* 2010, vol. 20, pp. 941-956, a review with 149 references).

sEH inhibition has been associated to various beneficial biological effects, that may be translated into various therapeutic treatments (cf. e.g. H.C. Shen and B.D. Hammock, "Discovery of inhibitors of soluble epoxide hydrolase: A target with multiple potential therapeutic indications", *J Med Chem.* 2012, vol. 55, pp. 1789-1808, a review with 117 references; K.M. Wagner et al. “Soluble epoxide hydrolase as a therapeutic target for pain, inflammatory and neurodegenerative diseases”, *Pharmacol Ther.* 2017, vol 180, pp 62-76, a review with 186 references).

More specifically the documents cited below have described the usefulness of sEH inhibition in the treatment of the following diseases: hypertension (*Recent Pat Cardiovasc Drug Discov.* 2006 Jan;1(1):67-72), atherosclerosis (*J Cardiovasc Pharmacol.* 2008 Oct;52(4):314-23), pulmonary diseases such as chronic obstructive pulmonary disorder, asthma, sarcoidosis, and cystic fibrosis, (*Am J Respir Cell Mol Biol.* 2012 May;46(5):614-22 / *Am J Respir Crit Care Med.* 2014 Oct 15;190(8):848-50 / *Resp. Res.*, 2018, 19:236 / *Free Rad. Biol. Med.*, 2012, 53, 160), kidney diseases such as acute kidney injury, diabetic nephrology, chronic kidney diseases, hypertension-mediated kidney disorders and high fat diet-mediated renal injury (*Bioorg Med Chem Lett.* 2014 Jan 15;24(2):565-70 / *Am J Physiol Renal Physiol.* 2013 Jan 15;304(2):F168-76 / *Am J Physiol Renal Physiol.* 2014 Oct 15;307(8):F971-80 / *Frontiers Pharmacol.* 2019, 9:1551 / *Proc Natl Acad Sci USA*. 2019, 116:5154-5159), stroke (*J Biol Chem.* 2014 Dec 26;289(52):35826-38 / *PLoS One.* 2014 May 13;9(5):e97529), pain (*J Agric Food Chem.* 2011 Apr 13;59(7):2816-24 / *Inflamm Allergy Drug Targets.* 2012 Apr;11(2):143-58), neuropathic pain (*J Agric Food Chem.*

2011 Apr 13;59(7):2816-24 / *Drug Discov Today* 2015 Nov;20(11):1382-90 / *Proc Natl Acad Sci U S A.* 2015 Jul 21;112(29):9082-7), inflammation (*Inflamm Allergy Drug Targets.* 2012 Apr;11(2):143-58 / *Proc Natl Acad Sci U S A.* 2005 Jul 12;102(28):9772-7), pancreatitis in particular acute pancreatitis (*Mol Pharmacol.* 2015 Aug;88(2):281-90), immunological disorders (WO 00/23060 A2), neurodevelopmental disorders such as schizophrenia and autism spectrum disorder (*Proc Natl Acad Sci USA*, 2019, 116:7083-7088), eye diseases (WO 2007/009001 A1 / *Frontiers Pharmacol.* 2019, 10:95) in particular diabetic keratopathy (*Diabetes.* 2018 Jun;67(6):1162-1172), wet age-related macular degeneration (*ACS Chem Biol.* 2018 Jan 19; 13:45-52) and retinopathy (*Nature.* 2017 Dec 14;552(7684):248-252) such as premature retinopathy and diabetic retinopathy, cancer (*Prog Lipid Res.* 2014 Jan;53:108-23), obesity (*Nutr Metab Cardiovasc Dis.* 2012 Jul;22(7):598-604), including obesity-induced colonic inflammation (*Proc Natl Acad Sci U S A.* 2018 May 15;115(20):5283-5288), diabetes (*Proc Natl Acad Sci U S A.* 2011 May 31;108(22):9038-43), metabolic syndrome (*Exp Diabetes Res.* 2012;2012:758614), preeclampsia (*Med. Hypotheses*, 2017 Oct;108:81-5), anorexia nervosa ("Pharmacokinetic optimization of six soluble epoxide hydrolase inhibitors for the therapeutic use in a murine model of anorexia" Abstracts of Papers, 241st ACS National Meeting & Exposition, Anaheim, CA, United States, March 27-31, 2011 (2011), MEDI-92), depression (*J Neurosci Res.* 2017 Dec;95(12):2483-2492), male sexual dysfunction (*Biomed. & Pharmacother.* 2019, 115: 108897) such as erectile dysfunction (*Phytother Res.* 2016 Jul;30(7):1119-27), wound healing (*J Surg Res.* 2013 Jun 15;182(2):362-7 / *BioRxiv*. 2019 March 8, doi:10.1101/571984), NSAID-induced ulcers (*J Pharmacol Exp Ther.* 2016 Jun;357(3):529-36), emphysema (*Am J Respir Cell Mol Biol.* 2012 May;46(5):614-22), scrapie (*Life Sci.* 2013 Jun 21;92(23):1145-50), Parkinson's disease (*Mol Neurobiol.* 2015 Aug;52(1):187-95 / *Proc Natl Acad Sci. USA*, 2018, 115:E5815-E5823), arthritis (*Drug Metab Dispos.* 2015 May;43(5):788-802), arrhythmia (*Cardiovasc Ther.* 2011 Apr;29(2):99-111), cardiac fibrosis (*Alcoholism*. 2018, 42, 1970), Alzheimer's disease (*Pharmacol Ther.* 2017 Dec;180:62-76 / *BioRxiv*. 2019 Apr 10, doi:10.1101/605055), Raynaud's syndrome (WO 2003/002555 A1), Niemann-Pick-type C disease (*Experimental Molecular Medicine*. 2018, 50:149), cardiomyopathy (*Int J Cardiol.* 2012 Mar 8;155(2):181-7), vascular cognitive impairment (*Prostaglandins Other Lipid Mediat.* 2014 Oct;113-115:30-7), mild cognitive impairment (*Pharmacol Ther.* 2017 Dec;180:62-76), inflammatory bowel diseases (*Dig Dis Sci.* 2012 Oct;57(10):2580-91 / *PLoS One*. 2019 Apr 19, 14(4):e0215033), cirrhosis (*Toxicol Appl Pharmacol.* 2015 Jul 15;286(2):102-11), non-alcoholic fatty liver disease (*PLoS One*. 2014 Oct 13, 9(10):e110162), non-alcoholic steatohepatitis (*Am J Physiol Gastrointest Liver Physiol*. 2019, 316, G527-

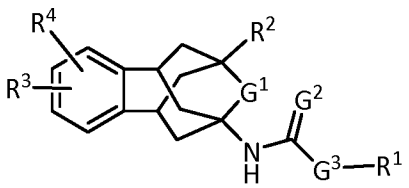
G538), liver fibrosis (*Clinics Res Hepatol Gastroenterol* 2018, 42, 118-125), osteoporosis (*FASEB J.* 2015 Mar;29(3):1092-101), chronic periodontitis (*J Pharmacol Exp Ther.* 2017 Jun;361(3):408-416), sepsis (*FASEB J.* March 2008 22 (Meeting Abstract Supplement) 479.17), seizure disorders such as epilepsy (*PLoS One.* 2013 Dec 11;8(12):e80922), dementia (*Prostaglandins Other Lipid Mediat.* 2014 Oct;113-115:30-7), edema such as cerebral edema (*Stroke.* 2015 Jul;46(7):1916-22.), attention-deficit hyperactivity disorder (WO 2017/120012 A1), schizophrenia (*Proc Natl Acad Sci U S A.* 2016 Mar 29;113(13):E1944-52), drug dependency (WO 2017/120012 A1), social anxiety (WO 2017/120012 A1), colitis (*Anticancer Res.* 2013 Dec;33(12):5261-5271), amyotrophic lateral sclerosis (WO 2016/133788 A1), chemotherapy induced side effects (*Toxicology.* 2017 Aug 15;389:31-41), laminitis (*Equine Vet J.* 2017 May;49(3):345-351), inflammatory joint pain and synovitis (*J Vet Pharmacol Ther.* 2018 Apr;41(2):230-238), endothelial dysfunction (*Prostaglandins Other Lipid Mediat.* 2017 Jul;131:67-74), subarachnoid hemorrhage (*Stroke.* 2015 Jul;46(7):1916-22), including aneurysmal subarachnoid hemorrhage (*J Neurosurg Anesthesiol.* 2015 Jul; 27(3):222-240), traumatic brain injury (*Oncotarget.* 2017 Sep 21;8(61):103236-60), cerebral ischemia (*Scientific Reports.* 2018, 8:5279), and diabetes-induced learning and memory impairment (*Prostaglandins Other Lipid Mediat.* 2018 May;136:84-89).

Despite the high inhibitory activity of many of the reported sEH inhibitory compounds, until now no sEH inhibitor has reached the market. Thus, there is a need to develop new sEH inhibitors.

The inventors have now found a new family of polycyclic compounds having high inhibitory activity for soluble epoxide hydrolase.

SUMMARY OF INVENTION

An aspect of the present invention relates to the provision of compounds of formula (I)



(I)

or a stereoisomer or a pharmaceutically acceptable salt thereof, wherein:

G^1 represents an oxygen atom or a methylene group or a single bond;

G^2 represents an oxygen atom or a sulphur atom;

G^3 represents a radical selected from the group consisting of $–NH–(CH_2)_m–$, $–O–(CH_2)_m–$ and $–(CH_2)_n–$;

m is an integer from 0 to 6;

n is an integer from 1 to 7;

R^1 is a radical selected from the group consisting of:

a) C_6-C_{10} aryl which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl and methylaminocarbonylpyridyloxy;

b) heteroaryl having from 2 to 11 carbon atoms and 1, 2 or 3 heteroatoms selected from the group consisting of N, O and S and which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl and C_1-C_6 alkoxycarbonylmethyl;

c) saturated or partially unsaturated, monocyclic or bicyclic heterocyclyl having from 5 to 11 carbon atoms and 1, 2 or 3 heteroatoms selected from the group consisting of N, O and S and which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, C_3-C_6 cycloalkyl-C(=O), nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethylcarbonyl (CF_3CO), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl, C_1-C_6 alkylsulfonyl, C_3-C_6 cycloalkylsulfonyl, benzyl, heteroarylmethyl, pyridincarbonyl, phenylcarbonyl, tetrahydropyrancarbonyl, C_6-C_{10} arylsulfonyl which may be optionally substituted by 1 to 2 substituents selected from the group consisting of halogen atoms, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl and phenyl which may be optionally substituted by 1 to 4 substituents selected from the group consisting

of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_3-C_6 cycloalkyl and C_1-C_6 alkoxycarbonylmethyl;

d) C_6-C_{10} cycloalkyl which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl, pyridinyloxy which may be unsubstituted or substituted by a group selected from COOH and $CONHCH_3$, and phenoxy which may be unsubstituted or substituted by COOH, $COOR^5$, $CONH_2$, CN or OH;

R^2 is a radical selected from the group consisting of hydrogen or deuterium atoms, halogen atoms, methyl, hydroxy and C_1-C_6 alkoxy;

R^3 and R^4 are radicals which may be identical or different and which are independently selected from the group consisting of hydrogen atoms, halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), carboxylic group (COOH), hydroxy (OH), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl and C_1-C_6 alkoxycarbonylmethyl;

or R^3 and R^4 may form together a radical $–O-(CH_2)_p-O-$, wherein p is an integer from 1 to 3;

R^5 is a radical selected from C_1-C_6 alkyl and C_3-C_6 cycloalkyl.

In a particular embodiment G^1 represents a methylene group.

In a particular embodiment G^1 represents an oxygen atom.

In a particular embodiment G^1 represents a single bond.

In a particular embodiment G^2 represents an oxygen atom.

In a particular embodiment G^3 represents a radical selected from the group consisting of $–NH–(CH_2)_m–$ wherein m is an integer from 0 to 6 and $–(CH_2)_m–$ wherein n is an integer from 1 to 7, more particularly G^3 represents a radical$–NH–(CH_2)_m–$ wherein m is an integer from 0 to 6.

In a particular embodiment when G^3 is selected from the group consisting of –NH–$(CH_2)_m$– and –O–$(CH_2)_m$– wherein m has a value of 0.

In a particular embodiment when G^3 is –$(CH_2)_n$– wherein n has a value of 1.

In a particular embodiment R^1 is selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted cyclohexyl and substituted or unsubstituted piperidinyl. In a more specific embodiment the substituents are selected from the group consisting of methyl, trifluoromethyl, acetyl, 4-carboxy-phenoxy, isopropyl-sulfonyl, benzyl, tert-butoxycarbonyl, trifluorophenyl, propionyl, tetrahydropyran-4-carbonyl, 2-fluorobenzoyl, acetylphenyl, and 8-benzyl.

In a particular embodiment R^2 is selected from the group consisting of hydrogen atoms, fluorine atoms, chlorine atoms, methyl, hydroxyl and C_1-C_3 alkoxy. When G^1 represents an oxygen atom R^2 is preferably selected from the group consisting of hydrogen and deuterium atoms and methyl.

In another particular embodiment R^2 is preferably selected from the group consisting of hydrogen, methyl, hydroxyl, methoxy, fluorine and chlorine, more specifically methyl.

In a particular embodiment R^3 and R^4 are radicals which may be identical or different and which are independently selected from the group consisting of hydrogen atoms, halogen atoms, C_1-C_6 acyl, trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), nitro (NO_2), amino (NH_2) and C_1-C_6 alkoxy. In a particular embodiment R^3 and R^4 may be selected from the group consisting of hydrogen, fluorine, acetyl, nitro, amino and methoxy.
In a particular embodiment R^3 is hydrogen and R^4 is a radical selected from the group consisting of hydrogen atoms, halogen atoms, C_1-C_6 acyl, trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), nitro (NO_2), amino (NH_2) and C_1-C_6 alkoxy.

In a particular embodiment the compound is selected from the group consisting of:

i. *p*-tolyl (9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)carbamate
ii. 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(4-(trifluoromethyl)phenyl)thiourea

iii. 1-(1-acetylpiperidin-4-yl)-3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)urea

iv. 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)urea

v. 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

vi. 1-(1-acetylpiperidin-4-yl)-3-(9-hydroxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

vii. 1-(1-acetylpiperidin-4-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

viii. 1-(1-acetylpiperidin-4-yl)-3-(9-fluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

ix. 1-(1-acetylpiperidin-4-yl)-3-(9-chloro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

x. 4-(((1r,4r)-4-(3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)ureido)cyclohexyl)oxy)benzoic acid

xi. 4-(((1r,4r)-4-(3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)ureido)cyclohexyl)oxy)benzoic acid

xii. 1-[1-(isopropylsulfonyl)piperidin-4-yl]-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xiii. 1-(1-benzylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xiv. 1-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-acetylpiperidin-4-yl)urea

xv. 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xvi. 1-(1-acetylpiperidin-4-yl)-3-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xvii. *tert*-butyl 4-(2-((9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)amino)-2-oxoethyl)piperidine-1-carboxylate

xviii. *N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-(piperidin-4-yl)acetamide

xix. 2-[1-(isopropylsulfonyl)piperidin-4-yl]-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide

xx. 2-(1-acetylpiperidin-4-yl)-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide

xxi. 1-(9-methyl-6,7,8,9,10,11-hexahydro-5*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(2,3,4-trifluorophenyl)urea

xxii. 1-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)-3-(2,3,4-trifluorophenyl)urea

xxiii. 2-(1-benzylpiperidin-4-yl)-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide

xxiv. 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-propionylpiperidin-4-yl)urea

xxv. 1-(1-(4-acetylphenyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxvi. 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-(tetrahydro-2*H*-pyran-4-carbonyl)piperidin-4-yl)urea

xxvii. 1-(1-(2-fluorobenzoyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxviii. 1-((1R,3s,5S)-8-benzyl-8-azabicyclo[3.2.1]octan-3-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxix. 1-(1-acetylpiperidin-4-yl)-3-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxx. 1-(1-acetylpiperidin-4-yl)-3-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxi. 1-(1-acetylpiperidin-4-yl)-3-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxii. 1-(1-acetylpiperidin-4-yl)-3-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxiii. 1-(1-acetylpiperidin-4-yl)-3-(5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-yl)urea

xxxiv. 1-(benzo[*d*]thiazol-2-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxv. 1-(1-acetylpiperidin-4-yl)-3-(1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxvi. 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethano-benzo[*e*]oxonin-3(2*H*)-yl-5-*d*)urea

Another aspect of the present invention relates to pharmaceutical or veterinary compositions comprising therapeutically effective amounts of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, and preferably adequate amounts of pharmaceutically acceptable excipients. Pharmacy in the context of the

present invention relates both to human medicine and veterinary medicine.

Another aspect of the present invention relates to compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, and to compositions comprising therapeutically effective amounts of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, for use as a medicament.

In a particular embodiment the present invention relates to compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, and to compositions comprising therapeutically effective amounts of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof for use in the treatment or prevention in an animal, including a human, of a disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase.

Another aspect of the present invention relates to the use of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, or compositions comprising therapeutically effective amounts of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, in the manufacture of a medicament.

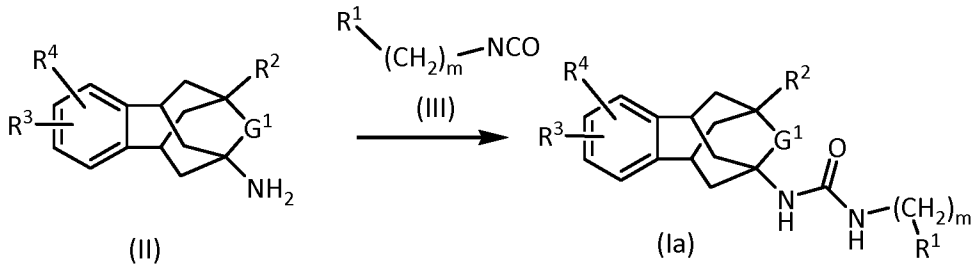
In a particular embodiment the present invention relates to the use of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, or compositions comprising therapeutically effective amounts of compounds of formula (I), or stereoisomers or pharmaceutically acceptable salts thereof, in the manufacture of a medicament for the treatment or prevention in an animal, including a human, of a disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase.

In particular embodiments the disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase are selected from the group consisting of hypertension, atherosclerosis, pulmonary diseases such as chronic obstructive pulmonary disorder, asthma, sarcoidosis and cystic fibrosis, kidney diseases such as acute kidney injury, diabetic nephrology, chronic kidney diseases, hypertension-mediated kidney disorders and high fat diet-mediated renal injury, stroke, pain, neuropathic pain, inflammation, pancreatitis in particular acute pancreatitis, immunological disorders, neurodevelopmental disorders such as schizophrenia and autism spectrum disorder, eye diseases in particular diabetic keratopathy, wet age-

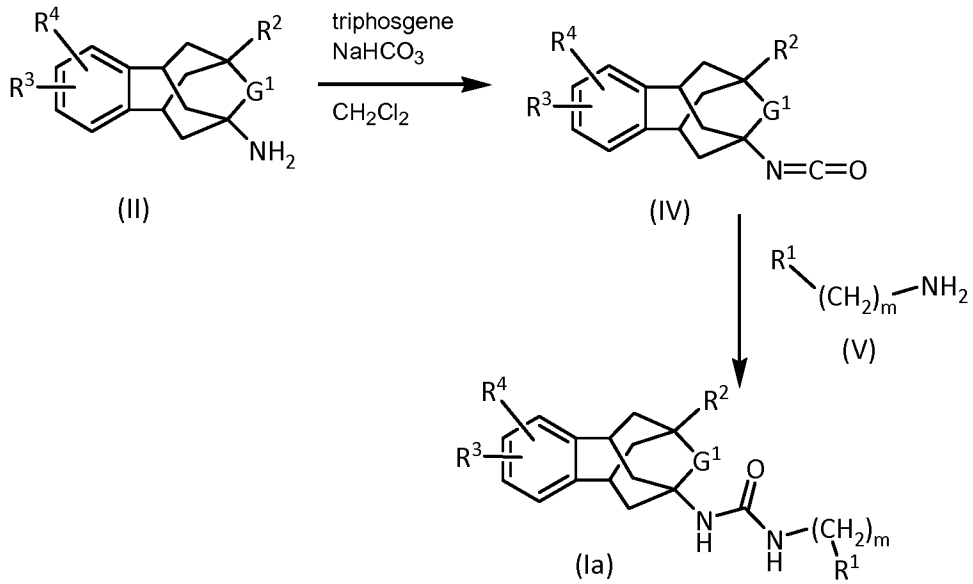
related macular degeneration and retinopathy such as premature retinopathy and diabetic retinopathy, cancer, obesity, including obesity-induced colonic inflammation, diabetes, metabolic syndrome, preeclampsia, anorexia nervosa, depression, male sexual dysfunction such as erectile dysfunction, wound healing, NSAID-induced ulcers, emphysema, scrapie, Parkinson's disease, arthritis, arrhythmia, cardiac fibrosis, Alzheimer's disease, Raynaud's syndrome, Niemann-Pick-type C disease, cardiomyopathy, vascular cognitive impairment, mild cognitive impairment, inflammatory bowel diseases, cirrhosis, non-alcoholic fatty liver disease, non-alcoholic steatohepatitis, liver fibrosis, osteoporosis, chronic periodontitis, sepsis, seizure disorders such as epilepsy, dementia, edema such as cerebral edema, attention-deficit hyperactivity disorder, schizophrenia, drug dependency, social anxiety, colitis, amyotrophic lateral sclerosis, chemotherapy induced side effects, laminitis, inflammatory joint pain and synovitis, endothelial dysfunction, subarachnoid hemorrhage, including aneurysmal subarachnoid hemorrhage, traumatic brain injury, cerebral ischemia and diabetes-induced learning and memory impairment.

In another aspect, the present invention relates to methods of treatment or prevention in an animal, including a human, of a disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase, by administration of pharmaceutical or veterinary compositions comprising compounds of formula (I). Methods for treatment of the aforementioned particular diseases and disorders are particular embodiments of the present invention.

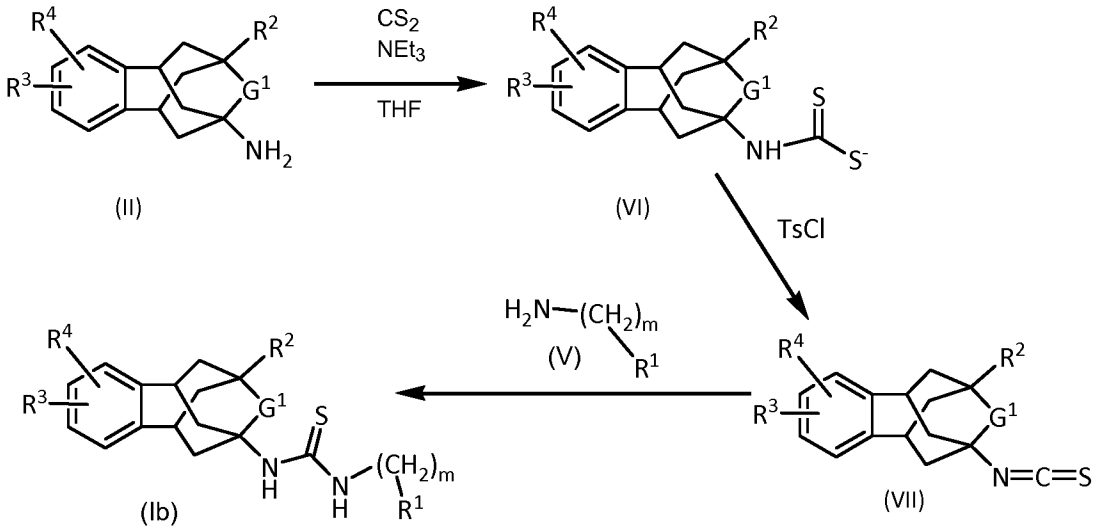
According to another aspect of the present invention, the compounds of formula (Ia) wherein G^2 is oxygen, G^3 is $–NH-(CH_2)_m-$ may be prepared by reacting the amine of formula (II), preferably in the form of a salt such as the hydrochloride with isocyanate of formula (III), in an inert solvent such as dichloromethane (DCM), and in the presence of a base such as triethylamine.



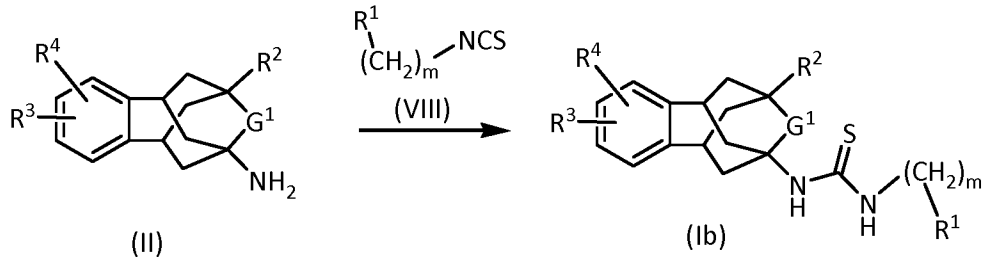
According to another aspect of the present invention, the compounds of formula (Ia), wherein G^2 is oxygen, G^3 is –NH-$(CH_2)_m$-, may also be prepared by converting in a first step the amine of formula (II), preferably in the form of a salt, into isocyanate of formula (IV) by reaction with an ($NH_2 \rightarrow NCO$)-converting reagent, such as triphosgene, in an inert solvent, such as DCM. In a second step, the amine of formula (V) is reacted with the isocyanate of formula (IV) to yield compound of formula (Ia). The coupling reaction may be carried out without catalyst and the reaction conveniently takes place at room temperature in the presence of an organic solvent, typically DCM, tetrahydrofuran (THF) or *N,N*-dimethylformamide (DMF).



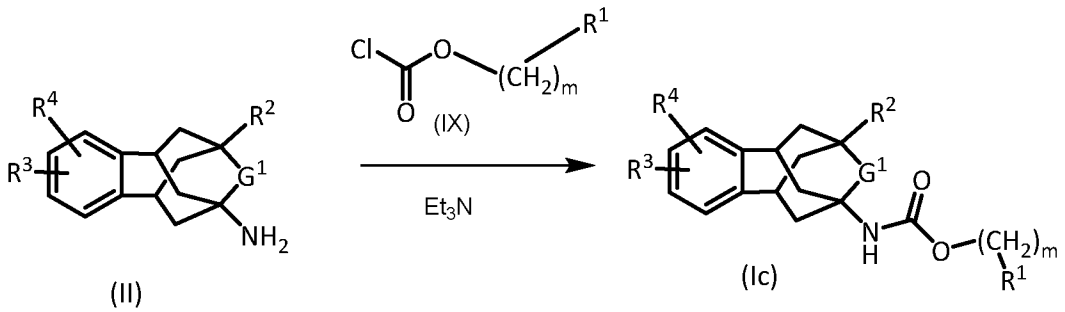
According to another aspect of the present invention, the compounds of formula (Ib), wherein G^2 is sulfur, G^3 is –NH-$(CH_2)_m$-, may be prepared by converting in a first step the amine of formula (II) preferably in the form of a salt, into a dithiocarbamate salt of formula (VI) by reaction with carbon disulfide in an inert solvent, such as THF, in the presence of a base, such as triethylamine. In a second step, the dithiocarbamate salt is decomposed in the presence of tosyl chloride to yield the isothiocyanate of formula (VII) which is subsequently reacted with an amine of formula R^1-$(CH_2)_m$-NH_2 of formula (V) to yield compound of formula (Ib).



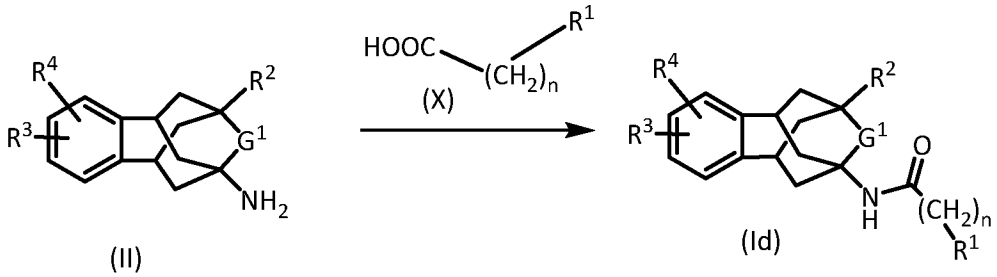
According to another aspect of the present invention, the compounds of formula (Ib) wherein G^2 is sulphur and G^3 is $–NH-(CH_2)_m-$ may also be prepared by reacting the amine of formula (II), preferably in the form of a salt such as the hydrochloride with thioisocyanate of formula $SCN-(CH_2)_m-R^1$ (VIII), in an inert solvent, such as DCM, and in the presence of a base such as triethylamine.



According to another aspect of the present invention, the compounds of formula (Ic), wherein G^2 and G^3 are both oxygen, may be prepared by reacting the amine of formula (II) with the chloroformate of formula (IX) in the presence of a base such as triethylamine.

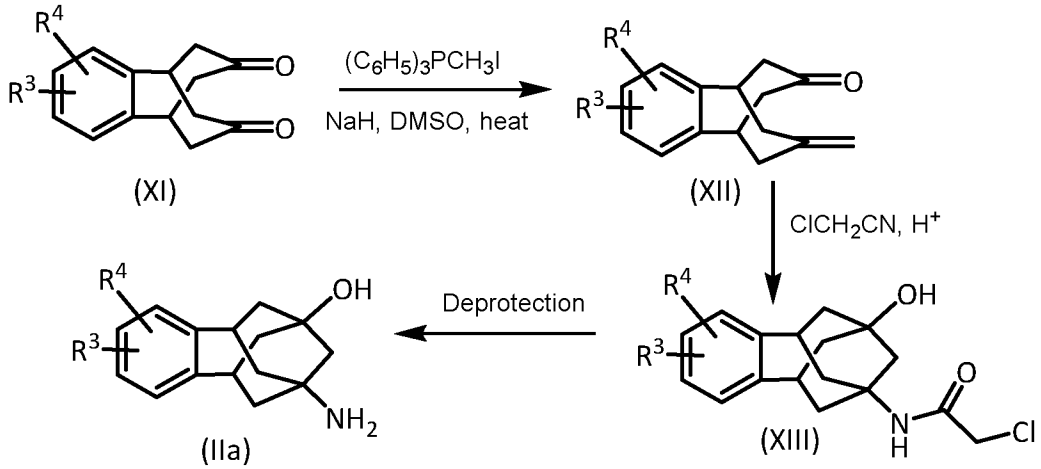


According to another aspect of the present invention, the compounds of formula (Id), wherein G^2 is oxygen and G^3 is $-(CH_2)_n-$, may be prepared by reacting the amine of formula (II), preferably in the form of a salt such as the hydrochloride, with a carboxylic acid of formula (X) in the presence of a coupling agent such as EDCI or HOBt or using an acyl chloride in the presence of a base, such as triethylamine, in an organic solvent such as ethyl acetate.



The amines of formula (II) may be obtained using a range of different reactions depending on the nature of the substituents G^1, R^2, R^3 and R^4 and some amines of formula (II) are disclosed in the art (see for example *Bioorg Med Chem.* 2010, 18, 46; *Bioorg Med Chem.* 2012, 20, 942; *Bioorg Med Chem.* 2014, 22, 2678; *Bioorg Med Chem.* 2015, 23, 290).

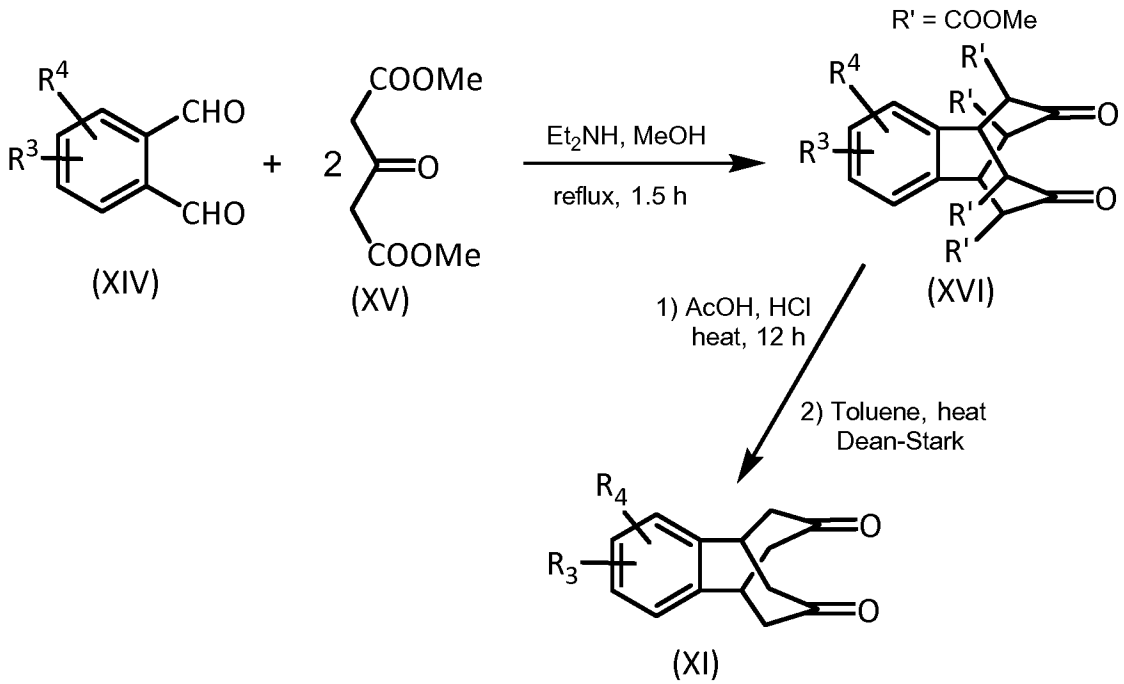
When G^1 is CH_2 and R^2 is OH the amines of formula (IIa) may be prepared according to the reaction scheme shown below:



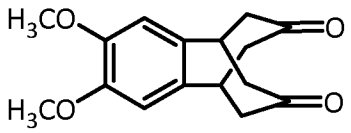
The deprotection step of the chloroacetamide to yield the final amine (IIa) may be carried out by refluxing overnight the compound (XIII) in the presence of thiourea and acetic acid in ethanol.

Diketone (XI) is a known compound when $R^3 = R^4 = H$ (*Liebigs Ann Chem.* 1973; 1839-1850). In general, substituted diketones of formula (XI) may be prepared from substituted *o*-phthalaldehydes (XIV) according to the reaction scheme shown below.

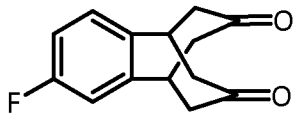
Starting from suitably substituted *o*-phthalaldehyde derivatives of formula (XIV) and



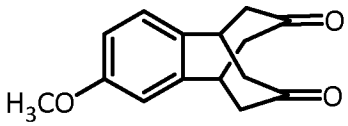
following the reaction scheme shown above, it is also possible to prepare diketones (XI) with different substituents such as those shown below:



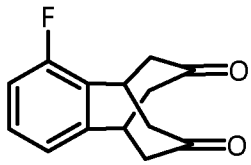
(XIa)



(XIb)

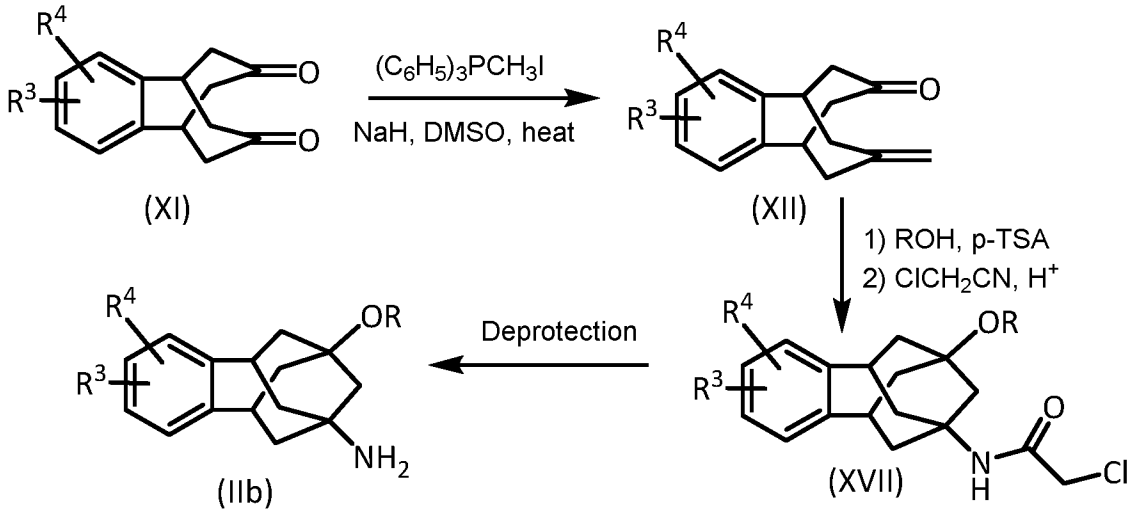


(XIc)



(XId)

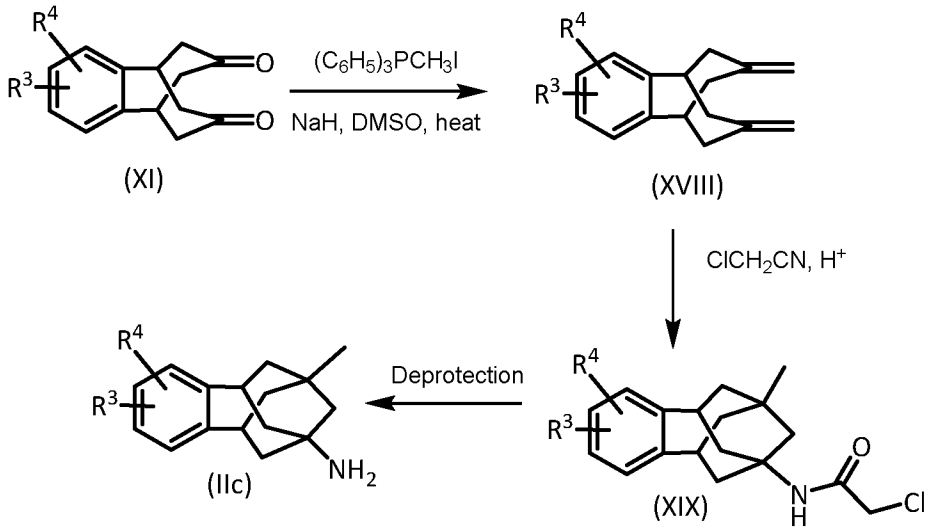
When G^1 is CH_2 and R^2 is C_1-C_6 alkoxy the amines of formula (IIb) may be prepared according to the reaction scheme shown below:



wherein R is C_{1-6} alkyl

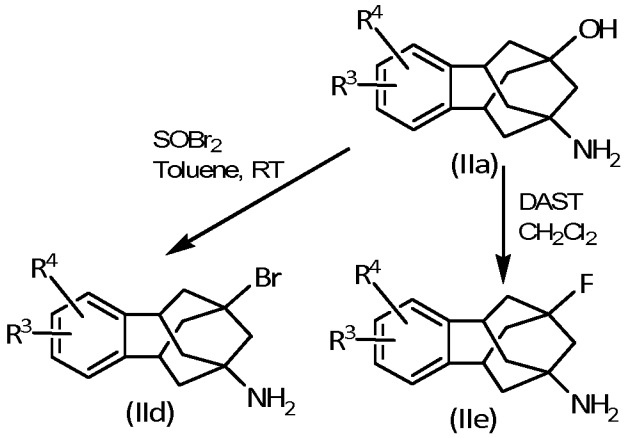
The deprotection step of the chloroacetamide to yield the final amine (IIb) may be carried out by refluxing overnight the compound (XVII) in the presence of thiourea and acetic acid in ethanol.

When G^1 is CH_2 and R^2 is methyl the amines of formula (IIc) may be prepared according to the reaction scheme shown below:

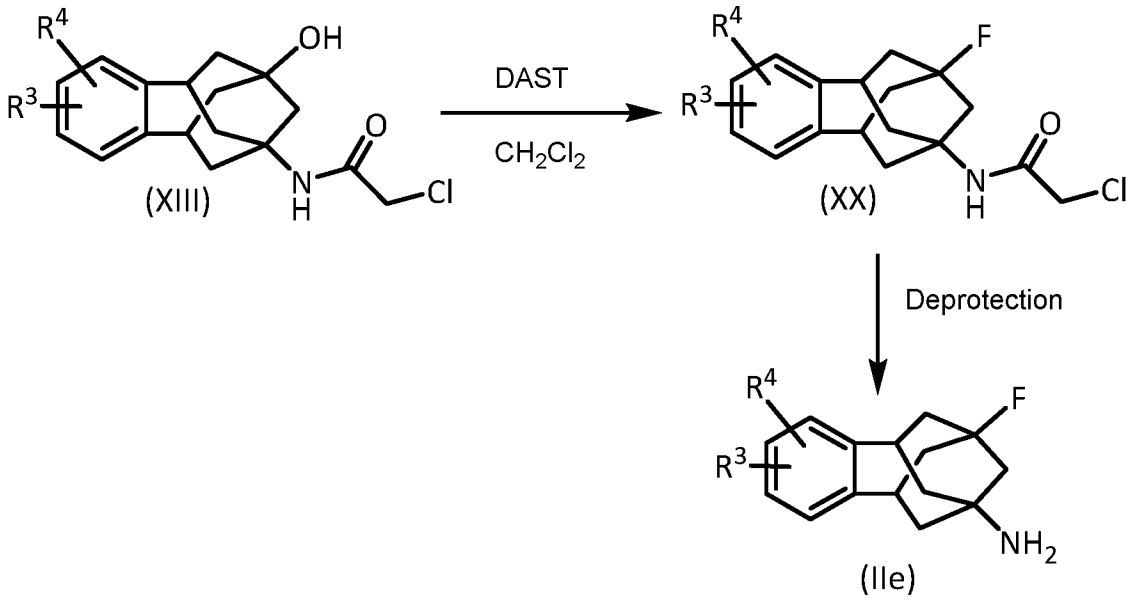


The deprotection step of the chloroacetamide to yield the final amine (IIc) may be carried out by refluxing overnight the compound (XIX) in the presence of thiourea and acetic acid in ethanol.

When G^1 is CH_2 and R^2 is bromine or fluorine the amines of formula (IId) and (IIe) may be prepared according to the reaction scheme shown below:

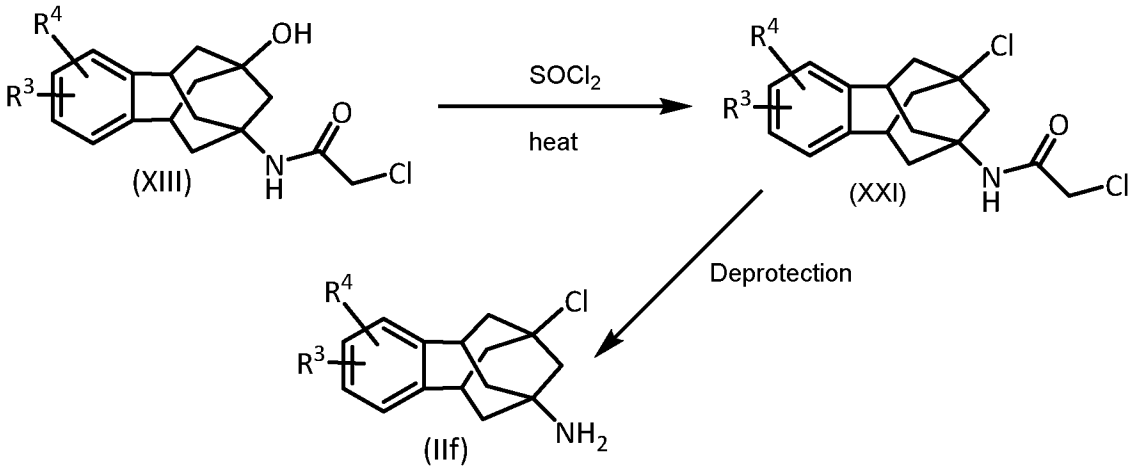


Alternatively, the amine (IIe) may be obtained starting from compound (XIII) according to the scheme below:



The deprotection step of the chloroacetamide to yield the final amine (IIe) may be carried out by refluxing overnight the compound (XX) in the presence of thiourea and acetic acid in ethanol.

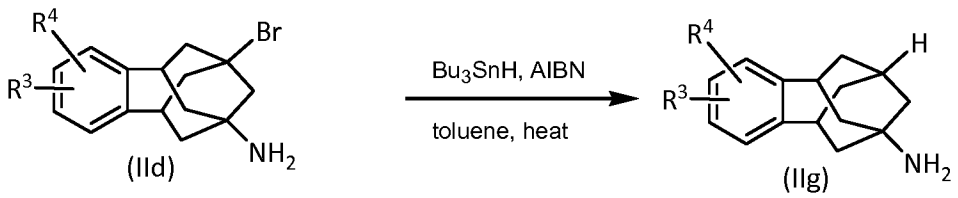
When G^1 is CH_2 and R^2 is chlorine the amines of formula (IIf) may be prepared according to the reaction scheme shown below:



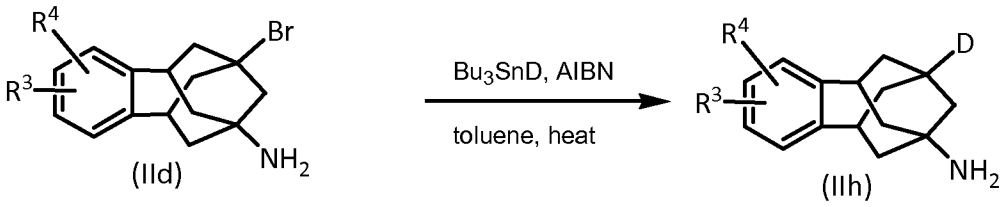
The deprotection step of the chloroacetamide to yield the final amine (IIf) may be carried out by refluxing overnight the compound (XXI) in the presence of thiourea and acetic acid in ethanol.

When G^1 is CH_2 and R^2 is hydrogen the amines of formula (IIg) may be prepared

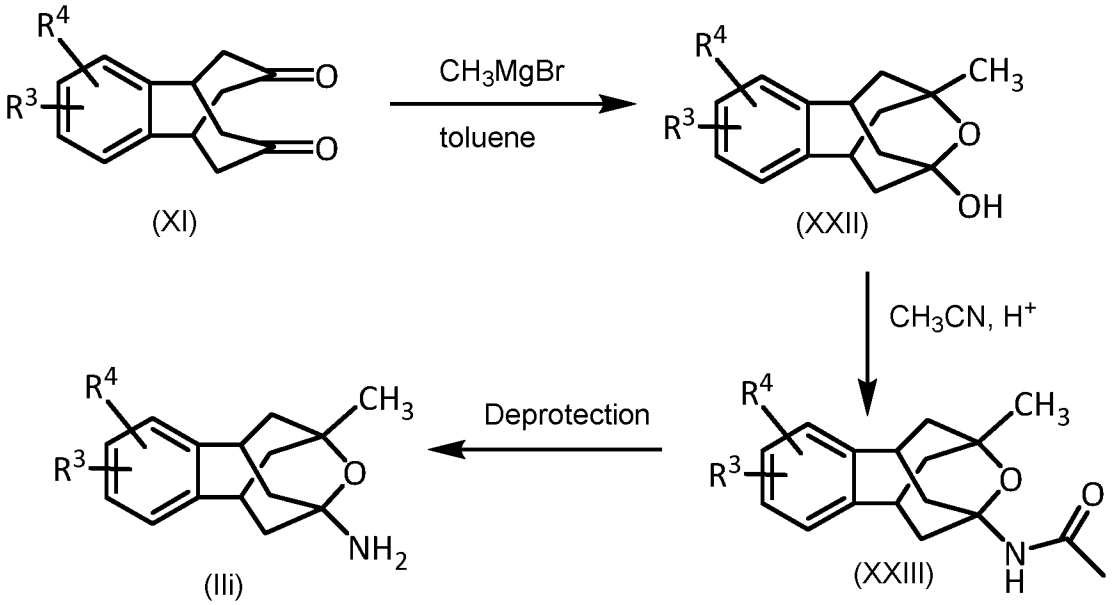
according to the reaction scheme shown below:



When G^1 is CH_2 and R^2 is deuterium the amines of formula (IIh) may be prepared according to the reaction scheme shown below:

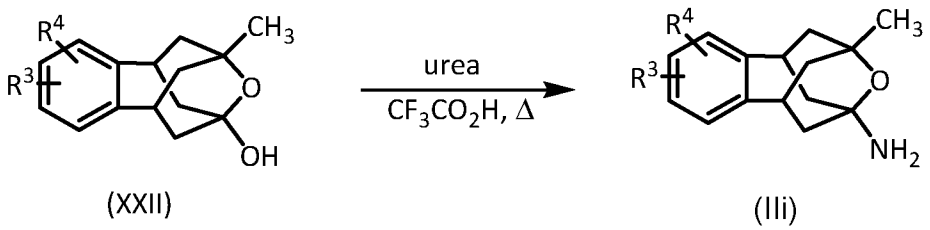


When G^1 is O and R^2 is methyl the amines of formula (IIi) may be prepared according to the reaction scheme shown below:



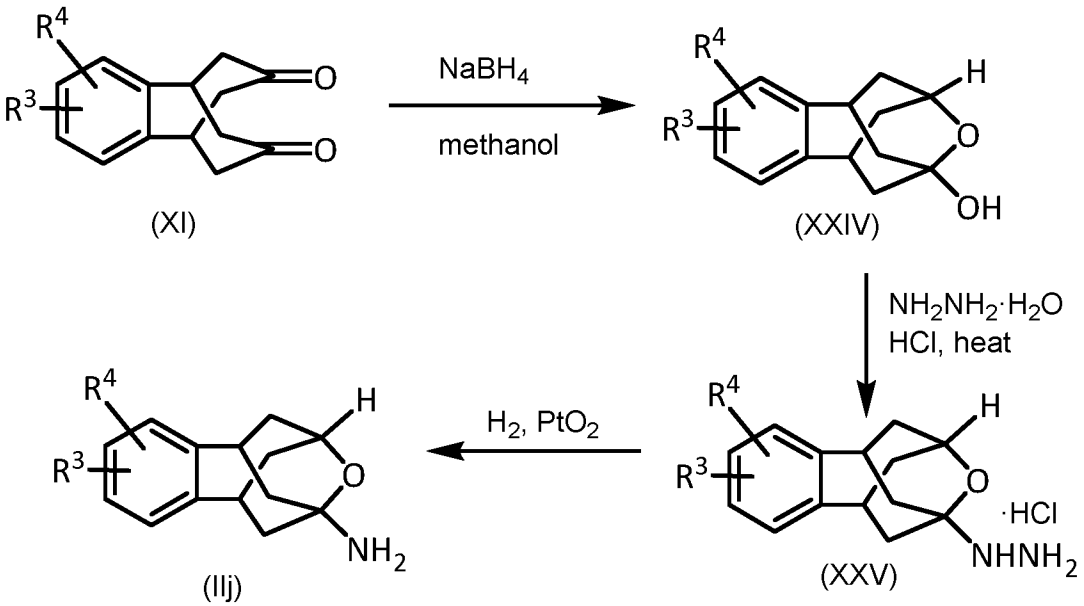
The deprotection step of the acetamide to yield the final amine (IIi) may be carried out by refluxing overnight the compound (XXIII) in the presence of conc. HCl as reported for $R^3 = R^4 = H$ in *Bioorg Med Chem* 2010, 18, 46-57.

Alternatively, when G^1 is O and R^2 is methyl the amines of formula (Ili) may be prepared according to the reaction scheme shown below:



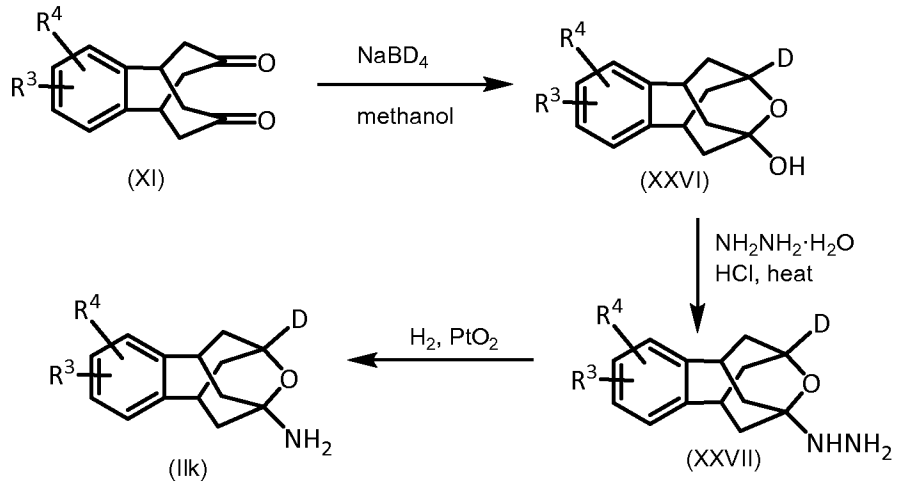
(XXII) (Ili)

When G^1 is O and R^2 is hydrogen the amines of formula (Ilj) may be prepared according to the reaction scheme shown below:

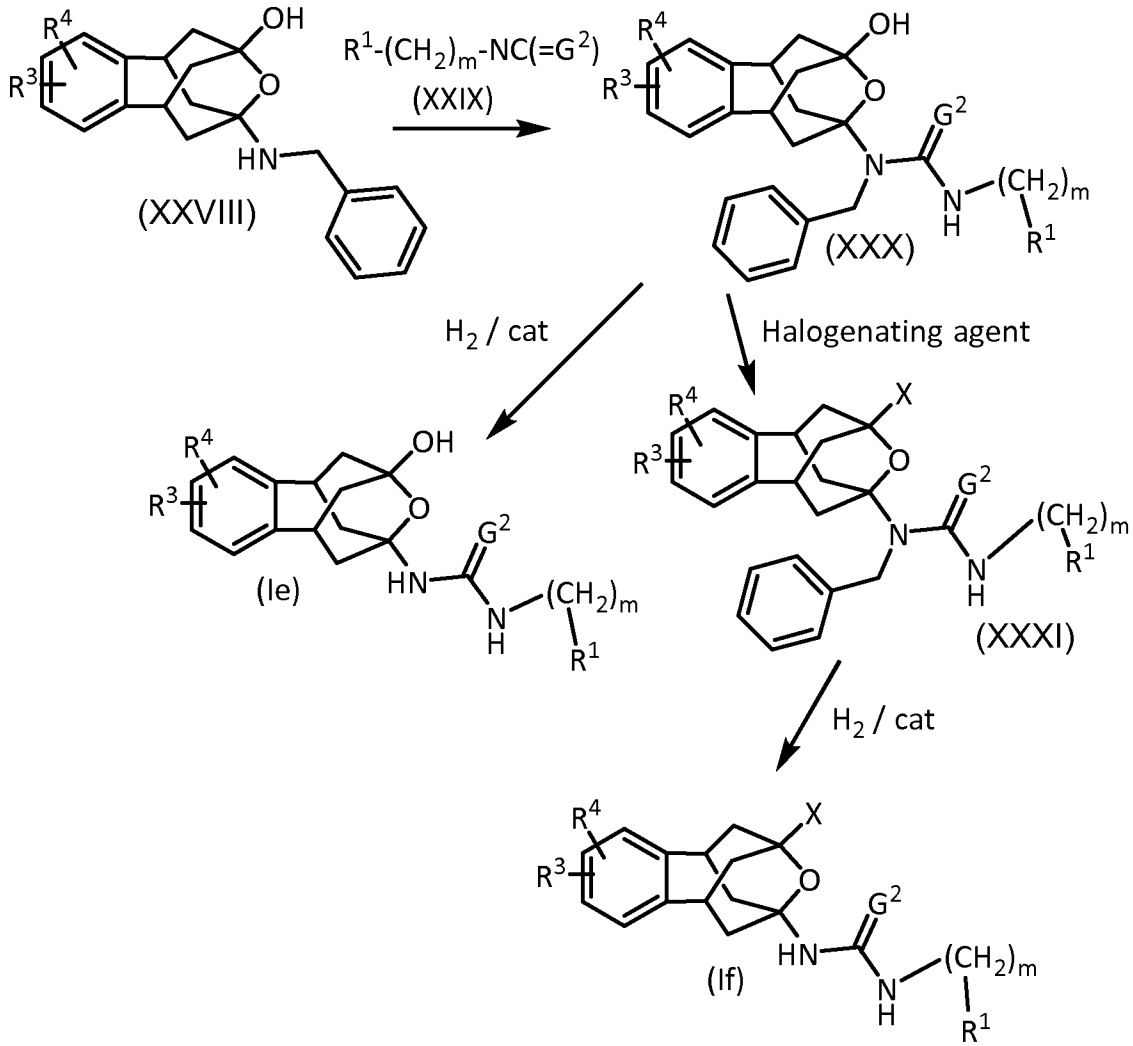


(XI) (XXIV) (XXV) (Ilj)

When G^1 is O and R^2 is deuterium the amines of formula (Ilk) may be prepared according to the reaction scheme shown below:



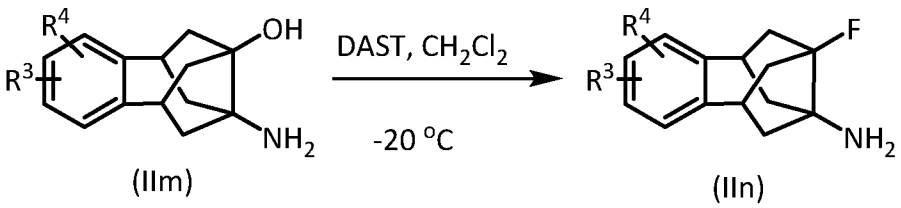
When G^1 is O and R^2 is a halogen or a hydroxyl group the compounds of formula (Ie) and (If) may be prepared according to the reaction scheme shown below:



When X is fluorine in the second step compound (XXX) is converted to compound (XXXI) using (diethylamino)sulfur trifluoride (DAST) as halogenating agent, when X is chlorine the halogenating agent is $SOCl_2$ and when X is bromine the halogenating agent is $SOBr_2$.

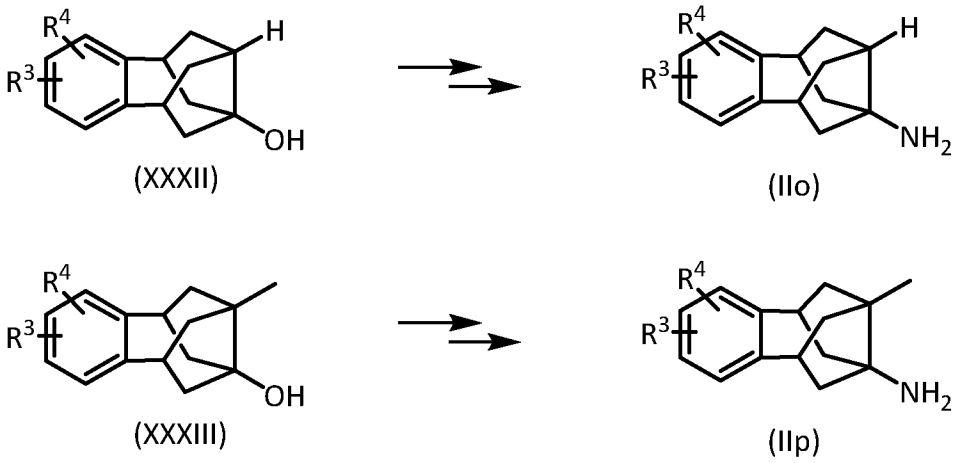
The preparation of compound (XXVIII) is described from compound (XI) (for R^3=R^4=H) in patent application DE 2 210 799 A1. The synthetic process described therein may be also used for the preparation of compounds where R^3 and/or R^4 are different from hydrogen.

When G^1 is a bond and R^2 is a fluorine the compounds of formula (IIn) may be prepared according to the reaction scheme shown below:

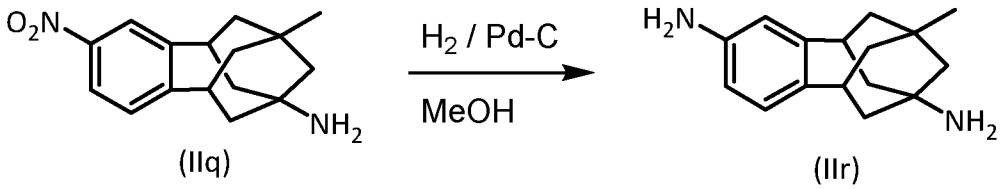


The preparation of compound (IIm) is described (for R^3=R^4=H) in *Liebigs Ann.* 1995, 523-535. The synthetic process described therein may be also used for the preparation of compounds where R^3 and/or R^4 are different from hydrogen.

Compounds of formula (IIo) and (IIp) may be prepared, respectively, from compounds (XXXII) and (XXXIII) through one or more well-known reactions. Compounds (XXXII) and (XXXIII) are synthesized from compounds of formula (XI) according to methods reported in the literature for R^3=R^4=H (*Liebigs Ann Chem.* 1973; 1839-1850 and *Aust J Chem.* 1983, 36, 2465-2472) which methods may also be used for the preparation of compounds where R^3 and/or R^4 are different from hydrogen.

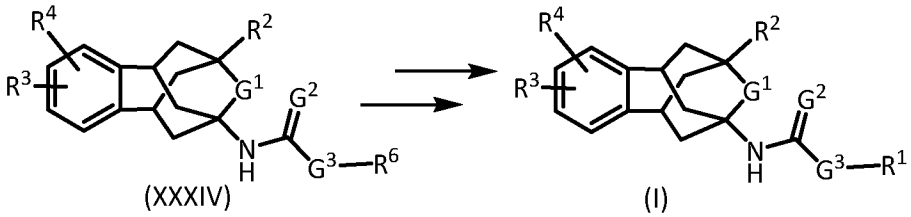


It is also possible to convert some compounds of formula (II) to other compounds of formula (II) by modifying the nature of the groups R^3 and R^4 by conventional methods known to the person skilled in the art. As an example, compound of formula (IIq) may be converted to compound of formula (IIr) by catalytic hydrogenation.

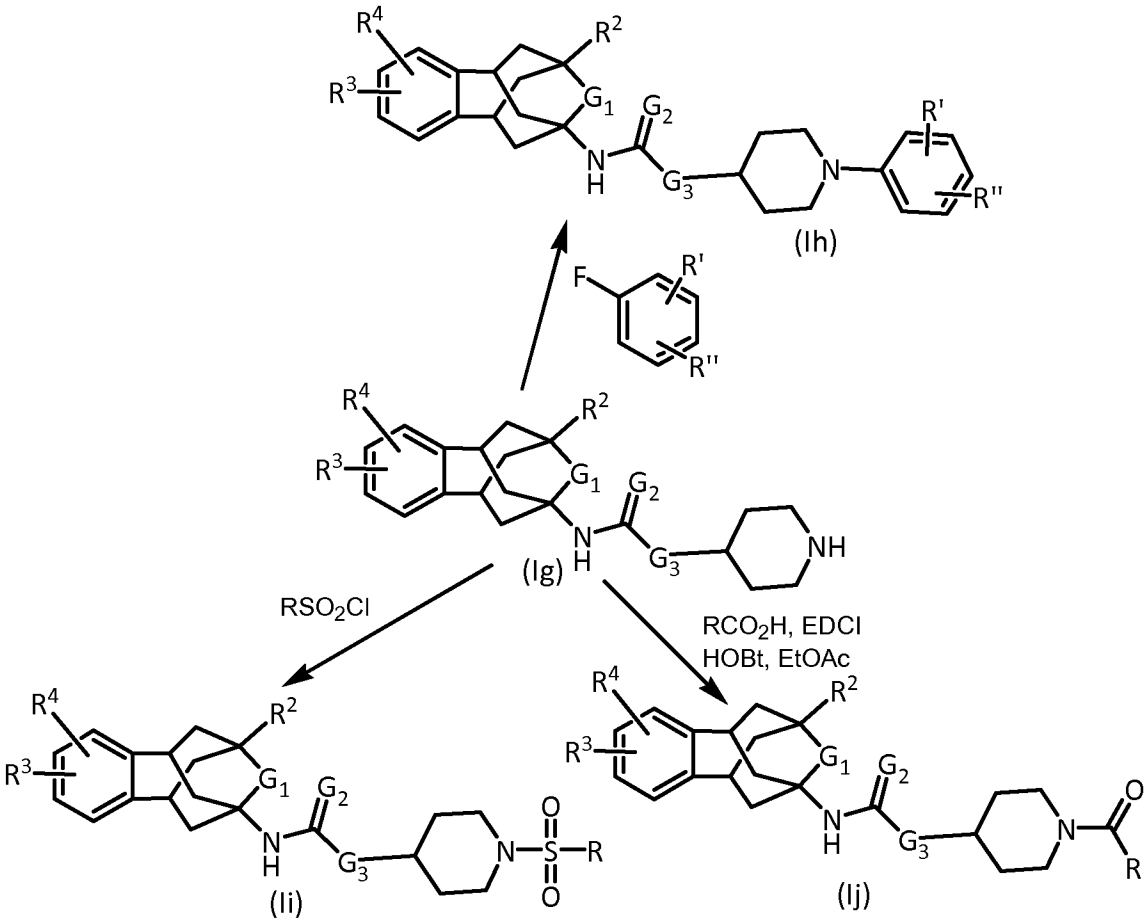


It is worth mentioning that it is possible to convert some compounds of formula (I) of the invention to other compounds of formula (I) by modifying the nature of the groups R^3 and R^4 by conventional methods known to the person skilled in the art. As an example, compounds of formula (I) wherein R^3 and R^4 are hydrogen atoms may be converted to compounds where one R^3 and R^4 is hydrogen and the other one is a C_{1-6} acyl group through a Friedel-Craft reaction. As another example compounds of formula (I) wherein R^3 and/or R^4 are a nitro group may be converted to compounds where said R^3 and/or R^4 is an amino group by catalytic hydrogenation.

Finally, it is worth mentioning that the compounds of the invention may also be prepared following the methods explained above from precursors of formula (XXXIV) wherein the rest R^6 is a precursor of the rest R^1 which is converted into said rest R^1 through one or more well-known reactions. It is also possible that the rest R^6 is already a group R^1 which is converted into another group R^1 through one or more well-known reactions.



Examples of said synthetic strategy are provided below wherein the group R^6 is an unsubstituted piperidinyl rest and R^1 is a piperidinyl rest carrying substituents as defined in the claims:



The reaction of compound (Ig) to yield compound (Ih) is carried out using K_2CO_3 and anhydrous DMSO applying heat. The reaction of compound (Ig) to yield compound (Ij) is carried out either as shown (RCO_2H, EDCI, HOBt, EtOAc) or using RCOCl and Et_3N in DCM.

In addition to the three kind of derivatives shown in the scheme above, it is also possible to go from the unsubstituted piperidine in (Ig) to benzyl piperidines. The procedure involves the reaction of the piperidine (Ig) with benzaldehydes and sodium

cyanoborohydride in acetic acid / methanol.

As used herein, the term methylene designates the radical –(CH_2)-.

As used herein the term aryl designates an aromatic carbocyclic ring which may be unsubstituted or substituted. Non-limiting examples of unsubstituted aryl groups are phenyl and anthranyl.

As used herein the term halogen atoms designates atoms selected from the group consisting of chlorine, fluorine, bromine and iodine atoms, preferably fluorine, chlorine or bromine atoms. The term halo when used as a prefix has the same meaning.

As used herein the term C_p acyl designates a group alkyl having p-1 carbon atoms which is linked to a carbonyl group (CH_3-$(CH_2)_{p-2}$-CO-). Non limiting examples of acyl groups are acetyl, propionyl, butyryl, valeryl and caproyl.

As used herein the term C_q alkyl designates linear or branched hydrocarbon radicals (C_qH_{2q+1}-). Non-limiting examples of alkyl groups are methyl, ethyl, *n*-propyl *i*-propyl, *n*-butyl, *i*-butyl, *sec*-butyl, *tert*-butyl, *n*-pentyl, *i*-pentyl and *n*-hexyl.

As used herein the term mono-C_r-alkylamino designates a C_r-alkyl linked to a group NH (C_r-alkyl-NH-). Non-limiting examples of monoalkylamino groups are methylamino (CH_3-NH-), ethylamino (CH_3-CH_2-NH-) and *n*-propylamino (CH_3-CH_2-CH_2-NH-).

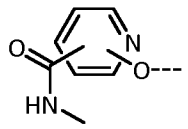
As used herein the term di-C_s-alkylamino designates two alkyl rest linked to a group N ((C_s-alkyl)$_2$-N-) wherein the two alkyl rests may have the same or different number of carbon atoms. Non-limiting examples of dialkylamino groups are dimethylamino ((CH_3)$_2$NH-), diethylamino ((CH_3-CH_2)$_2$N-), ethylmethylamino ((CH_3)(CH_3-CH_2)N-) and di-*n*-propylamino ((CH_3-CH_2-CH_2)$_2$N-).

As used herein the term C_t alkoxy designates a linear or branched alkyl group linked to an oxygen atom (CH_3-$(CH_2)_{t-1}$-O-). Non-limiting examples of alkoxy groups are methoxy, ethoxy, *n*-propoxy, *i*-propoxy, *n*-butoxy, *i*-butoxy, *sec*-butoxy, *tert*-butoxy, *n*-pentoxy, *i*-pentoxy and *n*-hexoxy.

As used herein the term C_u alkoxycarbonylmethyl designates a C_u alkoxy rest linked to a group -CO-CH_2- ((CH_3-$(CH_2)_{u-1}$)-O-CO-CH_2-). Non-limiting examples of

alkoxycarbonylmethyl groups are methoxycarbonylmethyl and ethoxycarbonylmethyl.

As used herein the term methylaminocarbonylpyridyloxy is used to designate the group:



As used herein the term heteroaryl designates an heteroaromatic ring containing carbon, hydrogen and one or more heteroatoms selected from N, O and S as part of the ring. Said radicals may be unsubstituted or substituted by one or more substituents. Non-limiting examples of heteroaryl groups are pyridyl, pyrimidinyl, furyl, thienyl, pyrazolyl, oxazolyl and thiazolyl.

As used herein the term saturated or partially unsaturated heterocyclyl is used to designate a non-aromatic ring containing carbon, hydrogen and one or more heteroatoms selected from N, O and S as part of the ring. In particular, an heterocyclyl group may be monocyclic or bicyclic. Non-limiting examples of saturated heterocyclyl groups are piperidinyl, morpholinyl, tetrahydropyranyl and piperazinyl.

As used herein the term cycloalkyl designates hydrocarbon cyclic groups. Said cycloalkyl groups may have a single cyclic ring or a polycyclic ring. Non-limiting examples of cycloalkyl groups are cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl.

As used herein the term alkylsulfonyl designates a linear or branched alkyl group linked to a sulfonyl group (CH_3-$(CH_2)_{v-1}$-SO_2-). Non-limiting examples of alkylsulfonyl groups are methylsulfonyl (CH_3-SO_2-), ethylsulfonyl (CH_3-CH_2-SO_2-) and *n*-propylsulfonyl (CH_3-CH_2-CH_2-SO_2-).

As used herein the term cycloalkylsulfonyl designates a cycloalkyl group linked to a sulfonyl group. Non-limiting examples of cycloalkylsulfonyl groups are cyclopropylsulfonyl, cyclobutylsulfonyl, cyclopentylsulfonyl and cyclohexylsulfonyl.

As used herein the term arylsulfonyl designates an aryl group linked to a sulfonyl group. Non-limiting examples of alkylsulfonyl groups are phenylsulfonyl and naphthalenesulfonyl.

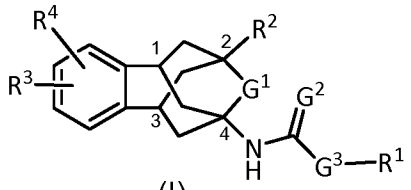
As used herein the term pyridincarbonyl designates a pyridyl group linked to a carbonyl group (C_5H_4N-CO-).

As used herein the term phenylcarbonyl designates a phenyl group linked to a carbonyl group (C_6H_5-CO-).

As used herein the term tetrahydropyrancarbonyl designates a tetrahydropyranyl group linked to a carbonyl group (C_5H_9O-CO-).

As used herein the term pharmaceutically acceptable salt designates any salt which, upon administration to the patient is capable of providing (directly or indirectly) a compound as described herein. For instance, pharmaceutically acceptable salts of compounds provided herein are synthesized from the parent compound, which contains a basic or acidic moiety, by conventional chemical methods. Generally, such salts are, for example, prepared by reacting the free acid or base forms of these compounds with a stoichiometric amount of the appropriate base or acid in water or in an organic solvent or in a mixture of both. Generally, non-aqueous media like ether, ethyl acetate, ethanol, 2-propanol or acetonitrile are preferred. Examples of the acid addition salts include mineral acid addition salts such as, for example, hydrochloride, hydrobromide, hydroiodide, sulfate, nitrate, phosphate, and organic acid addition salts such as, for example, acetate , trifluoroacetate, maleate , fumarate , citrate , oxalate , succinate, tartrate, malate, mandelate, methanesulfonate and *p*-toluenesulfonate. Examples of the alkali addition salts include inorganic salts such as, for example, sodium, potassium, calcium and ammonium salts, and organic alkali salts such as, for example, ethylenediamine, ethanolamine, *N*,*N*-dialkylenethanolamine, triethanolamine and basic aminoacids salts.

As used herein the term stereoisomers designates molecules that have the same molecular formula and sequence of bonded atoms (constitution), but differ in the three-dimensional orientations of their atoms in space. The compounds of formula (I) have at least two chiral carbon atoms (marked as 1 and 3 in the formula depicted below) and, thus, several stereoisomers of said compounds may exist. Said stereoisomers are encompassed by formula (I).



(I)

Throughout the description and claims the word "comprise" and variations of the word, are not intended to exclude other technical features, additives, components, or steps. Furthermore, the word "comprise" encompasses the case of "consisting of". Additional objects, advantages and features of the invention will become apparent to those skilled in the art upon examination of the description or may be learned by practice of the invention. The following examples are provided by way of illustration, and they are not intended to be limiting of the present invention. Furthermore, the present invention covers all possible combinations of particular and preferred embodiments described herein.

ABREVIATIONS:

The following abbreviations have been used along the present application:

anh.:	anhydrous
AcOH:	acetic acid
AcCl:	acetyl chloride
AIBN:	azobisisobutyronitrile
Bis/Tris:	2-Bis(2-hydroxyethyl)amino-2-(hydroxymethyl)-1,3-propanediol
BSA:	bovine serum albumin
Bu_3SnD:	tributyl(deuterio)stannane
Calcd:	calculated
d:	doublet
DAST:	diethylaminosulfur trifluoride
Dec:	decomposes
DCM:	dichloromethane
DMF:	*N,N*-dimethylformamide
DMSO:	dimethylsulfoxide
dq	doublet of quartets
dt	doublet of triplets
EDCI:	1-ethyl-3-(3-dimethylaminopropyl)carbodiimide
ESI:	electrospray ionization
Et_2O:	diethylether

Et_3N: triethylamine
EtOAc: ethyl acetate
EtOH: ethanol
HOBt: hydroxybenzotriazole
h: hours
Hz Hertz
HRMS: high resolution mass spectroscopy
IR: infrared
m: multiplet
MeOH: methanol
mp: melting point
n-Bu: *n*-butyl
NMR: nuclear magnetic resonance
NSAID: non steroidal anti-inflammatory drug
p-TSA: *p*-toluenesulfonic acid
PHOME: cyano(6-methoxynaphthalen-2-yl)methyl 2-(3-phenyloxiran-2-yl)acetate
s: singlet
sEH: soluble epoxide hydrolase
t: triplet
THF: tetrahydrofuran
TPPU: *N*-[1-(1-Oxopropyl)-4-piperidinyl]-*N'*-[4-(trifluoromethoxy)phenyl]urea
UV: ultraviolet

EXAMPLES

Analytical methods

- Melting points were determined in open capillary tubes with a MFB 595010 M Gallenkamp melting point apparatus.
- Infrared (IR) spectra were run either on a Perkin-Elmer Spectrum RX I spectrophotometer (using the attenuated total reflectance technique) or on a spectrophotometer Nicolet Avatar 320 FT-IR. Absorption values are expressed as wavenumbers (cm^{-1}); only significant absorption bands are given.
- Elemental analyses were carried out at the Microanalysis Service of the IIQAB (CSIC, Barcelona, Spain) with a Carlo Erba model 1106 analyzer.
- Preparative normal phase chromatography was performed on a CombiFlash Rf 150 (Teledyne Isco) with pre-packed RediSep Rf silica gel cartridges. Thin-layer chromatography was performed with aluminum-backed sheets with silica gel 60 F254

(Merck, ref 1.05554 or Sigma-Aldrich, ref 60805), and spots were visualized with UV light, 1% aqueous solution of $KMnO_4$ and/or iodine.

- High-resolution mass spectrometry (HRMS) analyses were performed with an LC/MSD TOF Agilent Technologies spectrometer.
- Analytical grade solvents were used for crystallization, while pure for synthesis solvents were used in the reactions, extractions and column chromatography.
- The analytical samples of all of the new compounds which were subjected to pharmacological evaluation possess a purity ≥95% as evidenced by their elemental analysis.

Reference example 1: 2-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione.

In a round-bottomed flask equipped with a condenser and magnetic stirring a solution of 4-fluorophthalaldehyde (3.08 g, 20 mmol) and dimethyl 3-oxopentanedioate (6.98 g, 40 mmol) in MeOH (60 mL) was prepared. Four drops of diethylamine were added and the reaction was heated at reflux for 1.5 h, the reaction was cooled down and 7 drops more of diethylamine were added and the reaction was stored at 4˚C overnight. The precipitate was filtered off under vacuum and was washed with cold MeOH (4 mL), obtaining tetramethyl 2-fluoro-7,11-dioxo-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7] annulene-6,8,10,12-tetracarboxylate as white needles (3.05 g). A solution of this solid in glacial acetic acid (18 mL) and conc. HCl (5 mL) was heated at reflux for 12 h. The solvent was removed under vacuum to give a solid. A solution of this solid in toluene (50 mL) was heated a reflux for 16 h in a Dean-Stark apparatus. The toluene was removed under vacuum to give pure 2-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (1.53 g, 33% overall yield) as a light brown solid. mp 105-107 °C. IR (NaCl disk): 2923, 2848, 1710, 1607, 1593, 1490, 1428, 1380, 1346, 1253, 1208, 1119, 1074, 985, 944, 865, 806 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{14}H_{13}FO_2+H]^+$: 233.0972, found: 233.0967.

Reference example 2: 2-methoxy-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione:

From 4-methoxyphthalaldehyde (10.2 g, 61.9 mmol), dimethyl 3-oxopentanedioate (21.5 g, 124 mmol) and diethylamine (28 drops) in MeOH (380 mL) and following the procedure described in reference example 1, tetramethyl 2-methoxy-7,11-dioxo-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene-6,8,10,12-tetracarboxylate was obtained (19.4 g, 66% yield). From the aforementioned tetracarboxylate (250 mg, 0.5 mmol), conc. HCl (0.4 mL) and glacial acetic acid (1.4 mL) and following the procedure

described in reference example 1, 2-methoxy-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (125 mg, 98% yield) was obtained.
mp 157-158 °C. IR (NaCl disk): 2941, 2910, 2837, 1701, 1610, 1585, 1504, 1431, 1414, 1370, 1321, 1300, 1266, 1166, 1094, 1033, 989 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{15}H_{16}O_3+H]^+$: 245.1172, found: 245.1180.

Reference example 3: 2,3-dimethoxy-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo [7]annulene-7,11-dione:

From 4,5-dimethoxyphthalaldehyde (6.54 g, 33.7 mmol), dimethyl 3-oxopentanedioate (11.7 g, 67.4 mmol) and diethylamine (19 drops) in MeOH (130 mL) and following the procedure described in reference example 1, tetramethyl 2,3-dimethoxy-7,11-dioxo-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene-6,8,10,12-tetracarboxylate was obtained (6.84 g, 40% yield). From the aforementioned tetracarboxylate (6.84 g, 13.5 mmol), conc. HCl (10 mL) and glacial acetic acid (35 mL), and following the procedure described in reference example 1, 2,3-dimethoxy-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo [7]annulene-7,11-dione (2.8 g, 76% yield) was obtained.
mp 236-237 °C. IR (NaCl disk): 2952, 2840, 1698, 1605, 1516, 1467, 1451, 1416, 1355, 1336, 1254, 1221, 1192, 1162, 1025, 1002, 880, 811 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{16}H_{18}O_4+H]^+$: 275.1278, found: 275.1279.

Reference example 4: 1-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione.

From 3-fluorophthalaldehyde (11.2 g, 73.6 mmol), dimethyl 3-oxopentanedioate (25.6 g, 147 mmol) and diethylamine (33 drops) in MeOH (220 mL) and following the procedure described in reference example 1, tetramethyl 1-fluoro-7,11-dioxo-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene-6,8,10,12-tetracarboxylate was obtained (18.5 g, 54% yield). The aforementioned tetracarboxylate (18.5 g, 39.9 mmol), conc. HCl (31 mL) and glacial acetic acid (103 mL), and following the procedure described in reference example 1, 1-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione was obtained (8.73 g, 94% yield).
mp > 150 °C (dec.). IR (NaCl disk): 2940, 2908, 1701, 1619, 1585, 1468, 1421, 1370, 1303, 1245, 1222, 1203, 1072, 1052, 988, 931, 897, 789, 746 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{14}H_{13}FO_2+H]^+$: 233.0972, found: 233.0976.

Reference example 5: 2-fluoro-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene.

In a 3-necked round-bottomed flask equipped with magnetic stirring and argon atmosphere, a suspension of NaH (1.08 g, 60 % purity, 27.0 mmol) in anhydrous DMSO (13.3 mL) was heated at 75 ˚C over 45 min. The green suspension was cooled down to room temperature and methyltriphenylphosphonium iodide (10.92 g, 27.0 mmol) diluted in anhydrous DMSO (22 mL) and 2-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (1.53 g, 6.59 mmol) diluted in anhydrous DMSO (50 mL) were sequentially added. The resulting mixture was heated at 90 ˚C overnight. The reaction was cooled down and poured into water (80 mL). The aqueous layer was extracted with hexane (4 x 80 mL). The combined organic extracts were dried over anh. Na_2SO_4, filtered and concentrated under vacuum. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave 2-fluoro-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene as a colorless wax (1.09, 73% yield).

mp 108-109 °C. IR (NaCl disk): 3072, 2985, 2921, 2844, 1639, 1612, 1592, 1494, 1451, 1444, 1363, 1246, 1162, 1135, 1095, 1048, 974, 951, 930, 887, 820, 716, 658, 638, 598, 528 cm^{-1}.

Reference example 6: 2-methoxy-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene.

From 2-methoxy-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (4 g, 16.4 mmol) and following the procedure described in reference example 5, 2-methoxy-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene was obtained (1.5 g, 38 % yield).

mp 68-69°C. IR (NaCl disk): 3068, 2979, 2911, 2833, 1639, 1609, 1580, 1501, 1464, 1449, 1431, 1363, 1313, 1260, 1203, 1172, 1152, 1109, 1034, 955, 929, 889, 851, 809, 661, 613 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{17}H_{20}O+H]^+$: 241.1587, found: 241.1588.

Reference example 7: 2,3-dimethoxy-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene.

From 2,3-dimethoxy-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (2.8 g, 10.2 mmol) and following the procedure described in reference example 5, 2,3-dimethoxy-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene was obtained (633 mg, 23% yield).

mp 74-75 °C. IR (NaCl disk): 3068, 2977, 2913, 2832, 1639, 1606, 1515, 1464, 1450, 1429, 1414, 1358, 1342, 1293, 1261, 1240, 1225, 1191, 1173, 1103, 1023, 956, 931,

889, 804, 634 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{18}H_{22}O_2+H]^+$: 271.1693, found: 271.1688.

Reference example 8: 1-fluoro-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene.

From 1-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (4 g, 17.2 mmol) and following the procedure described in reference example 5, 1-fluoro-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene was obtained as a colourless oil (2.69 g, 69% yield).

IR (NaCl disk): 3071, 2981, 2921, 2838, 1639, 1614, 1583, 1464, 1446, 1429, 1365, 1248, 1046, 991, 935, 919, 895 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{16}H_{17}F+H]^+$: 229.1387, found: 229.1392.

Reference example 9: 1-fluoro-7-methylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulen-11-one

In a 3-necked round-bottomed flask equipped with magnetic stirring and argon atmosphere, a suspension of NaH (1.01 g, 60 % purity, 25.2 mmol) in anhydrous DMSO (50 mL) was heated at 75 ˚C over 45 min. The green suspension was cooled down to room temperature and methyltriphenylphosphonium iodide (10.61 g, 25.33 mmol) diluted in anhydrous DMSO (58 mL) and 1-fluoro-5,6,8,9-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (4.72 g, 20.3 mmol, from reference example 4) diluted in anhydrous DMSO (50 mL) were sequentially added. The resulting mixture was heated at 90 ˚C overnight. The reaction was cooled down and poured into water (80 mL). The aqueous layer was extracted with hexane (5 x 80 mL). The combined organic extracts were dried over anh. Na_2SO_4, filtered and concentrated under vacuum. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) afforded 1-fluoro-7-methylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulen-11-one (2.16, 55% yield).

mp 96 °C. IR (ATR): 2927, 2913, 2895, 1688, 1613, 1583, 1432, 1406, 1366, 1247, 1196, 1104, 1049, 1034, 1002, 970, 921, 911, 883, 819, 789, 749, 715, 657 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{15}H_{15}FO+H]^+$: 231.1180, found: 231.1180.

Reference example 10: 2-chloro-*N*-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

A suspension of 2-fluoro-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene (1.09 g, 4.77 mmol), chloroacetonitrile (1.2 mL, 19.1 mmol) and acetic acid (3.5 mL) was cooled to 0 ˚C and concentrated H_2SO_4 (1.53 mL, 28.6

mmol) was added dropwise (T < 10 ˚C). The mixture was allowed to reach room temperature and was stirred overnight. The suspension was added to ice (20 g) and after 10 min stirring, the suspension was extracted with DCM (3 x 15 mL). The combined organic layers were washed with NaOH 10 N (1 x 25 mL) and dried with anh. Na_2SO_4, filtered and concentrated under vacuum to obtain 2-chloro-*N*-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide as a white solid (1.2 g, 78% yield).

mp 141-144 °C. IR (NaCl disk): 3399, 3313, 3067, 2944, 2920, 2851, 1657, 1607, 1591, 1518, 1498, 1451, 1361, 1345, 1252, 1179, 1145, 966, 963, 863, 820 cm^{-1}. HRMS-ESI+ *m/z* $[M+H]^+$ calcd for $[C_{18}H_{21}ClFNO+H]^+$: 322.1368, found: 322.1370.

Reference example 11: 2-chloro-*N*-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

From 2-methoxy-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene (1.5 g, 6.24 mmol), and following the procedure described in reference example 10, 2-chloro-*N*-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide was obtained (1.18 g, 57% yield).

mp 144-145 °C. IR (NaCl disk): 3403, 3304, 3062, 2997, 2945, 2905, 2860, 2838, 1662, 1609, 1582, 1528, 1499, 1454, 1382, 1361, 1311, 1267, 1242, 1198, 1180, 1154, 1043, 1013, 955, 873 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{19}H_{24}ClNO_2+H]^+$: 334.1568, found: 334.1569.

Reference example 12: 2-chloro-*N*-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

From 2,3-dimethoxy-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene (498 mg, 1.84 mmol), and following the procedure described in reference example 10, 2-chloro-*N*-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide was obtained (501 mg, 75% yield).

mp 204-205 °C. IR (NaCl disk): 3306, 2941, 2907, 2861, 2838, 1666, 1605, 1516, 1467, 1452, 1415, 1381, 1361, 1345, 1293, 1252, 1231, 1191, 1168, 1092, 1021, 948, 861, 802 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{20}H_{26}ClNO_3+H]^+$: 364.1674, found: 364.1674.

Reference example 13: 2-chloro-*N*-(1-fluoro-9-hydroxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

A solution of 1-fluoro-7-methylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulen-11-one (2.06 g, 8.94 mmol), chloroacetonitrile (0.6 mL, 9.83 mmol) in DCM (21 mL)

was cooled to 0 ˚C and concentrated H_2SO_4 (0.75 mL) was added dropwise (T < 10 ˚C). The mixture was allowed to reach room temperature and was stirred overnight. The suspension was added to ice (20 g) and after 10 min stirring, the suspension was extracted with DCM (3 x 15 mL). The combined organic layers were washed with NaOH 10 N (1 x 25 mL) and dried with anh. Na_2SO_4, filtered and concentrated under vacuum. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave 2-chloro-*N*-(1-fluoro-9-hydroxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide as a white solid (921 mg, 32% yield).
mp 150 °C. IR (ATR): 3406, 3272, 3075, 2926, 2905, 2850, 1661, 1561, 1466, 1443, 1409, 1362, 1341, 1311, 1298, 1243, 1218, 1158, 1105, 1037, 991, 974, 891, 884, 791, 734, 679, 625 cm^{-1}. HRMS-ESI+ *m/z* $[M+H]^+$ calcd for $[C_{17}H_{19}ClFNO_2+H]^+$: 324.1161, found: 324.1162.

Reference example 14: 2-chloro-*N*-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

From 1-fluoro-7,11-dimethylene-6,7,8,9-tetrahydro-5*H*-5,9-propanobenzo[7]annulene (2.36 g, 10.36 mmol), and following the procedure described in reference example 10, 2-chloro-*N*-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide was obtained (2.28 g, 68% yield). The analytical sample was obtained by crystallization from DCM.
mp 154-155 °C. IR (NaCl disk): 3402, 3308, 3073, 2947, 2911, 2863, 2840, 1660, 1613, 1583, 1529, 1463, 1363, 1348, 1312, 1242, 1186, 1155, 979, 798, 748 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{18}H_{21}ClFNO+H]^+$: 322.1368, found: 322.1374.

Reference example 15: 2-chloro-*N*-(1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

A solution of 2-chloro-*N*-(1-fluoro-9-hydroxy-5,6,8,9,10,11-hexahydro-7H-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (611 mg, 1.89 mmol) in DCM (10 mL) was cooled to -30 °C with a dry ice in an acetone bath. Then DAST (2.8 mL, 1 M in DCM, 2.8 mmol) was added and the reaction mixture was stirred with the dry ice in an acetone bath overnight. To the resulting solution water (10 mL) was added and the pH adjusted to ~12 with NaOH 1 N. The two layers were separated, the aqueous phase was extracted further with DCM (2 x 8 mL), and the combined organic phases were dried over anh. Na2SO4, filtered and concentrated under vacuum. Crystallization from DCM/Pentane afforded 2-chloro-*N*-(1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (420 mg, 68% yield).

mp 180 °C. IR (ATR): 3276, 3075, 2964, 2940, 2901, 2858, 1671, 1650, 1552, 1463, 1442, 1360, 1317, 1282, 1242, 1175, 1143, 1104, 1066, 1018, 1004, 979, 929, 901, 887, 865, 799, 746, 737, 696, 662 cm^{-1}. HRMS-ESI+ *m/z* $[M+H]^+$ calcd for $[C_{17}H_{18}ClF_2NO+H]^+$: 326.1118, found: 326.1116.

Reference example 16: 2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

Thiourea (25 mg, 0.32 mmol) and glacial acetic acid (200 µL) were added to a solution of 2-chloro-*N*-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo [9]annulen-7-yl)acetamide (87 mg, 0.27 mmol) in absolute ethanol (5 mL) and the mixture was heated at reflux overnight. The resulting suspension was then tempered to room temperature, water (5 mL) was added and the pH adjusted to 12 with 5 N NaOH solution. EtOAc (5 mL) was added, the phases were separated and the aqueous phase was extracted with further EtOAc (2 x 5 mL). The combined organic layers were dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a light brown oil. Its hydrochloride was obtained by adding an excess of Et_2O/HCl to a solution of the amine in ethyl acetate, followed by filtration of the resulting beige precipitate affording 2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11 dimethanobenzo[9]annulen-7-amine hydrochloride (18 mg, 24% yield).

mp >300 °C (dec.). IR (KBr disk): 3200-2500 (2983, 2945, 2917, 2867), 2059, 1612, 1595, 1501, 1456, 1444, 1431, 1379, 1364, 1302, 1283, 1256, 1246, 1186, 1157, 1143, 1132, 1030, 1004, 962, 863, 814 cm^{-1}. Anal. Calcd for $C_{16}H_{20}FN\cdot$ 2.6 HCl: C 56.50, H 6.70, N 4.12. Found: C 56.18, H 6.40, N 4.01.

Reference example 17: 2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

From 2-chloro-*N*-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (1.10 g, 3.95 mmol), and following the procedure described in reference example 16, 2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride was obtained. The analytical sample was obtained by crystallization from DCM/Pentane (779 mg, 81 % yield).

mp >250 °C (dec.). IR (KBr disk): 3200-2500 (2985, 2942, 2908), 2056, 1735, 1609, 1582, 1499, 1449, 1379, 1364, 1334, 1305, 1268, 1252, 1205, 1170, 1132, 1103, 1040, 1001, 954, 869, 849, 815, 756, 692 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{17}H_{23}NO+H]^+$: 258.1852, found: 258.1862.

Reference example 18: 2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

From 2-chloro-*N*-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (436 mg, 1.2 mmol), and following the procedure described in reference example 16, 2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride was obtained (285 mg, 73% yield).

mp >200 °C (dec.). IR (KBr disk): 3200-2500 (2993, 2918, 2831), 2047, 1701, 1606, 1517, 1451, 1416, 1386, 1365, 1327, 1310, 1291, 1252, 1237, 1192, 1174, 1131, 1098, 1031, 973, 950, 863, 798, 586, 543 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{18}H_{25}NO_2+H]^+$: 288.1958, found: 288.1954.

Reference example 19: 1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

From 2-chloro-*N*-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (1 g, 3.11 mmol), and following the procedure described in reference example 16, 1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride was obtained. The analytical sample was obtained by crystallization from Methanol (521 mg, 59 % yield).

mp >200 °C (dec.). IR (KBr disk): 3200-2500 (2945, 2717), 2060, 1677, 1608, 1584, 1511, 1464, 1390, 1380, 1366, 1317, 1303, 1248, 1214, 1199, 1165, 1132, 1071, 1052, 1032, 1000, 977, 946, 885, 877, 854, 798, 747, 623 cm^{-1}. HRMS-ESI+ m/z [M+H]+ calcd for $[C_{16}H_{20}FN+H]^+$: 246.1653, found: 246.1649.

Reference example 20: 2-chloro-*N*-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

To a cold (0˚C) solution of known 2-chloro-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (*Bioorg Med Chem.* 2012, 20, 942) (3 g, 9.87 mmol) in acetic anhydride (10.5 mL) were carefully added glacial acetic acid (1.6 mL) and fuming nitric acid (1.85 mL). The mixture was allowed to reach room temperature and left stirring overnight. The obtained yellow solution was then poured to ice–water (20 mL), and extracted with DCM (3 x 40 mL). The combined organic extracts were washed with aqueous 2 N NaOH (1 x 40 mL), water (1 x 40 mL) and brine (1 x 40 mL). The organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow residue. Purification by column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave 2-chloro-*N*-(9-methyl-2-

nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (2.92 g, 85% yield) as a white solid.

mp 174 °C. IR (KBr disk): 3403, 3288, 3077, 2946, 2922, 2847, 1667, 1607, 1588, 1520, 1456, 1409, 1348, 1229, 1166, 1136, 1082, 1051, 1009, 972, 945, 896, 865, 841, 797, 740, 764, 704, 666 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{18}H_{21}ClN_2O_3+H]^+$: 349.1313, found: 349.1313.

Reference example 21: 9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

From 2-chloro-*N*-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (677 mg, 1.94 mmol) and following the procedure described in reference example 16, 9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride was obtained (443 mg, 74% yield).

mp >225 °C (dec.). IR (KBr disk): 3200-2500 (2928, 2641, 2603, 2535), 2066, 1648, 1612, 1591, 1522, 1487, 1458, 1352, 1304, 1286, 1256, 1221, 1181, 1134, 1088, 1031, 955, 946, 895, 884, 865, 836, 799, 766 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{16}H_{20}N_2O_2+H]^+$: 273.1598, found: 273.1604.

Reference example 22: 1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

From 2-chloro-*N*-(1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (382 mg, 1.17 mmol), and following the procedure described in reference example 16, 1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride was obtained (218 mg, 65 % yield). The analytical sample was obtained by crystallization from methanol.

mp >200 °C (dec.). IR (ATR): 2980-2831 (2950, 2911, 2867), 2703, 2676, 2559, 2063, 1611, 1588, 1509, 1465, 1445, 1363, 1321, 1246, 1194, 1105, 1095, 1008, 1002, 988, 967, 903, 888, 860, 801, 743, 673 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{15}H_{17}F_2N+H]^+$: 250.1402, found: 250.1401.

Reference example 23: 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulene-2,7-diamine dihydrochloride.

To a solution of amine 9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine (201 mg, 0.738 mmol) in methanol (25 mL), Pd on charcoal (68.6 mg, cat. 10% Pd) was added and the resulting suspension was hydrogenated at 1 atm of H_2 at room temperature for 48 h. The black suspension was

filtered and the solvent removed by concentration under vacuum to give 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulene-2,7-diamine as a brown solid (130 mg, 89% yield). Its dihydrochloride was obtained by addition of an excess of Et_2O/HCl to a solution of the diamine in methanol followed by filtration of the resulting brown precipitate.

mp 294-295 °C. IR (KBr disk): 3200-2500 (3024, 2912, 2847, 2588), 1994, 1598, 1502, 1454, 1381, 1365, 1303, 1261, 1173, 1131, 1021, 957, 877, 827, 576, 473 cm^{-1}. Anal. Calcd. for $C_{16}H_{22}N_2 \cdot 3.4$ HCl: C 52.46, H 6.99, N 7.65. Found C 52.64, H 7.18, N 7.43.

Reference example 24: 2-chloro-*N*-(2-hydroxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

To a solution of *N*-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-chloroacetamide (999 mg, 3.10 mmol) in H_2O (5 mL) and conc. HCl (5 mL), at 0 °C, was added dropwise a solution of sodium nitrite (427 mg, 6.21 mmol) in H_2O (2 mL). To the resulting solution was added CuCl (652 mg, 6.56 mmol) in conc. HCl (3 mL) and over 10 min gas evolution was observed. The resulting solution was warmed to 60 °C for 90 minutes, then was cooled to room temperature, diluted in H_2O (60 mL) and extracted with DCM (4 x 90 mL). The combined organic extracts were washed with sat. $NaHCO_3$ and brine, were dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a dark green solid. Purification by column chromatography (SiO_2, Hexane/Ethyl Acetate mixture) gave the 2-chloro-*N*-(2-hydroxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (78 mg, 9% yield) as a white solid.

mp 98-100 °C. IR (NaCl disk): 3300-2700 (3266, 3186, 3118, 2966, 2942, 2916, 2861), 2175, 1590, 1568, 1504, 1451, 1426, 1376, 1356, 1309, 1267, 1161, 1130, 1081, 1058, 827, 804 cm^{-1}. HRMS-ESI- m/z $[M-H]^-$ calcd for $[C_{18}H_{22}ClNO_2-H]^-$: 318.1266, found: 318.1272.

Reference example 25: 2-hydroxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

From 2-chloro-*N*-(2-hydroxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (72 mg, 0.23 mmol), and following the procedure described in reference example 16, 2-hydroxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride was obtained (42 mg, 67% yield). The analytical sample was obtained by crystallization from Methanol/Diethyl ether.

mp 183-185 °C. Anal. Calcd for $C_{16}H_{21}NO{\cdot}1.7HCl{\cdot}1H_2O$: C 59.43, H 7.70, N 4.33. Found C 59.63, H 7.44, N 4.77.

Reference example 26: *N*-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

To a cold (0 ˚C) solution of known (*Tetrahedron Lett.* 1987, 28, 1585-1588) *N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (2.68 g, 9.93 mmol) in acetic anhydride (10.6 mL) were carefully added glacial acetic acid (1.6 mL) and fuming nitric acid (1.86 mL). The mixture was allowed to reach room temperature and left stirring overnight. The obtained yellow solution was then poured to ice–water (20 mL), and extracted with DCM (3 x 40 mL). The combined organic extracts were washed with aqueous 2 N NaOH (1 x 40 mL), water (1 x 40 mL) and brine (1 x 40 mL). The organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow residue. Purification by column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave *N*-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (1.88 g, 60% yield) as a white solid.

mp 174-176 °C. IR (NaCl disk): 3398, 3301, 3201, 3063, 2943, 2917, 2863, 1653, 1588, 1523, 1455, 1346, 1322, 1304, 1268, 1245, 1217, 1166, 1141, 1124, 1081, 1037, 1010, 945, 893, 865, 838, 798, 763, 740, 701 cm^{-1}. HRMS-ESI+ m/z [M+H]+ calcd for $[C_{18}H_{22}N_2O_3+H]^+$: 315.1703, found: 315.1714.

Reference example 27: *N*-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

From *N*-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (2.64 g, 8.41 mmol), PtO_2 (258 mg) in absolute EtOH and following the procedure described in the reference example 23, *N*-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (1.9 g, 80% yield) was obtained after purification by column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures).

mp 112-113 °C. IR (NaCl disk): 3432, 3324, 3224, 3056, 3004, 2938, 2903, 2856, 2835, 1651, 1618, 1546, 1507, 1447, 1362, 1344, 1300, 1262, 1194, 1164, 1136, 1065, 862, 735, 701 cm^{-1}. HRMS-ESI+ m/z [M+H]+ calcd for $[C_{18}H_{24}N_2O+H]^+$: 285.1961, found: 285.1972.

Reference example 28: *N*-(2-chloro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

From *N*-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide hydrochloride (1.04 g, 3.25 mmol) in H_2O (6 mL) and conc. HCl (6 mL), sodium nitrite (448 mg, 6.5 mmol) in H_2O (2 mL), CuCl (691 mg, 6.99 mmol) dissolved in conc. HCl solution (3 mL), and following the procedure described in reference example 24, *N*-(2-chloro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide was obtained (210 mg, 21% yield).

mp 190-191 °C. IR (NaCl disk): 3301, 3196, 3071, 2921, 2855, 1651, 1594, 1549, 1487, 1454, 1414, 1364, 1343, 1308, 1281, 1263, 1211, 1139, 1109, 1012, 950, 875, 820 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{18}H_{22}ClNO+H]^+$: 304.1463, found: 304.1460.

Reference example 29: 2-chloro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride.

A mixture of *N*-(2-chloro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (190 mg, 0.63 mmol), conc. HCl (4 mL), H_2O (8 mL) and isopropanol (6 mL) was stirred under reflux for 4 days. The solution was cooled down and isopropanol was concentrated under vacuum. The aqueous phase was extracted with EtOAc (3 x 8 mL) and then was basified with a solution of 5 N NaOH. The base aqueous solution was extracted with further EtOAc (3 x 10 mL), dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow oil. Purification by column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave 2-chloro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine. Its hydrochloride was obtained by adding an excess of Et_2O/HCl to a solution of the amine in EtOAc (10 mg, 5.5% yield).

mp > 250 °C. IR (KBr disk): 3200-2500 (2990, 2950, 2916, 2861), 2058, 1597, 1570, 1509, 1488, 1454, 1416, 1380, 1365, 1302, 1217, 1155, 1133, 1093, 1032, 1000, 948, 875, 820, 771, 673 cm^{-1}. Anal. Calcd for $C_{16}H_{20}ClN{\cdot}1.35$ HCl: C 61.79, H 6.95, N 4.50. Found C 61.70, H 6.78, N 4.93.

Reference example 30: 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-yl methanesulfonate.

To a solution of 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-ol (1.19 g, 5.97 mmol) in pyridine (9 mL), (prepared as reported in *Liebigs Ann Chem.* 1973; 1839-1850), mesyl chloride (2.32 mL, 29.28 mmol) was added slowly with stirring at room temperature. The mixture was then heated at 120 ˚C for 5 h. After cooling, crushed ice (100 g) was added and the mixture was extracted with DCM (5 x 40 mL). The combined organic phase was washed with 2 N HCl (2 x 40 mL), H_2O (2 x 40 mL),

saturated aqueous $NaHCO_3$ (2 x 40 mL), and dried over anh. Na_2SO_4. After filtration and removal of the solvent under reduced pressure, 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-yl methanesulfonate (1.32 g, 80% yield) was isolated as a dark oil that was used in the next step without further purification.

5 IR (NaCl disk): 3060, 3010, 2934, 2857, 1488, 1451, 1341, 1232, 1175, 1145, 1102, 1046, 1012, 992, 966, 923, 853, 800, 753 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{15}H_{18}O_3S+NH_4]^+$: 296.1315, found: 296.1318.

Reference example 31: 7-iodo-5,6,7,8,9,10-hexahydro-5,8:7,10-dimethanobenzo[8]
10 **annulene.**

A mixture of H_3PO_4 (99%, 135 g), 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-yl methanesulfonate (1.32 g, 4.75 mmol) and NaI (63 g, 420 mmol) were stirred at 150 ˚C for 6 h. After cooling, H_2O (150 mL) was added slowly to the mixture. The resulting purple solution was extracted with DCM (4 x 80 mL)
15 and the combined organic phase was washed with 10% aqueous sodium thiosulfate (1 x 100 mL), dried over anh. Na_2SO_4 and the solvent was removed under vacuum to obtain 7-iodo-5,6,7,8,9,10-hexahydro-5,8:7,10-dimethanobenzo[8]annulene as a white solid (1.39 g, 95 %).

mp 132-133 °C. IR (NaCl disk) 3052, 3013, 2950, 2892, 2852, 1490, 1447, 1304, 1278,
20 1232, 1215, 1095, 1046, 1032, 967, 830, 778, 755 cm^{-1}. GC-MS (EI): 310 $[(M)^{\cdot+}$, 2], 183 $[(M-I)^+$, 100], 141 (73), 129 (23), 128 (15).

Reference example 32: 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulene-7(6*H*)-carboxylic acid.

25 To a solution of 7-iodo-5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulene (2.03 g, 6.5 mmol) in dry and degassed toluene (20 mL) was added methyl oxalyl chloride (2.39 g, 19.5 mmol) and bis(tributyltin) (4.5 g, 7.8 mmol). The mixture was irradiated in a quartz reactor under argon atmosphere with a 125 W Hg lamp for 20 h. Then, DCM (15 mL), methanol (0.6 mL) and triethylamine (1.2 mL) were successively added to the
30 reaction mixture at 0° C and was concentrated under vacuum to give a dark oil (3.99 g). A solution of this oil in a 40% methanol solution of KOH (50 mL) was heated to reflux for 2 h. Water (50 mL) was added and the reaction was refluxed for 3 h. The reaction mixture was allowed to cool down to room temperature and the methanol was removed under vacuum. Water (40 mL) was added to the residue and the aqueous
35 layer was washed with DCM (4 x 50 mL). After that, the aqueous phase was acidified with conc. HCl until pH=1 and extracted with DCM (4 x 50 mL). The organic extracts were dried over anh. Na_2SO_4, filtered and concentrated under reduced pressure to give

5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulene-7(6*H*)-carboxylic acid as a brown solid (555 mg, 37% overall yield). An analytical sample of the acid was obtained by crystallization from DCM/Pentane.

mp 188-189 °C. IR (NaCl disk): 3300-2800 (3065, 3011, 2946, 2858), 1690, 1488, 1450, 1410, 1318, 1290, 1231, 1218, 1092, 1052, 1038, 941 cm^{-1}. HRMS-ESI- m/z $[M-H]^-$ calcd for $[C_{15}H_{16}O_2-H]^-$: 227.1078, found: 227.1078.

Reference example 33: 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6H)-amine hydrochloride.

To a solution of 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulene-7(6*H*)-carboxylic acid (90 mg, 0.39 mmol) in toluene (1.2 mL), Et_3N (73 µL, 0.53 mmol) and diphenylphosphoryl azide (159 mg, 0.58 mmol) were added and heated at reflux for 3 h. The mixture was cooled down and washed with 1 N HCl (10 X 2 mL). Thereafter, to the organic layer was added 6 N HCl (1.6 mL) and the suspension was heated at reflux for 24 h. The reaction mixture was then cooled to room temperature and the two phases were separated. The aqueous phase was extracted with ethyl acetate (3 x 3 mL). The combined organic phases were washed with 5 N NaOH (3 x 10 mL), dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-amine. Its hydrochloride was obtained by adding an excess of HCl in methanol to a solution of the amine in methanol. The methanol was removed under reduced pressure to give 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6H)-amine hydrochloride as a brown solid (35 mg, 45% yield). An analytical sample was obtained by crystallization from Methanol/Diethyl ether.

mp > 250 °C (dec). IR (KBr disk): 3100-2500 (2943, 2881), 2043, 1622, 1598, 1501, 1448, 1336, 1246, 1089, 1057, 1028, 952, 769, 749, 614 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{14}H_{17}N+H]^+$: 200.1434, found: 200.1432.

Example 34: *p*-tolyl (9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)carbamate.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9] annulen-7-amine hydrochloride (250 mg, 0.95 mmol) in DCM (2 mL), *p*-tolyl chloroformate (194 mg, 1.14 mmol) and Et_3N (287 mg, 2.84 mmol) were added. The reaction mixture was stirred at room temperature overnight and then the solvent was evaporated under vacuum. The residue was dissolved in EtOAc (30 mL) and water (20 mL) and phases were separated. The aqueous phase was extracted with further EtOAc (2 x 30 mL). The combined organic phases were dried over anh. Na_2SO_4, filtered and

concentrated under vacuum to obtain 300 mg of a yellow gum. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave *p*-tolyl (9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)carbamate (46 mg, 14% yield) as a white solid.

mp 114-115 °C. IR (NaCl disk): 3330, 3018, 2944, 2919, 2854, 1744, 1591, 1531, 1502, 1452, 1379, 1362, 1345, 1255, 1214, 1198, 1167, 1137, 1069, 1042, 1014, 987, 948, 900, 825, 757 cm^{-1}. Anal. Calcd for $C_{24}H_{27}NO_2 \cdot 0.3\ C_5H_{12} \cdot 0.05\ CH_2Cl_2$: C 79.22, H 7.99, N 3.62. Found: C 79.23, H 7.88, N 3.45.

Example 35: 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(4-(trifluoromethyl)phenyl)thiourea.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (250 mg, 0.95 mmol) in DCM (2 mL), 1-isothiocyanato-4-(trifluoromethyl)benzene (193 mg, 0.95 mmol) and Et_3N (287 mg, 2.84 mmol) were added. The reaction mixture was stirred at room temperature overnight and then the solvent was evaporated under vacuum. The residue was dissolved in EtOAc (30 mL) and water (20 mL) and phases were separated. The aqueous phase was extracted with further EtOAc (2 x 30 mL). The combined organic phases were dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain 369 mg of a yellow solid. The product was washed with Et_2O to obtain 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(4-(trifluoromethyl)phenyl)thiourea (188 mg, 46% yield) as a white solid.

mp 158-159°C. IR (NaCl disk): 3283, 2911, 2834, 1615, 1532, 1493, 1454, 1422, 1324, 120, 1166, 1124, 1067, 1015, 948, 909, 837, 759, 732, 697, 665 cm^{-1}. Anal. Calcd for $C_{24}H_{25}F_3N_2S$: C 66.96, H 5.85, N 6.51. Found: C 66.79, H 5.95, N 6.37.

Example 36: 1-(1-acetylpiperidin-4-yl)-3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[e]oxonin-3(2*H*)-yl)urea.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (180 mg, 0.69 mmol) in DCM (3 mL) and saturated aqueous $NaHCO_3$ solution (2 mL), triphosgene (102 mg, 0.34 mmol) was added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic one was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of isocyanate in DCM. To this solution were added 1-(4-aminopiperidin-1-yl)ethan-1-one hydrochloride (122 mg, 0.68 mmol) and Et_3N (139 mg, 1.37 mmol). The mixture was stirred overnight at room temperature, diluted with further DCM (10 mL) and washed with 2N NaOH

solution (2 x 10 mL). The organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a yellow residue (206 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)urea as a white solid (135 mg, 49% yield). The analytical sample was obtained by crystallization from hot EtOAc (112 mg).

mp 208-209 °C. IR (NaCl disk): 3357, 3054, 3012, 2969, 2926, 2853, 1646, 1611, 1546, 1492, 1450, 1358, 1324, 1268, 1222, 1156, 1101, 1088, 1035, 1212, 991, 947, 918, 900, 866, 829, 760, 733, 699 cm^{-1}. Anal. Calcd for $C_{23}H_{31}N_3O_3$: C 69.49, H 7.86, N 10.57. Found: C 69.47, H 7.92, N 10.38.

Example 37: 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethano-benzo[*e*]oxonin-3(2*H*)-yl)urea.

To a solution of 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (300 mg, 1.19 mmol) in DCM (7 mL) and saturated aqueous $NaHCO_3$ solution (7 mL), triphosgene (130 mg, 0.44 mmol) was added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic one was washed with brine (10 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of isocyanate in DCM. To this solution were added 1-(4-aminopiperidin-1-yl)ethan-1-one hydrochloride (203 mg, 1.43 mmol) and Et_3N (292 mg, 2.88 mmol). The mixture was stirred overnight at room temperature, diluted with further DCM (10 mL) and washed with 2N NaOH solution (2 x 10 mL). The organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a yellow residue (400 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)urea as a white solid (50 mg, 49% yield).

mp 200-202 °C. IR (NaCl disk): 3347, 3065, 3016, 2922, 1645, 1624, 1548, 1492, 1451, 1436, 1362, 1323, 1268, 1230, 1211, 1196, 1109, 1073, 1022, 980, 967 cm^{-1}.HRMS-ESI+ *m/z* $[M+H]^+$ calcd for $[C_{22}H_{29}N_3O_3+H]^+$: 384.2282, found: 384.2285.

Example 38: 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (180 mg, 0.69 mmol) in DCM (3 mL) and saturated aqueous $NaHCO_3$ solution (2 mL), triphosgene (102 mg, 0.34 mmol) was added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were

separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution were added 1-(4-aminopiperidin-1-yl)ethan-1-one hydrochloride (122 mg, 0.68 mmol) and Et_3N (138 mg, 1.36 mmol). The mixture was stirred overnight at room temperature, diluted with further DCM (10 mL) and washed with 2N NaOH solution (2 x 10 mL). Organics were dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a yellow oil (232 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea as a white solid (143 mg, 53% yield). The analytical sample was obtained by crystallization from hot EtOAc (113 mg).

mp 206-207 °C. IR (NaCl disk): 3359, 3065, 3016, 2938, 2906, 2860, 1644, 1620, 1555, 1493, 1452, 1360, 1344, 1319, 1267, 1228, 1212, 1136, 1090, 1049 cm^{-1}. Anal. Calcd for $C_{24}H_{33}N_3O_2$·0.21 Ethyl Acetate: C 71.91, H 8.45, N 10.06. Found: C 71.73, H 8.43, N 10.27.

Example 39: 1-(1-acetylpiperidin-4-yl)-3-(9-hydroxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 1-(4-aminopiperidin-1-yl)ethan-1-one (192 mg, 1.35 mmol) in DCM (4 mL) and saturated aqueous $NaHCO_3$ solution (3 mL) triphosgene (200 mg, 0.68 mmol) was added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic one was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 9-amino-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-ol hydrochloride (300 mg, 1.14 mmol) followed by Et_3N (228 mg, 2.25 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum. Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-(isopropylsulfonyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (19 mg, 4.2% yield) as a grey solid.

mp 222-223 °C. IR (NaCl disk): 3313, 2921, 2852, 1733, 1716, 1646, 1621, 1557, 1542, 1506, 1490, 1472, 1455, 1358, 1336, 1318, 1300, 1265, 1231, 1204, 1134, 1104, 1053 cm^{-1}. Anal. Calcd for $C_{23}H_{31}N_3O_3$·0.2 C_5H_{12} · 0.9 H_2O: C 67.33, H 8.29, N 9.81. Found: C 67.25, H 8.15, N 9.72

Example 40: 1-(1-acetylpiperidin-4-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-methoxy-5,6,8,9,10,11-hexahydro-7H-5,9:7,11-dimethano-benzo[9]annulen-7-amine (300 mg, 1.23 mmol) in DCM (4.5 mL) and saturated aqueous $NaHCO_3$ solution (3 mL) triphosgene (183 mg, 0.61 mmol) was added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and organics were washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (210 mg, 1.47 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a white gum (521 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (148 mg, 30% yield) as a white solid. The analytical sample was obtained by crystallization from hot EtOAc (119 mg).

mp 212-213 °C. IR (NaCl disk): 3358, 2930, 2847, 1646, 1617, 1555, 1495, 1451, 1356, 1319, 1266, 1228, 1094, 1075, 972, 849, 755, 735 cm^{-1}. Anal. Calcd for $C_{24}H_{33}N_3O_3$·0.15 EtOAc: C 69.56, H 8.12, N 9.89. Found: C 69.63, H 8.28, N 8.86

Example 41: 1-(1-acetylpiperidin-4-yl)-3-(9-fluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-fluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9] annulen-7-amine (143 mg, 0.53 mmol) in DCM (4 mL) and saturated aqueous $NaHCO_3$ solution (2 mL) was added triphosgene (78 mg, 0.26 mmol). The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (90 mg, 0.63 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellow gum (259 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(9-fluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (180 mg, 85% yield). The analytical sample was obtained by crystallization from hot DCM (57 mg).

mp 228-229 °C. IR (NaCl disk): 3357, 2927, 2856, 1643, 1618, 1553, 1494, 1451, 1358, 1340, 1316, 1267, 1227, 1207, 1134, 1097, 1042, 1004 cm^{-1}. Anal. Calcd for $C_{23}H_{30}FN_3O_2$·0.15 C_5H_{12} · 0.62 H_2O: C 67.59, H 7.91, N 9.96. Found: C 67.61, H 7.93, N 8.94.

Example 42: 1-(1-acetylpiperidin-4-yl)-3-(9-chloro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-chloro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9] annulen-7-amine hydrochloride (150 mg, 0.53 mmol) in DCM (3 mL) saturated aqueous $NaHCO_3$ solution (3 mL) and triphosgene (58 mg, 0.20 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (90 mg, 0.63 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a white solid (204 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(9-chloro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (115 mg, 55% yield) as a white solid.

mp 209-210 °C. IR (NaCl disk): 3358, 3019, 2926, 2855, 1644, 1619, 1556, 1494, 1452, 1358, 1319, 1301, 1268, 1228, 1206, 1135, 1090, 1050, 991, 969, 947, 802, 761, 735 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{23}H_{30}ClN_3O_2+H]^+$: 416.2099, found: 416.2100.

Example 43: 4-(((1r,4r)-4-(3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[e]oxonin-3(2*H*)-yl)ureido)cyclohexyl)oxy)benzoic acid.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (200 mg, 0.76 mmol) in DCM (3.5 mL) and saturated aqueous $NaHCO_3$ solution (2.2 mL) was added triphosgene (113 mg, 0.38 mmol). The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of isocyanate in DCM. To this solution were added 4-(((1r,4r)-4-aminocyclohexyl)oxy)benzoic acid hydrochloride (206 mg, 0.76 mmol) and Et_3N (153 mg, 1.52 mmol). The mixture was stirred overnight at room temperature. The resulting suspension was evaporated to obtain a white solid, which was suspended in DCM (20 mL) and washed with 2N HCl solution (2 x 10 mL). The resulting organic suspension was filtered to afford a white solid (200 mg, 54% yield).

mp: 220-222 °C. IR (NaCl disk): 3352, 2626, 1678, 1601, 1558, 1506, 1454, 1373, 1343, 1312, 1288, 1247, 1221, 1161, 1104, 1029, 997, 953, 776 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{29}H_{34}N_2O_5+H]^+$: 491.254, found: 491.254.

Example 44: 4-(((1r,4r)-4-(3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)ureido)cyclohexyl)oxy)benzoic acid.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (180 mg, 0.69 mmol) in DCM (3 mL) and saturated aqueous $NaHCO_3$ solution (2 mL) was added triphosgene (102 mg, 0.34 mmol). The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of isocyanate in DCM. To this solution were added 4-(((1r,4r)-4-aminocyclohexyl)oxy)benzoic acid hydrochloride (206 mg, 0.76 mmol) and Et_3N (153 mg, 1.52 mmol). The mixture was stirred overnight at room temperature. The resulting suspension was evaporated and the residue was suspended in DCM (20 mL) and washed with 2N HCl solution (2 x 10 mL). The resulting organic suspension was filtered and the filtrate was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a white gum. Crystallization from hot EtOAc provided 4-(((1r,4r)-4-(3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)ureido)cyclohexyl)oxy)benzoic acid as a white solid (55 mg, 16% yield).

mp 182-183 °C. IR (NaCl disk): 3335, 2921, 2855, 1692, 1681, 1642, 1632, 1602, 1564, 1537, 1504, 1494, 1469, 1453, 1419, 1360, 1307, 1248, 1163, 1122, 1096, 1969 cm^{-1}. Anal. Calcd for $C_{30}H_{36}N_2O_4 \cdot 1,5\ H_2O$: C 69.88, H 7.62, N 5.43. Found: C 69.53, H 7.37, N 5.10.

Reference example 45: *tert*-butyl [1-(isopropylsulfonyl)piperidin-4-yl] carbamate.

To a solution of *tert*-butyl (piperidin-4-yl)carbamate (850 mg, 4.24 mmol) in DCM (7 mL) was added Et_3N (858 mg, 8.48 mmol). The mixture was cooled down to 0 °C with an ice bath and then propane-2-sulfonyl chloride (725 mg, 5.09 mmol) was added dropwise. The reaction mixture was stirred at room temperature overnight. The suspension was washed with 2N NaOH solution (2 x 5 mL) and the organic phase was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain *tert*-butyl [1-(isopropylsulfonyl)piperidin-4-yl] carbamate (1.15 g, 89% yield).

Reference example 46: 1-(isopropylsulfonyl)piperidin-4-amine.

To a solution of *tert*-butyl (1-(isopropylsulfonyl)piperidin-4-yl)carbamate (1.15 g, 3.75 mmol) in dissolved in DCM (5 mL) and 4 M HCl in 1,4-dioxane (2 mL) was added. The mixture was stirred at room temperature for 2 days and the solvents were evaporated under vacuum. The residue was then dissolved in DCM (5 mL) and washed with 5N NaOH solution (5 mL). The organic layer was dried over anh. Na_2SO_4, filtered and

concentrated under vacuum to give 1-(isopropylsulfonyl)piperidin-4-amine (704 mg, 91% yield) as a yellow oil.

Example 47: 1-[1-(isopropylsulfonyl)piperidin-4-yl]-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (300 mg, 1.13 mmol) in DCM (6 mL) and saturated aqueous $NaHCO_3$ solution (4 mL) was added triphosgene (169 mg, 0.57 mmol). The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM.

To a solution of 1-(isopropylsulfonyl)piperidin-4-amine (233 mg, 1.13 mmol) in anh. THF (5 mL) under argon atmosphere at -78 °C, was added dropwise a solution of *n*-butyllithium (2.5 M in hexanes, 0.59 mL, 1.47 mmol) during 20 minutes. After the addition, the mixture was tempered to 0 °C using an ice bath. This solution was added carefully to the solution of the isocyanate from the previous step cooled to 0 °C, under argon atmosphere. The reaction mixture was stirred at room temperature overnight. Methanol (2 mL) was then added to quench any unreacted *n*-butyllithium. The solvents were evaporated under vacuum to give an orange gum (506 mg). This residue was dissolved in EtOAc (10 mL) and washed with 2N HCl solution (2 x 5 mL) and the organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a white gum (241 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave a white solid. Crystallization from hot DCM/Pentane provided pure 1-(1-(isopropylsulfonyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (66 mg, 13% yield) as a white solid.

mp 218-219 °C. IR (NaCl disk): 3364, 3061, 3012, 2945, 2919, 2853, 1709, 1638, 1553, 1493, 1453, 1360, 1319, 1305, 1265, 1248, 1232, 1133, 1091, 1045, 943, 880, 841, 759, 732, 665, 592, 555 cm^{-1}. Anal. Calcd for $C_{25}H_{37}N_3O_3S$: C 65.33, H 8.11, N 9.14. Found: C 65.41, H 8.31, N 8.93

Example 48: 1-(1-benzylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine hydrochloride (250 mg, 0.95 mmol) in DCM (4.5 mL) and saturated aqueous $NaHCO_3$ solution (3 mL) was added triphosgene (140 mg, 0.47 mmol). The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were

separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (216 mg, 1.13 mmol). The reaction mixture was stirred at room temperature for 24 h and the solvent was evaporated under vacuum to obtain a yellow gum. Column chromatography (SiO_2, DCM/Methanol mixtures) gave the title compound as a white solid (159 mg, 36% yield).

mp 106-107 °C. IR (NaCl disk): 3318, 3058, 3025, 2945, 2918, 2838, 2792, 2761, 1632, 1559, 1493, 1453, 1361, 1343, 1321, 1302, 1281, 1234, 1209, 1136, 1120, 1066, 1028, 909, 757, 733, 698 cm^{-1}. Anal. Calcd for $C_{29}H_{37}N_3O \cdot 0.5$ Methanol: C 77.09, H 8.55, N 9.14. Found: C 77.19, H 8.36, N 8.98.

Reference example 49: *N*-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-chloroacetamide.

To a solution of 2-chloro-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide (2.0 g, 6.58 mmol) in DCM (50 mL) was added acetyl chloride (5.16 g, 65.8 mmol). Then, the mixture was treated with $AlCl_3$ (4.38 g, 32.9 mmol) and the resulting orange mixture was stirred for 1 h at room temperature. The solution was poured over ice (50 g) and saturated aqueous $NaHCO_3$ solution (40 mL) was added. After stirring 20 min, the mixture was extracted with DCM (3 x 50 mL) and the combined organic phases were dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a green gum (1.85 g). Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave *N*-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-chloroacetamide (1.27 g, 56% yield) as a yellowish solid.

Reference example 50: 1-(7-amino-9-methyl-6,7,8,9,10,11-hexahydro-5*H*-5,9:7,11-dimethanobenzo[9]annulen-2-yl)ethan-1-one hydrochloride.

A mixture of *N*-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-chloroacetamide (1.18 g, 3.43 mmol), thiourea (313 mg, 4.12 mmol), acetic acid (1.3 mL) and ethanol (6 mL) was stirred at reflux overnight. The mixture was tempered to room temperature and water (40 mL) and 10N NaOH solution (14 mL) were added. The mixture was extracted with EtOAc (3 x 50 mL) and the combined organic extracts were dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a yellow residue (980 mg) which was dissolved in EtOAc (5 mL) and an excess of HCl/Et_2O was added. The resulting suspension was filtrated obtaining a beige solid. This product was dissolved in DCM (50 mL) and washed with

5N NaOH solution (40 mL). The organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to obtain a yellow residue which was dissolved in EtOAc (5 mL) and an excess of HCl/Et_2O was added. The resulting suspension was filtered obtaining 1-(7-amino-9-methyl-6,7,8,9,10,11-hexahydro-5*H*-5,9:7,11-dimethanobenzo[9]annulen-2-yl)ethan-1-one as its hydrochloride (758 mg, 73% yield) as a beige solid.

Example 51: 1-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-acetylpiperidin-4-yl)urea.

To a solution of 1-(7-amino-9-methyl-6,7,8,9,10,11-hexahydro-5*H*-5,9:7,11-dimethanobenzo[9]annulen-2-yl)ethan-1-one hydrochloride (300 mg, 0.98 mmol) in DCM (5 mL) and saturated aqueous $NaHCO_3$ solution (3.52 mL) was added triphosgene (145 mg, 0.49 mmol). The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (167 mg, 1.17 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellow gum (483 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-acetylpiperidin-4-yl)urea (324 mg, 76% yield).

mp 144-145 °C. IR (NaCl disk): 3363, 3005, 2918, 2861, 2239, 1679, 1619, 1552, 1453, 1426, 1361, 1320, 1272, 1229, 1203, 1137, 1106, 1057, 973, 950, 917, 830, 731, 645 cm^{-1}. Anal. Calcd for $C_{26}H_{35}N_3O_3 \cdot 0.15\ C_5H_{12} \cdot 0.6\ C_3H_6O$: C 70.96, H 8.43, N 8.70. Found: C 70.83, H 8.60, N 8.88

Example 52: 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (600 mg, 1.94 mmol) in DCM (10 mL) saturated aqueous $NaHCO_3$ solution (10 mL) and triphosgene (213 mg, 0.718 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (331 mg, 2.33 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a

brown solid (840 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (640 mg, 75% yield) as a yellowish solid.
mp 155-156 °C. IR (NaCl disk): 3360, 2918, 2237, 1619, 1552, 1522, 1454, 1345, 1322, 1266, 1230, 1164, 1137, 1081, 974, 949, 911, 865, 838, 798, 761, 731, 644 cm^{-1}.
Anal. Calcd for $C_{24}H_{32}N_4O_4$: C 65.43, H 7.32, N 12.72. Found: C 65.22, H 7.45, N 12.56.

Example 53: 1-(1-acetylpiperidin-4-yl)-3-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (260 mg, 0.59 mmol) in EtOH (17 ml) was added PtO_2 (20 mg). The mixture was hydrogenated at room temperature and atmospheric pressure for 8 days. The resulting suspension was filtered and the filtrate was evaporated under vacuum to obtain a dark brown solid (223 mg), which was dissolved in DCM (10 mL). To this solution, Et_2O was added and a white solid precipitated (140 mg) . Column chromatography (SiO_2, DCM/Methanol mixtures) gave a white solid (82 mg, 34% yield).
mp 150-151 °C. IR (NaCl disk): 3344, 3006, 2905, 2853, 1614, 1556, 1505, 1454, 1360, 1344, 1320, 1303, 1266, 1229, 1194, 1162, 1136, 1060, 974, 868, 820, 734 cm^{-1}.
HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{24}H_{34}N_4O_2+H]^+$: 411.2755, found: 411.2756.

Example 54: *tert*-butyl 4-(2-((9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)amino)-2-oxoethyl)piperidine-1-carboxylate.

To a suspension of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (500 mg, 1.89 mmol) in EtOAc (5 mL), 2-(1-(*tert*-butoxycarbonyl)piperidin-4-yl)acetic acid (461 mg, 1.89 mmol), HOBt (384 mg, 2.84 mmol), EDC·HCl (440 mg, 2.84 mmol) and Et_3N (767 mg, 7.58 mmol) were added. The mixture was stirred at room temperature for 24 h. Water (10 mL) and DCM (20 mL) were added to the resulting suspension and the 2 phases were separated. The organic phase was washed with saturated aqueous $NaHCO_3$ solution (1x10 mL), brine (1x10 ml), 2N HCl solution (1x10 mL) and 2N NaOH (1x10 mL), dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow solid (515 mg, 60% yield).
^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.92 (s, 3H), 1.11 (dq, J = 4.4 Hz, J' = 11.6 Hz, 2H), 1.4 (s, 9H), 1.54 (d, J = 13.6 Hz, 2H), 1.63-1.68 (complex signal, 4H), 1.84 (s, 2H), 1.91 (m, 1H), 1.97 (s, 2H), 2.0 (d, J = 12.8 Hz, 2H), 2.14-2.18 (complex signal, 2H), 2.69 (t, J =

13.2 Hz, 2H), 3.06 (t, *J* = 6Hz, 2H), 4.06 (broad signal, 2H), 5.14 (s, 1H), 7.02-7.08 (complex signal, 4H).

Example 55: *N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo [9]annulen-7-yl)-2-(piperidin-4-yl)acetamide.

To a solution of *tert*-butyl 4-(2-((9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)amino)-2-oxoethyl)piperidine-1-carboxylate (250 mg, 0.55 mmol) in DCM (4 mL) was added 4M HCl in 1,4-dioxane (0.5 ml). The reaction mixture was stirred at room temperature for 3 days. Then, the solvent was evaporated under vacuum and the residue was dissolved in DCM (10 mL) and washed with 5N NaOH solution, dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow solid (189 mg, 97% yield).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 0.91 (s, 3H), 1.12 (dq, *J* = 4 Hz, *J'* = 12.0 Hz, 2H), 1.53 (d, *J* = 13.2 Hz, 2H), 1.62-1.71 (complex signal, 4H), 1.84 (s, 2H), 1.88 (m, 1H), 1.95-2.01 (complex signal, 4H), 2.14-2.19 (complex signal, 2H), 2.6 (dt, *J* = 2.8 Hz, *J'* = 12.0 Hz, 2H), 3.00-3.07 (complex signal, 4H), 5.15 (s, 1H), 7.02-7.09 (complex signal, 4H).

Example 56: 2-[1-(isopropylsulfonyl)piperidin-4-yl]-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

To a solution of *N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-(piperidin-4-yl)acetamide (185 mg, 0.52 mmol) in DCM (5 mL) was added Et_3N (63 mg, 0.63 mmol). The mixture was cooled down to 0 °C and propane-2-sulfonyl chloride (74 mg, 0.52 mmol) was added dropwise. Then, the reaction mixture was stirred at room temperature overnight and quenched by addition of 2N HCl solution (3 mL). The two phases were separated and the aqueous phase was extracted with EtOAc (2 x 20 mL). The combined organic phases were washed with 5N NaOH solution, dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow solid. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave a white solid (145 mg, 60% yield). The analytical sample was obtained by crystallization from hot EtOAc (76 mg).

mp 172 -173 °C. IR (NaCl disk): 3365, 3319, 3058, 3017, 2916, 2852, 1648, 1536, 1493, 1451, 1361, 1322, 1308, 1264, 1167, 1137, 1044, 1011, 993, 944, 904, 880, 800, 758, 731, 701, 665 cm^{-1}. Anal. Calcd for $C_{26}H_{38}N_2O_3S$·0.25 Methanol: C 67.56, H 8.42, N 6.00. Found: C 67.75 H 8.62, N 5.74.

Example 57: 2-(1-acetylpiperidin-4-yl)-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

To a solution of *N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethano-benzo[9]annulen-7-yl)-2-(piperidin-4-yl)acetamide (200 mg, 0.57 mmol) in anh. DCM (5 mL) under argon atmosphere was added anh. Et_3N (69 mg, 0.68 mmol). The mixture was cooled down to 0°C and acetyl chloride (45 mg, 0.57 mmol) was added dropwise. Then, the reaction mixture was stirred at room temperature overnight and quenched by addition of 2N HCl solution (3 mL). The two phases were separated and the aqueous layer was extracted with EtOAc (2 x 20 mL). The combined organic phases were washed with 2N NaOH solution, dried over anh. Na_2SO_4, filtered and concentrated under vacuum. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave a white solid (134 mg, 48% yield).

mp 85-86 °C. IR (NaCl disk): 3314, 3060, 3016, 2915, 2859, 2239, 1630, 1544, 1492, 1450, 1361, 1303, 1273, 1196, 1164, 1137, 1096, 1048 cm^{-1}. Anal. Calcd for $C_{25}H_{34}N_2O_2 \cdot 0.15$ DCM: C 74.17, H 8.49, N 6.88. Found: C 74.31, H 8.73, N 6.72.

Example 58: 1-(9-methyl-6,7,8,9,10,11-hexahydro-5*H*-5,9:7,11-dimethanobenzo[9] annulen-7-yl)-3-(2,3,4-trifluorophenyl)urea.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine (273 mg, 1.2 mmol) in anhydrous DCM (10 mL), 2,3,4-trifluorophenylisocyanate (147 mg, 1.0 mmol) and triethylamine (0.55 mg, 4 mmol) were added. The reaction mixture was stirred at room temperature overnight. Then the solvent was removed under vacuum. Column chromatography (SiO_2, Hexane/Ethyl Acetate mixture) of the crude and concentration under vacuum of the appropriate fractions gave the urea (38 mg, 13% yield) as a white solid.

mp 206-207 °C. IR (ATR): 3331, 2903, 2839, 1654, 1556, 1510, 1473, 1361, 1344, 1290, 1237, 1174, 1101, 1038, 1019, 1004, 800, 756, 690, 669, 625 cm^{-1}. Anal. Calcd for $C_{23}H_{23}F_3N_2O$: C 68.99, H 5.79, N 7.00. Found: C 68.94, H 5.92, N 6.71.

Example 59: 1-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)-3-(2,3,4-trifluorophenyl)urea.

To a solution of 5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-amine (275 mg, 1.2 mmol) in anhydrous DCM (10 mL), 2,3,4-trifluorophenylisocyanate (147 mg, 1.0 mmol) and and triethylamine (0.55 mg, 4 mmol) were added. The reaction mixture was stirred at room temperature overnight. Then the solvent was removed under vacuum. The desired urea was obtained as a white solid (205 mg, 54% yield).

mp 257-259 °C. IR (ATR): 3295, 3241, 3118, 2916, 2173, 1693, 1620, 1564, 1510, 1493, 1468, 1462, 1356, 1345, 1320, 1302, 1286, 1273, 1254, 1229, 1210, 1181, 1167, 1111, 1091, 1074, 1049, 1035, 1008, 999, 958, 906, 820, 812, 763, 646 cm^{-1}. Anal. Calcd for $C_{22}H_{21}F_3N_2O_2 \cdot 0.1H_2O$: C 65.37, H 5.29, N 6.93. Found: C 65.18, H 5.31,N 6.73. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{22}H_{21}F_3N_2O_2+H]^+$: 403.1633, found: 403.1631.

Example 60: 2-(1-benzylpiperidin-4-yl)-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide.

To a suspension of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (250 mg, 0.95 mmol) in EtOAc (5 mL), 2-(1-benzylpiperidin-4-yl)acetic acid hydrochloride (255 mg, 0.95 mmol), HOBt (192 mg, 1.42 mmol), EDC·HCl (220 mg, 1.42 mmol) and Et_3N (480 mg, 4.74 mmol) were added. The mixture was stirred at room temperature for 24 h. Water (10 mL) and DCM (10 mL) were added to the resulting suspension and the 2 phases were separated. The organic phase was washed with saturated aqueous $NaHCO_3$ solution (1x10 mL), brine (1x10 ml), dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give a yellow gum (479 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave a white solid (280 mg, 67% yield). The analytical sample was obtained by crystallization from hot EtOAc and Et_2O (124 mg).

mp 145-146 °C. IR (NaCl disk): 3302, 3060, 3024, 2917, 2841, 2798, 2755, 1641, 1544, 1493, 1452, 1361, 1342, 1309, 1279, 1211, 1184, 1143, 1077, 1008, 974, 943, 916, 794, 756, 737, 697 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{30}H_{38}N_2O+H]^+$: 443.3057, found: 443.3061.

Reference example 61: *tert*-butyl (1-propionylpiperidin-4-yl)carbamate.

To a solution of *tert*-butyl piperidin-4-ylcarbamate (500 mg, 2.49 mmol) in anh. THF (5 mL) was added Et_3N (252 mg, 2.49 mmol). The mixture was cooled down to 0 °C with an ice bath and then propionyl chloride (230 mg, 2.49 mmol) was added dropwise. The reaction mixture was stirred at room temperature for 2h. The suspension was filtrated and the filtered was evaporated to obtain the carbamate as a yellowish solid (661 mg, quantitative yield).

Reference example 62: 1-(4-aminopiperidin-1-yl)propan-1-one.

To a solution of *tert*-butyl (1-propionylpiperidin-4-yl)carbamate (660 g, 2.57 mmol) in DCM (3 mL) 4 M HCl in 1,4-dioxane (2 mL) was added. The mixture was stirred at room temperature overnight and the solvents were evaporated under vacuum. The residue was then dissolved in DCM (5 mL) and washed with 5N NaOH solution (5 mL).

The organic layer was dried over anh. Na_2SO_4, filtered and concentrated under vacuum to give 1-(4-aminopiperidin-1-yl)propan-1-one (335 mg, 83% yield) as a yellow oil.

Example 63: 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-propionylpiperidin-4-yl)urea.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (464 mg, 1.76 mmol) in DCM (10 mL) saturated aqueous $NaHCO_3$ solution (10 mL) and triphosgene (193 mg, 0.65 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)propan-1-one (350 mg, 2.11 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a white solid (741 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(9-methyl-5,6,8,9,10,11-hexahydro-7H-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-propionylpiperidin-4-yl)urea (597 mg, 83% yield) as a white solid. The analytical sample was obtained by crystallization from hot EtOAc and DCM (300 mg).

mp 207-208 °C. IR (NaCl disk): 3357, 2917, 2858, 1644, 1620, 1555, 1493, 1449, 1360, 1344, 1318, 1263, 1221, 1131, 1067, 1023, 971, 948, 758 cm^{-1}. Anal. Calcd for $C_{25}H_{35}N_3O_2 \cdot 0.15$ EtOAc: C 72.73, H 8.63, N 9.94. Found: C 72.65, H 8.49, N 9.82.

Example 64: 1-(1-(4-acetylphenyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (241 mg, 0.95 mmol) in DCM (5 mL) saturated aqueous $NaHCO_3$ solution (5 mL) and triphosgene (104 mg, 0.35 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (5 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-(4-aminopiperidin-1-yl)phenyl)ethan-1-one (250 mg, 1.15 mmol, prepared following the procedure reported in WO2007016496). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain an orange solid (475 mg). Column chromatography (SiO_2, Hexane/Ethyl Acetate mixtures) gave 1-(1-(4-acetylphenyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (120 mg, 27% yield) as a yellowish solid.

mp 211-212 °C. IR (NaCl disk): 3357, 2919, 2844, 1666, 1633, 1596, 1552, 1518, 1493, 1452, 1427, 1389, 1359, 1306, 1281, 1224, 1193, 1128, 1068, 956, 915, 825, 758 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{30}H_{37}N_3O_2+H]^+$: 472.2959, found: 472.2962.

Example 65: 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-(tetrahydro-2*H*-pyran-4-carbonyl)piperidin-4-yl)urea.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (258 mg, 0.98 mmol) in DCM (4 mL) saturated aqueous $NaHCO_3$ solution (4 mL) and triphosgene (107 mg, 0.36 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (2 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added (4-aminopiperidin-1-yl)(tetrahydro-2*H*-pyran-4-yl)methanone (215 mg, 1.10 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellow residue (534 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-(tetrahydro-2*H*-pyran-4-carbonyl)piperidin-4-yl)urea (207 mg, 45% yield) as a white solid.

mp 224-225 °C. IR (NaCl disk): 3356, 3064, 2945, 2919, 2850, 1639, 1613, 1552, 1493, 1446, 1360, 1344, 1320, 1278, 1261, 1238, 1211, 1126, 1089, 1068, 1018, 983, 941, 874, 818, 758, 733 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{28}H_{39}N_3O_3+H]^+$: 466.3064, found: 466.3065.

Example 66: 1-(1-(2-fluorobenzoyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (247 mg, 0.93 mmol) in DCM (4 mL) saturated aqueous $NaHCO_3$ solution (4 mL) and triphosgene (103 mg, 0.36 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added (4-aminopiperidin-1-yl)(2-fluorophenyl)methanone (250 mg, 1.12 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a white solid (486 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-

(1-(2-fluorobenzoyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (285 mg, 45% yield) as a white solid.
mp 265-266 °C. IR (NaCl disk): 3368, 2920, 2854, 1614, 1549, 1492, 1452, 1364, 1318, 1282, 1222, 1122, 1089, 1029, 974, 948, 817, 755 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{29}H_{34}FN_3O_2+H]^+$: 476.2708, found: 476.2711.

Example 67: 1-((1R,3s,5S)-8-benzyl-8-azabicyclo[3.2.1]octan-3-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (253 mg, 0.96 mmol) in DCM (4 mL) saturated aqueous $NaHCO_3$ solution (4 mL) and triphosgene (105 mg, 0.35 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added (1R,3s,5S)-8-benzyl-8-azabicyclo[3.2.1]octan-3-amine (250 mg, 1.15 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellow gum (498 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-((1R,3s,5S)-8-benzyl-8-azabicyclo[3.2.1]octan-3-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (293 mg, 65% yield) as a white solid. The analytical sample was obtained by crystallization from hot mixture EtOAc:Et_2O (187 mg).
mp 100-101 °C. IR (NaCl disk): 3319, 3022, 2944, 2919, 2843, 1632, 1557, 1493, 1452, 1344, 1321, 1304, 1279, 1263, 1235, 1164, 1122, 1056, 1027, 756, 729, 696 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{31}H_{39}N_3O+H]^+$: 470.3166, found: 470.3168.

Example 68: 1-(1-acetylpiperidin-4-yl)-3-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (150 mg, 0.53 mmol) in DCM (3 mL) saturated aqueous $NaHCO_3$ solution (3 mL) and triphosgene (59 mg, 0.20 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (91 mg, 0.64 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellowish oil (165

mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (103 mg, 49% yield) as a white solid.
mp 269-270 °C. IR (NaCl disk): 3357, 2919, 2856, 1644, 1620, 1555, 1499, 1453, 1361, 1342, 1320, 1228, 1153, 1138, 1064, 967, 863, 818 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{24}H_{32}FN_3O_2+H]^+$: 414.2551, found: 414.2553.

Example 69: 1-(1-acetylpiperidin-4-yl)-3-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-aminehydrochloride (150 mg, 0.51 mmol) in DCM (3 mL) saturated aqueous $NaHCO_3$ solution (3 mL) and triphosgene (56 mg, 0.19 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (87 mg, 0.61 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a brown oil (256 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (121 mg, 56 % yield) as a white solid.
mp 116-117 °C. IR (NaCl disk): 3359, 2905, 2861, 1644, 1619, 1551, 1501, 1452, 1360, 1343, 1319, 1267, 1227, 1153, 1136, 1042, 973, 807, 736 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{25}H_{35}N_3O_3+H]^+$: 426.2571, found: 4426.2760.

Example 70: 1-(1-acetylpiperidin-4-yl)-3-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (150 mg, 0.53 mmol) in DCM (3 mL) saturated aqueous $NaHCO_3$ solution (3 mL) and triphosgene (58 mg, 0.20 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (91 mg, 0.64 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellow oil (320 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-

acetylpiperidin-4-yl)-3-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (160 mg, 73% yield) as a white solid.
mp 122-123 °C. IR (NaCl disk): 3351, 2944, 2918, 2861, 1642, 1618, 1555, 1462, 1362, 1321, 1238, 1137, 1066, 976, 885, 798, 749 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{24}H_{32}FN_3O_2+H]^+$: 414.2551, found: 414.2554.

Example 71: 1-(1-acetylpiperidin-4-yl)-3-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (150 mg, 0.46 mmol) in DCM (3 mL) saturated aqueous $NaHCO_3$ solution (3 mL) and triphosgene (51 mg, 0.17 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (79 mg, 0.55 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a yellow oil (334 mg). Column chromatography (SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (168 mg, 80 % yield) as a white solid.
mp 127-128 °C. IR (NaCl disk): 3365, 3052, 2913, 2862, 2834, 1643, 1616, 1553, 1516, 1452, 1360, 1343, 1320, 1293, 1252, 1232, 1168, 1137, 1092, 1019, 974, 863, 801, 734 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{26}H_{37}N_3O_4+H]^+$: 456.2857, found: 456.2859.

Example 72: 1-(1-acetylpiperidin-4-yl)-3-(5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-yl)urea.

To a solution of 5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-amine hydrochloride (57 mg, 0.24 mmol) in DCM (1 mL) saturated aqueous $NaHCO_3$ solution (1 mL) and triphosgene (27 mg, 0.09 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (1 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (41 mg, 0.29 mmol). The reaction mixture was stirred at room temperature overnight and the solvent was evaporated under vacuum to obtain a brown gum (93 mg). Column chromatography

(SiO_2, DCM/Methanol mixtures) gave 1-(1-acetylpiperidin-4-yl)-3-(5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(*6H*)-yl)urea (47 mg, 53 % yield) as a white solid. mp 98-99 °C. IR (NaCl disk): 3359, 3013, 2927, 2856, 2239, 1621, 1556, 1449, 1372, 1334, 1318, 1268, 1238, 1225, 1192, 1153, 1107, 1081, 1048, 1041, 972, 920, 756, 730 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{22}H_{29}N_3O_2+H]^+$: 4368.2333, found: 368.2331.

Example 73: 1-(benzo[*d*]thiazol-2-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine (250 mg, 1.03 mmol) in DCM (3 mL) saturated aqueous $NaHCO_3$ solution (3 mL) and triphosgene (113 mg, 0.38 mmol) were added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic layer was washed with brine (3 mL), dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of the isocyanate in DCM.

To a solution of benzo[d]thiazol-2-amine (141 mg, 0.94 mmol) in anh. THF (8 mL) under argon atmosphere at -78 °C, was added dropwise a solution of *n*-butyllithium (2.5 M in hexanes, 0.38 mL, 0.94 mmol) during 20 minutes. After the addition, the mixture was tempered to 0 °C using an ice bath. This solution was added carefully to the solution of the isocyanate from the previous step cooled to 0 °C, under argon atmosphere. The reaction mixture was stirred at room temperature overnight. Methanol (3 mL) was then added to quench any unreacted *n*-butyllithium. The solvents were evaporated under vacuum to give a yellow solid (531 mg). Column chromatography (SiO2, Hexane/Ethyl Acetate mixtures) gave a 1-(benzo[*d*]thiazol-2-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea (65 mg, 15% yield) as a white solid.

mp 247-248 °C. IR (NaCl disk): 2926, 2851, 1712, 1675, 1593, 1537, 1445, 1358, 1268, 1217, 1556, 1116, 1080, 1044, 1015, 910, 845 $cm^{-1.}$ HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{24}H_{25}N_3O_2S+H]^+$: 420.1740, found: 368.2331.

Example 74: 1-(1-acetylpiperidin-4-yl)-3-(1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea.

To a solution of 1,9-difluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-amine hydrochloride (120 mg, 0.42 mmol) in DCM (3 mL) and saturated aqueous $NaHCO_3$ solution (3 mL), triphosgene (46 mg, 0.16 mmol) was added. The biphasic mixture was stirred at room temperature for 30 minutes and then the two phases were separated and the organic one was washed with brine (3 mL),

dried over anh. Na_2SO_4, filtered and evaporated under vacuum to obtain 1-2 mL of a solution of isocyanate in DCM. To this solution was added 1-(4-aminopiperidin-1-yl)ethan-1-one (72 mg, 0.51 mmol). The mixture was stirred overnight at room temperature and the solvent was then evaporated. Column chromatography (SiO_2, DCM/Methanol mixtures) afforded the urea (84 mg, 48% yield) as a yellowish solid. The analytical sample was obtained by crystallization from hot EtOAc/Pentane.

mp 248-249 °C. IR (ATR): 3382, 3266, 2923, 2164, 1645, 1622, 1562, 1503, 1464, 1454, 1425, 1362, 1341, 1325, 1318, 1304, 1244, 1232, 1185, 1135, 1099, 1059, 1036, 1015, 995, 978, 952, 929, 891, 868, 795, 746, 717, 695, 645, 625, 605, 590 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{23}H_{29}F_2N_3O_2+H]^+$: 418.2301; Found: 418.2300.

Reference example 75: 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-5-*d*-3(2*H*)-ol.

To a solution of 5,6,7,8-tetrahydro-7*H*-5,9-propanobenzo[7]annulene-7,11-dione (3.13 g, 14.6 mmol) in MeOH (88 mL), $NaBD_4$ (1 g, 23.9 mmol) was added portion-wise and the suspension was stirred under reflux for 6 h. The solution was cooled down and the solvent was removed under vacuum. To the obtained white solid, NaOH 2 N (100 mL) was added and the suspension was refluxed for 30 min. After that, the suspension was filtered and washed with H_2O (50 mL) to afford the 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-5-*d*-3(2*H*)-ol (2.88 g, 91 % yield) as a white solid.

mp 200 °C. IR (ATR): 3304, 2957, 2941, 2927, 2913, 1492, 1461, 1451, 1431, 1383, 1356, 1339, 1328, 1278, 1253, 1234, 1219, 1189, 1157, 1141, 1127, 1082, 1047, 1017, 1002, 958, 935, 863, 844, 773, 755, 718, 673 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{14}H_{15}DO_2+H]^+$: 218.1286, found: 218.1297.

Reference example 76: (1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl-5-*d*)hydrazine hydrochloride.

A solution of 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-5-*d*-3(2*H*)-ol (1.2 g, 5.52 mmol) in hydrazine hydrate (9 mL, aq. sol. 64%, 183.98 mmol) and HCl conc. (0.2 mL) was heated at reflux overnight. The solution was cooled down and the suspension was filtered. The obtained solid was dissolved in methanol and HCl/MeOH was added to afford (1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl-5-*d*)hydrazine hydrochloride (1.26 g, 85% yield).

mp 232-235 °C. IR (ATR): 3303, 3226, 2911, 2845, 2650, 1589, 1525, 1490, 1451, 1435, 1356, 1328, 1278, 1253, 1219, 1157, 1145, 1129, 1084, 1050, 1024, 1002, 958,

936, 892, 865, 830, 812, 771, 750, 721 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{14}H_{17}DN_2O+H]^+$: 232.1555, found: 232.1554.

Reference example 77: 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-5-*d*-3(2*H*)-amine hydrochloride.

A solution of 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[e]oxonin-3(2H)-yl-5-*d*)hydrazine hydrochloride (1 g, 3.7 mmol) and PtO_2 (100 mg) in ethanol (100 mL) was hydrogenated at room temperature, at a pressure of 1 atm for 5 days. The resulting suspension was filtered and the residue washed with methanol. The solvent was removed under vacuum affording a white solid. The solid was dissolved in MeOH and an excess of HCl/MeOH was added. The solvent was evaporated to afford 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-5-*d*-3(2*H*)-amine hydrochloride (791 mg, 85% yield) as a white solid. The analytical sample was obtained by crystallization from Methanol/Et_2O.

mp 195 °C. IR (ATR): 3304, 3010, 2940, 2913, 2847, 1510, 1490, 1451, 1435, 1379, 1356, 1328, 1280, 1251, 1235, 1221, 1157, 1126, 1082, 1041, 1000, 957, 937, 866, 844, 773, 762, 755, 720, 670 cm^{-1}. HRMS-ESI+ m/z $[M+H]^+$ calcd for $[C_{14}H_{16}DNO+H]^+$: 217.1446, found: 217.1449.

Example 78: 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethano-benzo[*e*]oxonin-3(2*H*)-yl-5-*d*)urea.

From 1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-5-*d*-3(2*H*)-amine hydrochloride and following the procedure of example 37, 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethano-benzo[*e*]oxonin-3(2*H*)-yl-5-*d*)urea was obtained

Example 79: *In vitro* determination of sEH inhibition activity

The following fluorescent assay was used for determination of the sEH inhibition activity (IC_{50}), with the substrate and comparative control compound (TPPU) indicated below.

Substrate: cyano(6-methoxynaphthalen-2-yl)methyl 2-(3-phenyloxiran-2-yl)acetate (PHOME; from Cayman Chemical, item number 10009134; CAS 1028430-42-3); cf. N.M. Wolf et al., *Anal. Biochem.* 2006, vol. 355, pp. 71-80.

TPPU: *N*-[1-(1-Oxopropyl)-4-piperidinyl]-*N'*-[4-(trifluoromethoxy)phenyl]urea.

Solutions:

- Assay buffer: Bis/Tris HCl 25 mM pH 7.0 containing 0.1 mg/mL of bovine serum albumin (BSA).

- PHOME at 200 μM in DMSO.
- Solution of recombinant human sEH (hsEH) (Cayman Chemical, item number 10011669), diluted with assay buffer.
- Inhibitors dissolved in DMSO at appropriated concentrations.

Protocol: In a black 96-well plate (Greiner Bio-One, item number 655900), fill the background wells with 90 μL and the positive control and inhibitor wells with 85 μL of assay buffer. Add 5 μL of DMSO to background and positive control wells, and then add 5 μL of inhibitor solution in inhibitor wells. Add 5 μL of the solution of hsEH to the positive control and inhibitor wells and stir the mixture. Prepare a 1/21 dilution of the solution of PHOME with assay buffer according to final volume required, and then add 105 μL of each well. Shake carefully the plate for 10 seconds and incubate for 5 minutes at room temperature. Read the appearance of fluorescence with excitation wavelength: 337 nm, and emission wavelength: 460 nm (FLUOStar OPTIMA microplate reader, BMG). The intensity of fluorescence was used to analyze and calculate the IC_{50} values. Results were obtained by regression analysis from at least three data points in a linear region of the curve. IC_{50} values are average of minimum three independent replicates.

Tables 1 and 2: human sEH inhibition activity (IC_{50}, nM) of selected compounds (I)[a]

Ex.	TTPU	35	36	38	39	40	41	42	43	44	47	48	51	52	53	56
IC_{50}	A	D	D	A	D	B	A	A	B	A	A	A	A	A	B	B

Ex.	57	58	59	60	63	64	65	66	67	68	69	70	71	72	73	74
IC_{50}	D	A	B	D	A	A	A	A	A	A	A	A	A	B	D	A

[a] A means that IC_{50} is lower than 10 nM, B means that IC_{50} is at least 10 nM but less than 50 nM, C means that IC_{50} is at least 50 nM but less than 100 nM and D means that IC_{50} is at least 100 nM but less than 1000nM.

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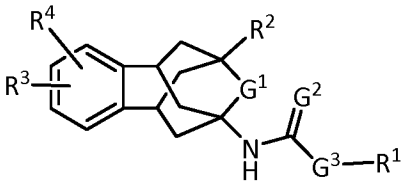
CLAIMS

1. A compound of formula (I)



(I)

or a stereoisomer or a pharmaceutically acceptable salt thereof, wherein:

G^1 represents an oxygen atom or a methylene group or a single bond;

G^2 represents an oxygen atom or a sulphur atom;

G^3 represents a radical selected from the group consisting of $–NH–(CH_2)_m–$, $–O–(CH_2)_m–$ and $–(CH_2)_n–$;

m is an integer from 0 to 6;

n is an integer from 1 to 7

R^1 is a radical selected from the group consisting of:

a) C_6-C_{10} aryl which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl and methylaminocarbonylpyridyloxy;

b) heteroaryl having from 2 to 11 carbon atoms and 1, 2 or 3 heteroatoms selected from the group consisting of N, O and S and which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl and C_1-C_6 alkoxycarbonylmethyl;

c) saturated or partially unsaturated, monocyclic or bicyclic heterocyclyl having from 5 to 11 carbon atoms and 1, 2 or 3 heteroatoms selected from the group consisting of N, O and S and which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, C_3-C_6 cycloalkyl-C(=O), nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethylcarbonyl (CF_3CO), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H),

carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl, C_1-C_6 alkylsulfonyl, C_3-C_6 cycloalkylsulfonyl, benzyl, heteroarylmethyl, pyridincarbonyl, phenylcarbonyl, tetrahydropyrancarbonyl, C_6-C_{10} arylsulfonyl which may be optionally substituted by 1 to 2 substituents selected from the group consisting of halogen atoms, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl and phenyl which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_3-C_6 cycloalkyl and C_1-C_6 alkoxycarbonylmethyl;

d) C_6-C_{10} cycloalkyl which may be optionally substituted by 1 to 4 substituents selected from the group consisting of halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), carboxylic group (COOH), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl, C_1-C_6 alkoxycarbonylmethyl, pyridinyloxy which may be unsubstituted or substituted by a group selected from COOH and $CONHCH_3$, and phenoxy which may be unsubstituted or substituted by COOH, $COOR^5$, $CONH_2$, CN or OH;

R^2 is a radical selected from the group consisting of hydrogen or deuterium atoms, halogen atoms, methyl, hydroxy and C_1-C_6 alkoxy;

R^3 and R^4 are radicals which may be identical or different and which are independently selected from the group consisting of hydrogen atoms, halogen atoms, C_1-C_6 acyl, nitro (NO_2), cyano (C≡N), carboxylic group (COOH), hydroxy (OH), trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), pentafluorosulfanyl (SF_5), sulfonyl (SO_3H), fluorosulfonyl (SO_2F), amino (NH_2), mono-C_1-C_6 alkylamino, di-C_1-C_6 alkylamino, C_1-C_6 alkoxy, C_1-C_6 alkyl and C_1-C_6 alkoxycarbonylmethyl;

or R^3 and R^4 may form together a radical $-O-(CH_2)_p-O-$, wherein p is an integer from 1 to 3;

R^5 is a radical selected from C_1-C_6 alkyl and C_3-C_6 cycloalkyl.

2. A compound according to claim 1 wherein G^1 represents a methylene group.

3. A compound according to any one of claims 1 to 2 wherein G^2 represents an oxygen atom.

4. A compound according to any one of claims 1 to 3 wherein G^3 represents a radical selected from the group consisting of $–NH–(CH_2)_m–$ and $–(CH_2)_n–$, m is an integer from 0 to 6 and n is an integer from 1 to 7.

5. A compound according to claim 4 wherein G^3 represents a radical$–NH–(CH_2)_m–$ and m is an integer from 0 to 6.

6. A compound according to any one of claims 1 to 5 wherein, when G^3 is selected from the group consisting of $–NH–(CH_2)_m–$ and $–O–(CH_2)_m–$, m has a value of 0 and wherein G^3 is $–(CH_2)_n–$ n has a value of 1.

7. A compound according to any one of claims 1 to 6 wherein R^1 is selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted cyclohexyl and substituted or unsubstituted piperidinyl.

8. A compound according to any one of claims 1 to 7 wherein R^2 is selected from the group consisting of hydrogen atoms, fluorine atoms, chlorine atoms, methyl, hydroxyl and C_1-C_3 alkoxy.

9. A compound according to any one of claims 1 to 8 wherein R^3 and R^4 are radicals which may be identical or different and which are independently selected from the group consisting of hydrogen atoms, halogen atoms, C_1-C_6 acyl, trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), nitro (NO_2), amino (NH_2) and C_1-C_6 alkoxy.

10. A compound according to any one of claims 1 to 9 wherein R^3 is hydrogen and R^4 is a radical selected from the group consisting of hydrogen atoms, halogen atoms, C_1-C_6 acyl, trifluoromethyl (CF_3), trifluoromethoxy (OCF_3), nitro (NO_2), amino (NH_2) and C_1-C_6 alkoxy.

11. The compound according to any one of the claims 1 to 10, which is selected from the group consisting of:

i. *p*-tolyl (9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)carbamate

ii. 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(4-(trifluoromethyl)phenyl)thiourea

iii. 1-(1-acetylpiperidin-4-yl)-3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)urea

iv. 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)urea

v. 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

vi. 1-(1-acetylpiperidin-4-yl)-3-(9-hydroxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

vii. 1-(1-acetylpiperidin-4-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

viii. 1-(1-acetylpiperidin-4-yl)-3-(9-fluoro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

ix. 1-(1-acetylpiperidin-4-yl)-3-(9-chloro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

x. 4-(((1r,4r)-4-(3-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)ureido)cyclohexyl)oxy)benzoic acid

xi. 4-(((1r,4r)-4-(3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)ureido)cyclohexyl)oxy)benzoic acid

xii. 1-[1-(isopropylsulfonyl)piperidin-4-yl]-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xiii. 1-(1-benzylpiperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xiv. 1-(2-acetyl-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-acetylpiperidin-4-yl)urea

xv. 1-(1-acetylpiperidin-4-yl)-3-(9-methyl-2-nitro-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xvi. 1-(1-acetylpiperidin-4-yl)-3-(2-amino-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xvii. *tert*-butyl 4-(2-((9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)amino)-2-oxoethyl)piperidine-1-carboxylate

xviii. *N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-2-(piperidin-4-yl)acetamide

xix. 2-[1-(isopropylsulfonyl)piperidin-4-yl]-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide

xx. 2-(1-acetylpiperidin-4-yl)-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide

xxi. 1-(9-methyl-6,7,8,9,10,11-hexahydro-5*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(2,3,4-trifluorophenyl)urea

xxii. 1-(5-methyl-1,5,6,7-tetrahydro-1,5:3,7-dimethanobenzo[*e*]oxonin-3(2*H*)-yl)-3-(2,3,4-trifluorophenyl)urea

xxiii. 2-(1-benzylpiperidin-4-yl)-*N*-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)acetamide

xxiv. 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-propionylpiperidin-4-yl)urea

xxv. 1-(1-(4-acetylphenyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxvi. 1-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)-3-(1-(tetrahydro-2*H*-pyran-4-carbonyl)piperidin-4-yl)urea

xxvii. 1-(1-(2-fluorobenzoyl)piperidin-4-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxviii. 1-((1R,3s,5S)-8-benzyl-8-azabicyclo[3.2.1]octan-3-yl)-3-(9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxix. 1-(1-acetylpiperidin-4-yl)-3-(2-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxx. 1-(1-acetylpiperidin-4-yl)-3-(2-methoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxi. 1-(1-acetylpiperidin-4-yl)-3-(1-fluoro-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxii. 1-(1-acetylpiperidin-4-yl)-3-(2,3-dimethoxy-9-methyl-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxiii. 1-(1-acetylpiperidin-4-yl)-3-(5,8,9,10-tetrahydro-5,8:7,10-dimethanobenzo[8]annulen-7(6*H*)-yl)urea

xxxiv. 1-(benzo[*d*]thiazol-2-yl)-3-(9-methoxy-5,6,8,9,10,11-hexahydro-7*H*-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxv. 1-(1-acetylpiperidin-4-yl)-3-(1,9-difluoro-5,6,8,9,10,11-hexahydro-7H-5,9:7,11-dimethanobenzo[9]annulen-7-yl)urea

xxxvi. 1-(1-acetylpiperidin-4-yl)-3-(1,5,6,7-tetrahydro-1,5:3,7-dimethano-benzo[e]oxonin-3(2*H*)-yl-5-d)urea

12. A pharmaceutical or veterinary composition comprising a therapeutically effective amount of a compound as defined in any one of the claims 1 to 11.

13. A compound as defined in any one of the claims 1 to 11 or a composition according to claim 12 for use as a medicament.

14. A compound as defined in any one of the claims 1 to 11 or a composition according to claim 12 for use in the treatment or prevention in an animal, including a human, of a disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase.

15. The compound or composition for use according to claim 14, wherein the disease or disorder is selected from the group consisting of hypertension, atherosclerosis, pulmonary diseases such as chronic obstructive pulmonary disorder, asthma, sarcoidosis and cystic fibrosis, kidney diseases such as acute kidney injury, diabetic nephrology, chronic kidney diseases, hypertension-mediated kidney disorders and high fat diet-mediated renal injury, stroke, pain, neuropathic pain, inflammation, pancreatitis in particular acute pancreatitis, immunological disorders, neurodevelopmental disorders such as schizophrenia and autism spectrum disorder, eye diseases in particular diabetic keratopathy, wet age-related macular degeneration and retinopathy such as premature retinopathy and diabetic retinopathy, cancer, obesity, including obesity-induced colonic inflammation, diabetes, metabolic syndrome, preeclampsia, anorexia nervosa, depression, male sexual dysfunction such as erectile dysfunction, wound healing, NSAID-induced ulcers, emphysema, scrapie, Parkinson's disease, arthritis, arrhythmia, cardiac fibrosis, Alzheimer's disease, Raynaud's syndrome, Niemann-Pick-type C disease, cardiomyopathy, vascular cognitive impairment, mild cognitive impairment, inflammatory bowel diseases, cirrhosis, non-alcoholic fatty liver disease, non-alcoholic steatohepatitis, liver fibrosis, osteoporosis, chronic periodontitis, sepsis, seizure disorders such as epilepsy, dementia, edema such as cerebral edema, attention-deficit hyperactivity disorder, schizophrenia, drug dependency, social anxiety, colitis, amyotrophic lateral sclerosis, chemotherapy induced side effects, laminitis, inflammatory joint pain and synovitis, endothelial dysfunction, subarachnoid hemorrhage, including aneurysmal subarachnoid hemorrhage, traumatic brain injury, cerebral ischemia and diabetes-induced learning and memory impairment.

16. Use of a compound as defined in any one of claims 1 to 11 or a composition according to claim 12 in the manufacture of a medicament.

17. Use of a compound according to any of claims 1 to 11 or a composition according to claim 12 in the manufacture of a medicament for the treatment or prevention in an animal, including a human, of a disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase.

18. Use according to claim 17, wherein the disease or disorder is selected from the group consisting of hypertension, atherosclerosis, pulmonary diseases such as chronic obstructive pulmonary disorder, asthma, sarcoidosis and cystic fibrosis, kidney diseases such as acute kidney injury, diabetic nephrology, chronic kidney diseases, hypertension-mediated kidney disorders and high fat diet-mediated renal injury, stroke, pain, neuropathic pain, inflammation, pancreatitis in particular acute pancreatitis, immunological disorders, neurodevelopmental disorders such as schizophrenia and autism spectrum disorder, eye diseases in particular diabetic keratopathy, wet age-related macular degeneration and retinopathy such as premature retinopathy and diabetic retinopathy, cancer, obesity, including obesity-induced colonic inflammation, diabetes, metabolic syndrome, preeclampsia, anorexia nervosa, depression, male sexual dysfunction such as erectile dysfunction, wound healing, NSAID-induced ulcers, emphysema, scrapie, Parkinson's disease, arthritis, arrhythmia, cardiac fibrosis, Alzheimer's disease, Raynaud's syndrome, Niemann-Pick-type C disease, cardiomyopathy, vascular cognitive impairment, mild cognitive impairment, inflammatory bowel diseases, cirrhosis, non-alcoholic fatty liver disease, non-alcoholic steatohepatitis, liver fibrosis, osteoporosis, chronic periodontitis, sepsis, seizure disorders such as epilepsy, dementia, edema such as cerebral edema, attention-deficit hyperactivity disorder, schizophrenia, drug dependency, social anxiety, colitis, amyotrophic lateral sclerosis, chemotherapy induced side effects, laminitis, inflammatory joint pain and synovitis, endothelial dysfunction, subarachnoid hemorrhage, including aneurysmal subarachnoid hemorrhage, traumatic brain injury, cerebral ischemia and diabetes-induced learning and memory impairment.

19. Method for the treatment or prevention of a disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase comprising administering to an animal, including a human, in need thereof an effective amount of a compound according to claim 1 or of a composition according to claim 12.

20. Method for the treatment according to claim 19, wherein the disease or disorder susceptible of improvement by inhibition of soluble epoxide hydrolase is selected from the group consisting of hypertension, atherosclerosis, pulmonary diseases such as chronic obstructive pulmonary disorder, asthma, sarcoidosis and cystic fibrosis, kidney

diseases such as acute kidney injury, diabetic nephrology, chronic kidney diseases, hypertension-mediated kidney disorders and high fat diet-mediated renal injury, stroke, pain, neuropathic pain, inflammation, pancreatitis in particular acute pancreatitis, immunological disorders, neurodevelopmental disorders such as schizophrenia and autism spectrum disorder, eye diseases in particular diabetic keratopathy, wet age-related macular degeneration and retinopathy such as premature retinopathy and diabetic retinopathy, cancer, obesity, including obesity-induced colonic inflammation, diabetes, metabolic syndrome, preeclampsia, anorexia nervosa, depression, male sexual dysfunction such as erectile dysfunction, wound healing, NSAID-induced ulcers, emphysema, scrapie, Parkinson's disease, arthritis, arrhythmia, cardiac fibrosis, Alzheimer's disease, Raynaud's syndrome, Niemann-Pick-type C disease, cardiomyopathy, vascular cognitive impairment, mild cognitive impairment, inflammatory bowel diseases, cirrhosis, non-alcoholic fatty liver disease, non-alcoholic steatohepatitis, liver fibrosis, osteoporosis, chronic periodontitis, sepsis, seizure disorders such as epilepsy, dementia, edema such as cerebral edema, attention-deficit hyperactivity disorder, schizophrenia, drug dependency, social anxiety, colitis, amyotrophic lateral sclerosis, chemotherapy induced side effects, laminitis, inflammatory joint pain and synovitis, endothelial dysfunction, subarachnoid hemorrhage, including aneurysmal subarachnoid hemorrhage, traumatic brain injury, cerebral ischemia and diabetes-induced learning and memory impairment.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/066181

A. CLASSIFICATION OF SUBJECT MATTER

INV. C07C271/56 C07C275/26 C07C335/16 C07D211/34 C07D211/58
C07D211/96 C07D277/82 C07D451/04 C07D493/08 A61K31/27
A61K31/17 A61P9/00 A61P29/00 A61P25/00

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)

C07C C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HONG C. SHEN: "Soluble epoxide hydrolase inhibitors: a patent review", EXPERT OPINION ON THERAPEUTIC PATENTS, vol. 20, no. 7, 2010, pages 941-956, XP055182103, ISSN: 1354-3776, DOI: 10.1517/13543776.2010.484804 cited in the application the whole document figures pages 944, 946, 947, compounds 8, 11, 25, 34, 39	1-20

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[X] Further documents are listed in the continuation of Box C.

[X] 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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 July 2019	08/08/2019

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/066181

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HONG C. SHEN ET AL: "Discovery of inhibitors of soluble epoxide hydrolase: a target with multiple potential therapeutic indications", JOURNAL OF MEDICINAL CHEMISTRY, vol. 55, no. 5, 2012, pages 1789-1808, XP055190495, ISSN: 0022-2623, DOI: 10.1021/jm201468j cited in the application the whole document figures 5-7, 9, compounds 9, 11-13, 16, 17, 19-21, 27, 28 -----	1-20
A	ELENA VALVERDE ET AL: "Searching for novel applications of the benzohomoadamantane scaffold in medicinal chemistry: Synthesis of novel 11[beta]-HSD1 inhibitors", BIOORGANIC & MEDICINAL CHEMISTRY, vol. 23, no. 24, 2015, pages 7607-7617, XP029342467, ISSN: 0968-0896, DOI: 10.1016/J.BMC.2015.11.004 the whole document figures 3-5; schemes 1-3; table 1 -----	1-20
A	DE 22 61 637 A1 (BASF AG) 20 June 1974 (1974-06-20) page 6, paragraph 3; claims 1,12; examples 14-16 -----	1-20

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/066181

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 2261637 A1	20-06-1974	NONE	