

Novel Thiophene Derivatives

5 Field of the invention

The present invention relates to S1P1/EDG1 receptor agonists of Formula (I) and their use as active ingredients in the preparation of pharmaceutical compositions. The invention also concerns related aspects including processes for the preparation
10 of the compounds, pharmaceutical compositions containing a compound of the Formula (I), and their use as compounds improving vascular function and as immunomodulating agents, either alone or in combination with other active compounds or therapies. A further aspect of the invention relates to novel compounds of Formulae (II) and (III) that serve as intermediates to prepare
15 compounds of Formula (I).

Background of the invention

The human immune system is designed to defend the body against foreign micro-organisms and substances that cause infection or disease. Complex regulatory
20 mechanisms ensure that the immune response is targeted against the intruding substance or organism and not against the host. In some cases, these control mechanisms are unregulated and autoimmune responses can develop. A consequence of the uncontrolled inflammatory response is severe organ, cell, tissue or joint damage. With current treatment, the whole immune system is usually
25 suppressed and the body's ability to react to infections is also severely compromised. Typical drugs in this class include azathioprine, chlorambucil, cyclophosphamide, cyclosporin, or methotrexate. Corticosteroids which reduce inflammation and suppress the immune response, may cause side effects when used in long term treatment. Nonsteroidal anti-inflammatory drugs (NSAIDs) can
30 reduce pain and inflammation, however, they exhibit considerable side effects. Alternative treatments include agents that activate or block cytokine signaling.

Orally active compounds with immunomodulating properties, without compromising immune responses and with reduced side effects would significantly improve current treatments of uncontrolled inflammatory disease.

In the field of organ transplantation the host immune response must be suppressed
5 to prevent organ rejection. Organ transplant recipients can experience some rejection even when they are taking immunosuppressive drugs. Rejection occurs most frequently in the first few weeks after transplantation, but rejection episodes can also happen months or even years after transplantation. Combinations of up to three or four medications are commonly used to give maximum protection against
10 rejection while minimizing side effects. Current standard drugs used to treat the rejection of transplanted organs interfere with discrete intracellular pathways in the activation of T-type or B-type white blood cells. Examples of such drugs are cyclosporin, daclizumab, basiliximab, everolimus, or FK506, which interfere with cytokine release or signaling; azathioprine or leflunomide, which inhibit nucleotide
15 synthesis; or 15-deoxyspergualin, an inhibitor of leukocyte differentiation.

The beneficial effects of broad immunosuppressive therapies relate to their effects; however, the generalized immunosuppression which these drugs produce diminishes the immune system's defense against infection and malignancies. Furthermore, standard immunosuppressive drugs are often used at high dosages
20 and can cause or accelerate organ damage.

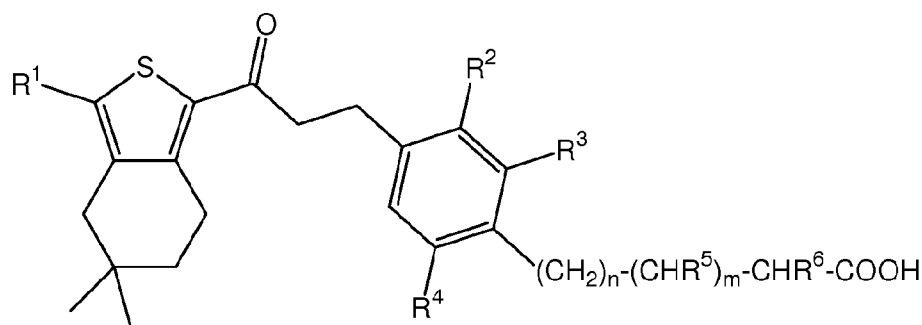
Description of the invention

The present invention provides novel compounds of Formula (I) that are agonists
25 for the G protein-coupled receptor S1P1/EDG1 and have a powerful and long-lasting immunosuppressive effect which is achieved by reducing the number of circulating and infiltrating T- and B-lymphocytes, without affecting their maturation, memory, or expansion. The reduction of circulating T- / B-lymphocytes as a result of S1P1/EDG1 agonism, possibly in combination with the observed improvement of
30 endothelial cell layer function associated with S1P1/EDG1 activation, makes such compounds useful to treat uncontrolled inflammatory disease and to improve vascular functionality.

The compounds of the present invention can be utilized alone or in combination with standard drugs inhibiting T-cell activation, to provide a new immunosuppressive therapy with a reduced propensity for infections when compared to standard immunosuppressive therapy. Furthermore, the compounds of the present invention can be used in combination with reduced dosages of traditional immunosuppressant therapies, to provide on the one hand effective immunosuppressive activity, while on the other hand reducing end organ damage associated with higher doses of standard immunosuppressive drugs. The observation of improved endothelial cell layer function associated with S1P1/EDG1 activation provides additional benefits of compounds to improve vascular function.

The nucleotide sequence and the amino acid sequence for the human S1P1/EDG1 receptor are known in the art and are published in e.g.: Hla, T., and Maciag, T. *J. Biol Chem.* **265** (1990), 9308-9313; WO 91/15583 published 17 October 1991; WO 99/46277 published 16 September 1999. The potency and efficacy of the compounds of Formula (I) are assessed using a GTP γ S assay to determine EC₅₀ values and by measuring the circulating lymphocytes in the rat after oral administration, respectively (see in Examples).

i) The invention relates to novel thiophenes of the Formula (I),



Formula (I)

wherein

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R¹ represents methyl, trifluoromethyl, or ethyl;

R² represents hydrogen, C₁₋₄-alkyl, methoxy, or halogen;

R³ represents hydrogen, C₁₋₄-alkyl, C₁₋₄-alkoxy, or halogen;

R⁴ represents hydrogen, C₁₋₄-alkyl, or halogen;

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R⁵ represents hydrogen;

R⁶ represents hydrogen or hydroxy;

10 in case **R⁶** represents hydroxy, **R⁵** can in addition represent hydroxy;

n represents 0;

m represents 0 or 1; and

15

in case **m** represents 1, **n** can in addition represent 1;

and salts as well as solvent complexes of such compounds.

20 The general terms used hereinbefore and hereinafter preferably have, within this disclosure, the following meanings, unless otherwise indicated:

Where the plural form is used for compounds, salts, pharmaceutical compositions, diseases and the like, this is intended to mean also a single compound, salt, or the
25 like.

Any reference hereinbefore or hereinafter to a compound of Formula (I), (II) or (III) is to be understood as referring also to enantiomers, mixtures of enantiomers such as racemates, diastereomers, mixtures of diastereomers, and mixtures of
30 enantiomers and diastereomers such as diastereomeric racemates, as well as salts (especially pharmaceutically acceptable salts) and solvent complexes (including hydrates) of such compounds, and morphological forms, as appropriate and expedient.

The term **C₁₋₄-alkyl**, alone or in combination with other groups, means saturated, branched or preferably straight chain groups with one to four carbon atoms, preferably one to three carbon atoms. Examples of C₁₋₄-alkyl groups are methyl,
5 ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *sec*-butyl, and *tert*-butyl.

The term **C₁₋₄-alkoxy** means an R-O group, wherein R is a C₁₋₄-alkyl. Preferred examples of C₁₋₄-alkoxy groups are methoxy, ethoxy, propoxy, and *iso*-propoxy.

10 The term **halogen** means fluoro, chloro, bromo or iodo, preferably fluoro or chloro.

Salts are preferably the pharmaceutically acceptable salts of the compounds of Formula (I).

15 Salt-forming groups are groups or radicals having basic or acidic properties. Compounds having at least one basic group or at least one basic radical, for example amino, a secondary amino group not forming a peptide bond or a pyridyl radical, may form acid addition salts, for example with inorganic acids. When several basic groups are present mono- or poly-acid addition salts may be formed.

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Compounds having acidic groups, such as a carboxy group or a phenolic hydroxy group, may form metal or ammonium salts, such as alkali metal or alkaline earth metal salts, for example sodium, potassium, magnesium or calcium salts, or ammonium salts with ammonia or suitable organic amines, such as tertiary
25 monoamines, for example triethylamine or tri-(2-hydroxyethyl)-amine, or heterocyclic bases, for example *N*-ethyl-piperidine or *N,N'*-dimethylpiperazine. Mixtures of salts are possible.

Compounds having both acidic and basic groups can form internal salts.

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For the purposes of isolation or purification, as well as in the case of compounds that are used further as intermediates, it is also possible to use pharmaceutically unacceptable salts, e.g. the picrates. Only pharmaceutically acceptable, non-toxic

salts may be used for therapeutic purposes, however, and those salts are therefore preferred.

The expression **pharmaceutically acceptable** salts encompasses either salts with
5 inorganic acids or organic acids like hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid, sulfamic acid, phosphoric acid, nitric acid, phosphorous acid, nitrous acid, citric acid, formic acid, acetic acid, oxalic acid, maleic acid, lactic acid, tartaric acid, fumaric acid, benzoic acid, mandelic acid, cinnamic acid, palmoic acid, stearic acid, glutamic acid, aspartic acid, methanesulfonic acid, ethanesulfonic acid,
10 ethanedisulfonic acid, p-toluenesulfonic acid, salicylic acid, succinic acid, trifluoroacetic acid, and the like that are non toxic to living organisms or, in case the compound of Formula (I) is acidic in nature, with an inorganic base like an alkali or earth alkali base, e.g. sodium hydroxide, potassium hydroxide, calcium hydroxide and the like. For other examples of pharmaceutically acceptable salts, reference
15 can be made to "Salt selection for basic drugs", *Int. J. Pharm.* (1986), **33**, 201-217.

The compounds of the Formula (I), (II) or (III) may contain one or more asymmetric carbon atoms and can be prepared in form of pure isomers (preferred) or mixtures of isomers such as mixtures of enantiomers like racemates, mixtures of
20 diastereomers, or mixtures of enantiomers and diastereomers such as diastereomeric racemates. The present invention encompasses all these forms. Mixtures can be separated in a manner known *per se*, e.g. by column chromatography, thin layer chromatography (TLC), high performance liquid chromatography (HPLC), or crystallization.

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ii) A particular embodiment of the invention relates to thiophene derivatives according to embodiment i), wherein **R¹** represents an ethyl group.

iii) A particular embodiment of the invention relates to thiophene derivatives
30 according to embodiment i), wherein **R¹** represents a methyl group.

iv) A particular embodiment of the invention relates to thiophene derivatives according to embodiment i), wherein **R¹** represents a trifluoromethyl group.

v) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to iv), wherein R^2 represents a methoxy group, and R^3 and R^4 represent hydrogen.

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vi) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to iv), wherein R^2 represents hydrogen, and R^3 and R^4 represent C_{1-4} -alkyl.

10 vii) Another particular embodiment of the invention relates to thiophene derivatives according to embodiment vi), wherein R^3 and R^4 represent a methyl group.

viii) Another particular embodiment of the invention relates to thiophene derivatives according to embodiment vi), wherein R^3 and R^4 represent an ethyl group.

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ix) A particularly preferred embodiment of the invention relates to thiophene derivatives according to embodiment vi), wherein R^3 represents a methyl group, and R^4 represents an ethyl group.

20 x) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to iv), wherein R^2 represents hydrogen, R^3 represents a methoxy group, and R^4 represents a chlorine atom.

25 xi) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to iv), wherein R^2 represents hydrogen, R^3 represents a methyl group, and R^4 represents a chlorine atom.

30 xii) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to xi), wherein R^5 and R^6 represent hydrogen.

xiii) Another particularly preferred embodiment of the invention relates to thiophene derivatives according to embodiment xii), wherein **n** represents 0 and **m** represents 1.

5 xiv) Another particular embodiment of the invention relates to thiophene derivatives according to embodiment xii), wherein **n** represents 1 and **m** represents 1.

xv) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to xi), wherein **m** represents 1, and **R⁵**
10 and **R⁶** represent hydroxy.

xvi) Another particular embodiment of the invention relates to thiophene derivatives according to embodiment xv), wherein **n** represents 0.

15 xvii) Another particular embodiment of the invention relates to thiophene derivatives according to any one of the embodiments i) to xi), wherein **R⁵** represents hydrogen, and **R⁶** represents hydroxy.

xviii) A further special embodiment of the invention relates to thiophene derivatives
20 according to embodiment i), wherein **R¹** represents trifluoromethyl, methyl or ethyl, **R²**, **R⁵** and **R⁶** represent hydrogen, **R³** and **R⁴** represent C₁₋₄-alkyl, **n** represents 0, and **m** represents 1.

xix) Specific thiophene compounds according to Formula (I) are:

25 3-{4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-2,6-dimethyl-phenyl}-propionic acid;

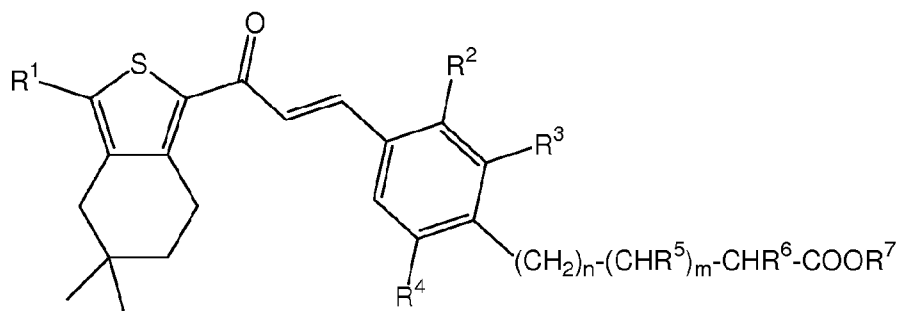
3-{4-[3-(5,5-dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-2-ethyl-6-methyl-phenyl}-propionic acid;

30 3-{2-ethyl-6-methyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propyl]-phenyl}-propionic acid; and

3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-6-methyl-phenyl}-propionic acid.

xx) A further specific thiophene compound according to Formula (I) is 3-{2,6-dimethyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propyl]-phenyl}-propionic acid.

5 xxi) A further aspect of the invention relates to novel thiophenes of Formula (II)



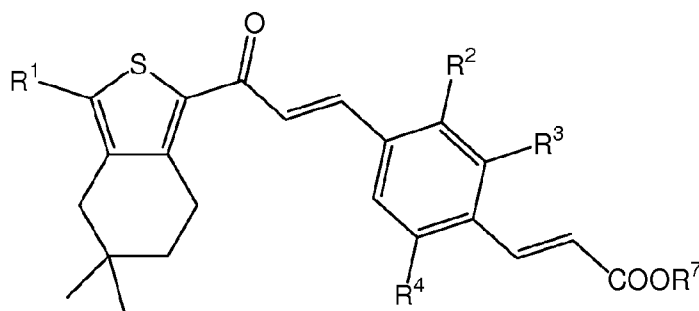
Formula (II)

wherein R^1 , R^2 , R^3 , R^4 , R^5 , R^6 , n and m are as defined for Formula (I) above, and

10 R^7 represents hydrogen, methyl, ethyl, or tert-butyl;

and salts as well as solvent complexes of such compounds.

xxii) Yet another aspect of the invention relates to novel thiophenes of Formula (III)



Formula (III)

wherein R^1 , R^2 , R^3 and R^4 are as defined for Formula (I) above, and

R^7 represents hydrogen, methyl, ethyl, or tert-butyl;

and salts as well as solvent complexes of such compounds.

The compounds of Formula (I) and their pharmaceutically acceptable salts can be used as medicaments, e.g. in the form of pharmaceutical compositions for enteral, parental or topical administration. They can be administered, for example, perorally, e.g. in the form of tablets, coated tablets, dragées, hard and soft gelatine capsules, solutions, emulsions or suspensions, rectally, e.g. in the form of suppositories, parenterally, e.g. in the form of injection solutions or infusion solutions, or topically, e.g. in the form of ointments, creams or oils.

The production of the pharmaceutical compositions can be effected in a manner which will be familiar to any person skilled in the art (see for example Mark Gibson, Editor, Pharmaceutical Preformulation and Formulation, IHS Health Group, Englewood, CO, USA, 2001; Remington, The Science and Practice of Pharmacy, 20th Edition, Philadelphia College of Pharmacy and Science) by bringing the described compounds of Formula (I) or their pharmaceutically acceptable salts, optionally in combination with other therapeutically valuable substances, into a galenical administration form together with suitable, non-toxic, inert, pharmaceutically acceptable solid or liquid carrier materials and, if desired, usual pharmaceutical adjuvants.

The pharmaceutical compositions comprising a compound of Formula (I) are useful for the prevention and/or treatment of diseases or disorders associated with an activated immune system.

Such diseases or disorders are selected from the group consisting of rejection of transplanted organs, tissue or cells; graft-versus-host diseases brought about by transplantation; autoimmune syndromes including rheumatoid arthritis; systemic lupus erythematosus; antiphospholipid syndrome; Hashimoto's thyroiditis; lymphocytic thyroiditis; multiple sclerosis; myasthenia gravis; type I diabetes; uveitis; episcleritis; scleritis; Kawasaki's disease, uveo-retinitis; posterior uveitis; uveitis associated with Behcet's disease; uveomeningitis syndrome; allergic encephalomyelitis; chronic allograft vasculopathy; post-infectious autoimmune diseases including rheumatic fever and post-infectious glomerulonephritis; inflammatory and hyperproliferative skin diseases; psoriasis; psoriatic arthritis;

atopic dermatitis; myopathy; myositis; osteomyelitis; contact dermatitis; eczematous dermatitis; seborrhoeic dermatitis; lichen planus; pemphigus; bullous pemphigoid; epidermolysis bullosa; urticaria; angioedema; vasculitis; erythema; cutaneous eosinophilia; acne; scleroderma; alopecia areata; keratoconjunctivitis; vernal

5 conjunctivitis; keratitis; herpetic keratitis; dystrophia epithelialis corneae; corneal leukoma; ocular pemphigus; Mooren's ulcer; ulcerative keratitis; scleritis; Graves' ophthalmopathy; Vogt-Koyanagi-Harada syndrome; sarcoidosis; pollen allergies; reversible obstructive airway disease; bronchial asthma; allergic asthma; intrinsic asthma; extrinsic asthma; dust asthma; chronic or inveterate asthma; late asthma

10 and airway hyper-responsiveness; bronchiolitis; bronchitis; endometriosis; orchitis; gastric ulcers; ischemic bowel diseases; inflammatory bowel diseases; necrotizing enterocolitis; intestinal lesions associated with thermal burns; coeliac disease; proctitis; eosinophilic gastroenteritis; mastocytosis; Crohn's disease; ulcerative colitis; vascular damage caused by ischemic diseases and thrombosis;

15 atherosclerosis; fatty heart; myocarditis; cardiac infarction; aortitis syndrome; cachexia due to viral disease; vascular thrombosis; migraine; rhinitis; eczema; interstitial nephritis; IgA-induced nephropathy; Goodpasture's syndrome; hemolytic-uremic syndrome; diabetic nephropathy; glomerulosclerosis; glomerulonephritis; tubulointerstitial nephritis; interstitial cystitis; multiple myositis; Guillain-Barré

20 syndrome; Meniere's disease; polyneuritis; multiple neuritis; myelitis; mononeuritis; radiculopathy; hyperthyroidism; Basedow's disease; thyrotoxicosis; pure red cell aplasia; aplastic anemia; hypoplastic anemia; idiopathic thrombocytopenic purpura; autoimmune hemolytic anemia; autoimmune thrombocytopenia; agranulocytosis; pernicious anemia; megaloblastic anemia; anerythroplasia; osteoporosis; fibroid

25 lung; idiopathic interstitial pneumonia; dermatomyositis; leukoderma vulgaris; ichthyosis vulgaris; photoallergic sensitivity; cutaneous T cell lymphoma; polyarteritis nodosa; Huntington's chorea; Sydenham's chorea; myocardosis; myocarditis; scleroderma; Wegener's granuloma; Sjogren's syndrome; adiposis; eosinophilic fascitis; lesions of gingiva, periodontium, alveolar bone, substantia

30 ossea dentis; male pattern alopecia or alopecia senilis; muscular dystrophy; pyoderma; Sezary's syndrome; hypophysitis; chronic adrenal insufficiency; Addison's disease; ischemia-reperfusion injury of organs which occurs upon preservation; endotoxin shock; pseudomembranous colitis; colitis caused by drug or

radiation; ischemic acute renal insufficiency; chronic renal insufficiency; lung cancer; malignancy of lymphoid origin; acute or chronic lymphocytic leukemias; lymphoma; pulmonary emphysema; cataracta; siderosis; retinitis pigmentosa; senile macular degeneration; vitreal scarring; corneal alkali burn; dermatitis erythema; ballous dermatitis; cement dermatitis; gingivitis; periodontitis; sepsis; pancreatitis; peripheral artery disease; carcinogenesis; solid cancer tumors; metastasis of carcinoma; hypobaropathy; autoimmune hepatitis; primary biliary cirrhosis; sclerosing cholangitis; partial liver resection; acute liver necrosis; cirrhosis; alcoholic cirrhosis; hepatic failure; fulminant hepatic failure; late-onset hepatic failure; and "acute-on-chronic" liver failure.

Preferred diseases or disorders to be treated and/or prevented with the compounds of Formula (I) are selected from the group consisting of rejection of transplanted organs such as kidney, liver, heart, lung, pancreas, cornea, and skin; graft-versus-host diseases brought about by stem cell transplantation; autoimmune syndromes including rheumatoid arthritis, multiple sclerosis, inflammatory bowel diseases such as Crohn's disease and ulcerative colitis, psoriasis, psoriatic arthritis, thyroiditis such as Hashimoto's thyroiditis, uveo-retinitis; atopic diseases such as rhinitis, conjunctivitis, dermatitis; asthma; type I diabetes; post-infectious autoimmune diseases including rheumatic fever and post-infectious glomerulonephritis; solid cancers and tumor metastasis.

Particularly preferred diseases or disorders to be treated and/or prevented with the compounds of Formula (I) are selected from the group consisting of rejection of transplanted organs selected from kidney, liver, heart and lung; graft-versus-host diseases brought about by stem cell transplantation; autoimmune syndromes selected from rheumatoid arthritis, multiple sclerosis, psoriasis, psoriatic arthritis, Crohn's disease, and Hashimoto's thyroiditis; and atopic dermatitis.

The present invention also relates to a method for the prevention or treatment of a disease or disorder mentioned herein comprising administering to a subject a pharmaceutically active amount of a compound of Formula (I).

Furthermore, compounds of the Formula (I) are also useful, in combination with one or several immunomodulating agents, for the prevention and/or treatment of the diseases and disorders mentioned herein. According to a preferred embodiment of the invention, said agents are selected from the group consisting of

5 immunosuppressants, corticosteroids, NSAID's, cytotoxic drugs, adhesion molecule inhibitors, cytokines, cytokine inhibitors, cytokine receptor antagonists and recombinant cytokine receptors.

The present invention also relates to the use of a compound of Formula (I) for the

10 preparation of a pharmaceutical composition, optionally for use in combination with one or several immunomodulating agents, for the prevention or treatment of the diseases and disorders mentioned herein.

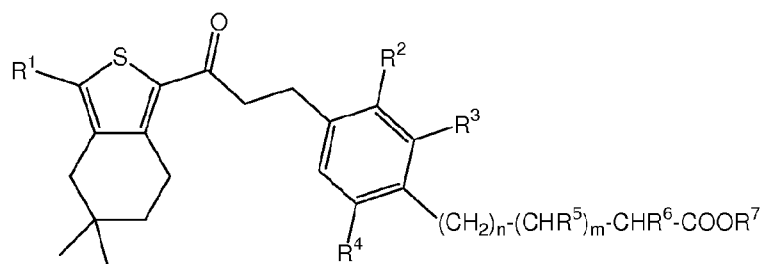
The present invention also relates to pro-drugs of a compound of Formula (I) that

15 convert *in vivo* to the compound of Formula (I) as such. Any reference to a compound of Formula (I) is therefore to be understood as referring also to the corresponding pro-drugs of the compound of Formula (I), as appropriate and expedient.

20 The compounds of Formula (I) can be manufactured by the methods given below, by the methods given in the Examples or by analogous methods. Optimum reaction conditions may vary with the particular reactants or solvents used, but such conditions can be determined by a person skilled in the art by routine optimisation procedures.

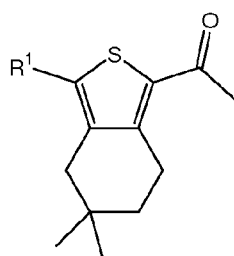
25 Compounds of the Formula (I) of the present invention can be prepared according to the general sequence of reactions outlined below. Only a few of the synthetic possibilities leading to compounds of Formula (I) are described.

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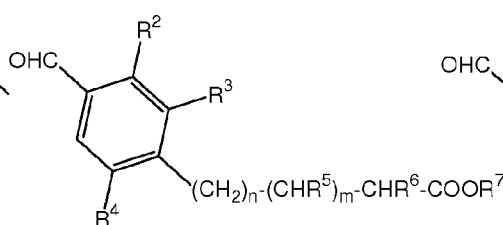


Structure 1

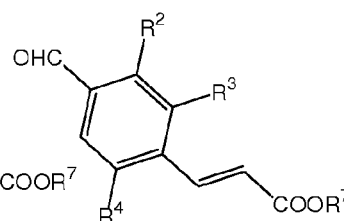
The compounds of Formula (I) may be prepared by reacting a compound of
 5 Structure 1 with a base such as aq. LiOH, aq. NaOH, aq. KOH, etc. or an acid such
 as aq. HCl, TFA, etc. in the presence or absence of additional solvents such as
 THF, dioxane, DMF, DMSO, DCM etc. Compounds of Structure 1 may be prepared
 by hydrogenation of a compound of Formula (II), or in case n represents 0, m
 represents 1 and R⁵ and R⁶ represent hydrogen, by hydrogenation of a compound
 10 of Formula (III) in the presence of a catalyst such as Pd/C, Pt/C etc. in a solvent
 such as methanol, ethanol, THF etc., or mixtures thereof.



Structure 2



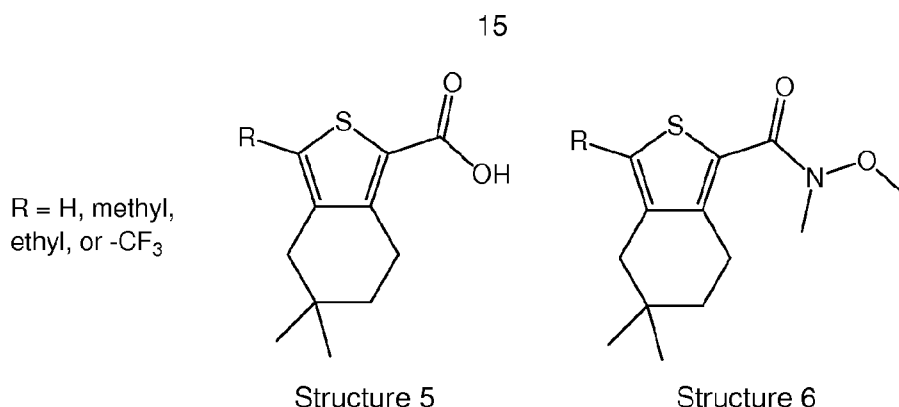
Structure 3



Structure 4

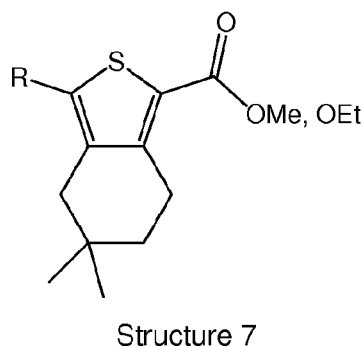
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Compounds of Formula (II) may be prepared by condensing a compound of
 Structure 2 with a compound of Structure 3 in the presence of HCl in a solvent such
 as ethanol, isopropanol, etc., or mixtures thereof, or in the presence of NaOH,
 LiOH, or KOH in a solvent such as methanol, ethanol, isopropanol, or mixtures
 20 thereof, at temperatures preferably between 0°C and 70°C. Similarly, a compound
 of Formula (III) may be prepared by condensing a compound of Structure 2 with a
 compound of Structure 4.



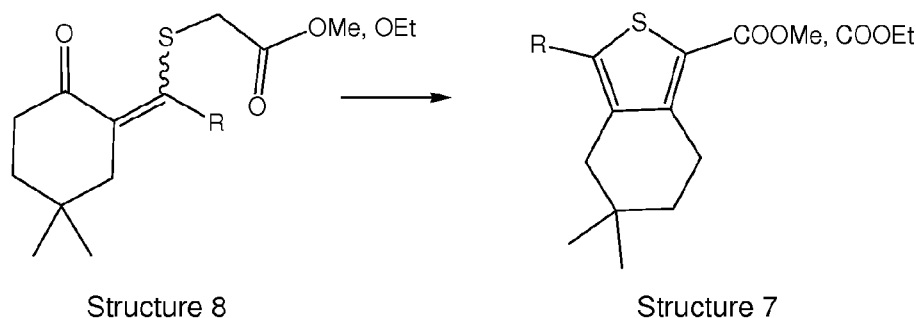
A compound of Structure 2 may be prepared by reacting a compound of Structure 5, wherein R is methyl, ethyl or trifluoromethyl, with MeLi in a solvent such as diethyl ether, or THF or mixtures thereof at temperatures between -20°C and 35°C. Alternatively, a compound of Structure 2 may also be prepared by reacting a compound of Structure 6, wherein R is methyl, ethyl or trifluoromethyl, with methyl magnesiumbromide, methyl magnesiumchloride, or methyl magnesiumiodide. The Weinreb amide of Structure 6 may be prepared by reacting an acid of Structure 5 with N,O-dimethylhydroxylamine hydrochloride in the presence of a coupling reagent such as EDC, DCC, etc. (Lit. e.g. M. Mentzel, H. M. R. Hoffmann, *Journal fuer Praktische Chemie/Chemiker-Zeitung* **339** (1997), 517-524; J. Singh, N. Satyamurthi, I. S. Aidhen, *Journal fuer Praktische Chemie* (Weinheim, Germany) **342** (2000), 340-347; V. K. Khlestkin, D. G. Mazhukin, *Current Organic Chemistry* **7** (2003), 967-993).

The compounds of Structure 5 may be prepared by reacting a compound of Structure 7 with an aq. base such as aq. NaOH, aq. LiOH, aq. KOH, etc. or an acid such as aq. HCl, TFA, etc. in a solvent such as water, ethanol, methanol, THF, etc., or mixtures thereof.



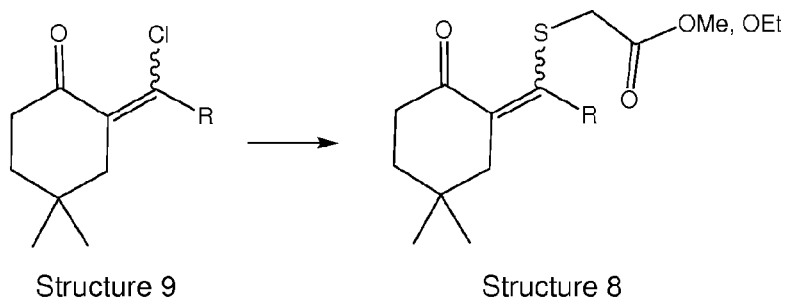
The compounds of Structure 7 are prepared by treating a compound of Structure 8 with a non-aqueous base such as NaOMe, NaOEt, KO-tert-Bu, DBU, etc. in a solvent such as methanol, ethanol, THF, DMF, etc., or mixtures thereof, preferably at elevated temperatures.

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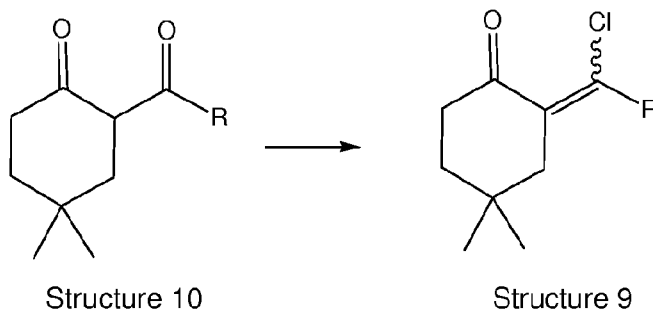
The compounds of Structure 8 are prepared by treating a compound of Structure 9 with a 2-mercaptoacetic acid ester in the presence of a base such as NaH, NaOEt, NaOMe, K-tert-butoxide, etc. in THF, dioxane, DMF, ethanol, methanol, etc., or mixtures thereof. In addition, the compounds of Structure 5 may also be prepared in a one-pot-three-step procedure starting from a compound of Structure 9 following the above reaction sequence.

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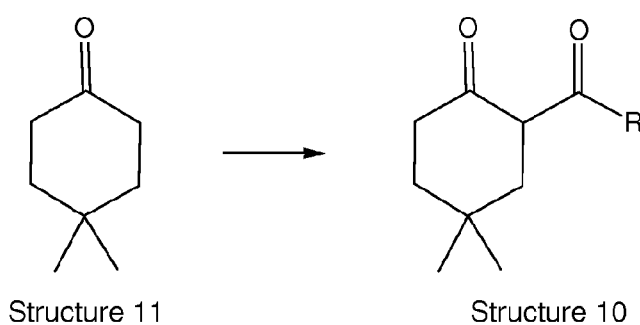


The compounds of Structure 9 are prepared by reacting a compound of Structure 10 with a chlorinating agent such as oxalylchloride in a solvent such as DCM, CHCl₃, THF, etc. (Lit. e.g. R. E. Mewshaw, Richard E. *Tetrahedron Lett.* **30** (1989), 3753-3756; F. A. Lakhvich, T. S. Khlebnikova, A. A. Akhrem, *Zhurnal Organicheskoi Khimii* **25** (1989), 2541-2549).

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The compounds of Structure 10, wherein R represents hydrogen, methyl or ethyl, may be prepared by acylating the compound of Structure 11 with an appropriate acylating agent such as ethyl or methyl formate, methyl or ethyl acetate, methyl or ethyl propionate, chloroformate, acetyl chloride, etc. in the presence of a base such as K-tert-butyrate, NaOMe, NaH, LDA, etc. in a solvent such as THF, toluene, EtOH etc. at temperatures between 0 and 60°C. (Lit. e.g. Ch. Kashima, S. Shibata, H. Yokoyama, T. Nishio, *Journal of Heterocyclic Chemistry* **40** (2003), 773-782; I. Yavari, Issa; M. Bayat, *Tetrahedron* **59** (2003), 2001-2005; J. P. Konopelski, J. Lin, P. J. Wenzel, H. Deng, G. I. Elliott, B. S. Gerstenberger, *Organic Letters* **4** (2002), 4121-4124; C. Wiles, P. Watts, S. J. Haswell, E. Pombo-Villar, *Tetrahedron Letters* **43** (2002), 2945-2948; R. Faure, A. Frideling, J.-P. Galy, I. Alkorta, J. Elguero, *Heterocycles* **57** (2002), 307-316; via imine: M. Hammadi, D. Villemin, *Synthetic Communications* **26** (1996), 2901-2904).

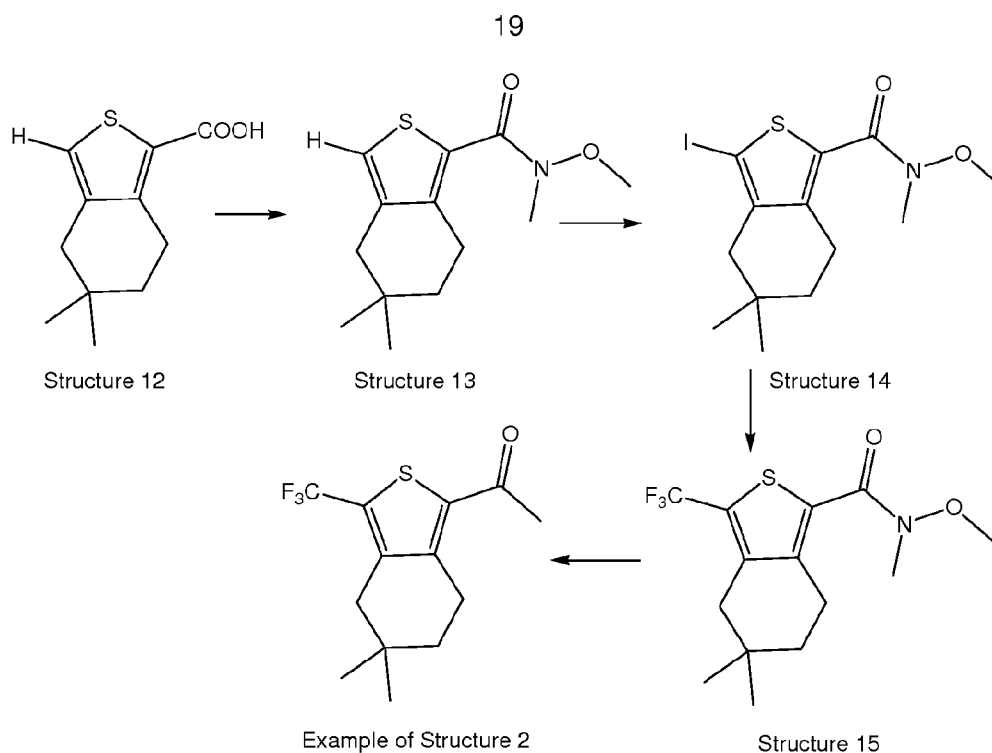


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The compound of Structure 11 is prepared according to procedures known to a person skilled in the art (Lit. e.g. M. E. Flaugh, T. A. Crowell, D. S. Farlow, *Journal of Organic Chemistry* **45** (1980), 5399-5400; A. M. Badger, M. J. Dimartino, C. K. Mirabelli, E. N. Cheeseman, J. W. Dorman, D. H. Picker, D. A. Schwartz, Eur. Pat.

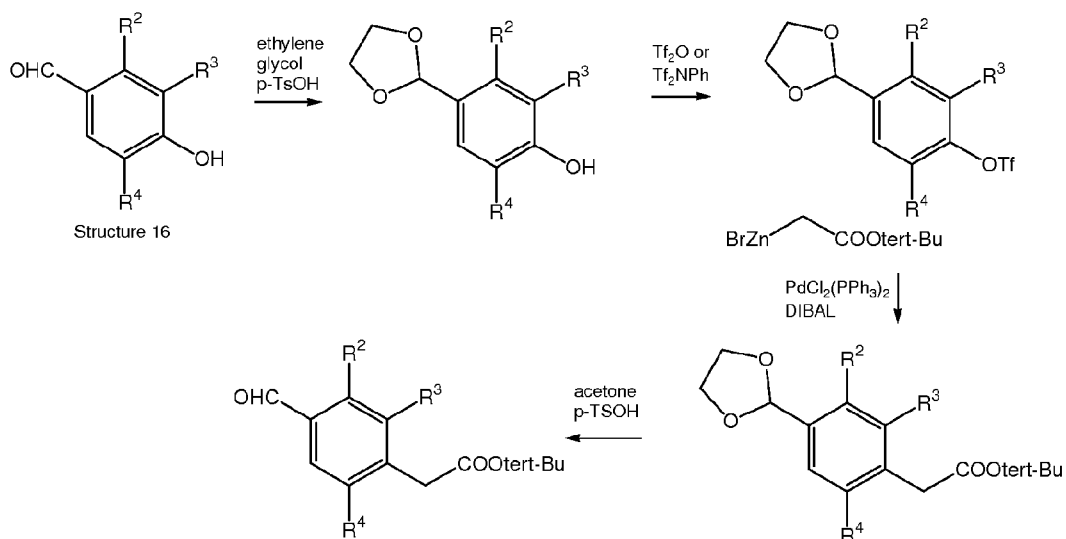
Appl. EP 310321 A2 (1989); N. R. Natale, R. O. Hutchins, *Organic Preparations and Procedures International* **9** (1977), 103-108; L. M. Rice, B. S. Sheth, J. W. Wheeler, *Journal of Heterocyclic Chemistry* **10** (1973), 731-735).

- 5 In addition, the compounds of Structure 5, wherein R represents a methyl or ethyl group, are preferably prepared from a compound of Structure 5 wherein R represents hydrogen (Structure 12) by reacting the latter compound with an excess of a strong base such as n-BuLi, tert-BuLi, LDA, etc. in a solvent such as THF, diethyl ether, etc. followed by the appropriate alkylating agent (e.g. methyl iodide, ethyl iodide, Lit. e.g. W.-D. Liu, C.-C. Chi, I.-F. Pai, A.-T. Wu, W.-S. Chung, *Journal of Organic Chemistry* **67** (2002), 9267-9275; D. W. Knight, A. P. Nott, *Tetrahedron Letters* **21** (1980), 5051-5054; R. Raap, *Canadian Journal of Chemistry* **49** (1971), 2155-2157).
- 10
- 15 The compounds of Structure 2 wherein R¹ represents a trifluoromethyl group are preferably prepared by the sequence outlined below. Hence, the compound of Structure 12 is transformed into its Weinreb amide of Structure 13, which is iodinated upon treatment with a strong base such as LDA followed by the addition of iodine in a solvent such as THF at low temperature (e.g. -78°C). The iodinated
- 20 compound of Structure 14 is reacted with methyl chlorodifluoroacetate as described in the literature (e.g. D. E. Nichols, S. Frescas, D. Marona-Lewicka, X. Huang, B. L. Roth, G. A. Gudelsky, J. F. Nash, *J. Med. Chem.* **37** (1994), 4346-4351) to give the trifluoromethyl compound of Structure 15. Treatment of the compound Structure 15 with a methyl Grignard reagent or methyl lithium furnishes the compound of
- 25 Structure 2 wherein R¹ represents a trifluoromethyl group.

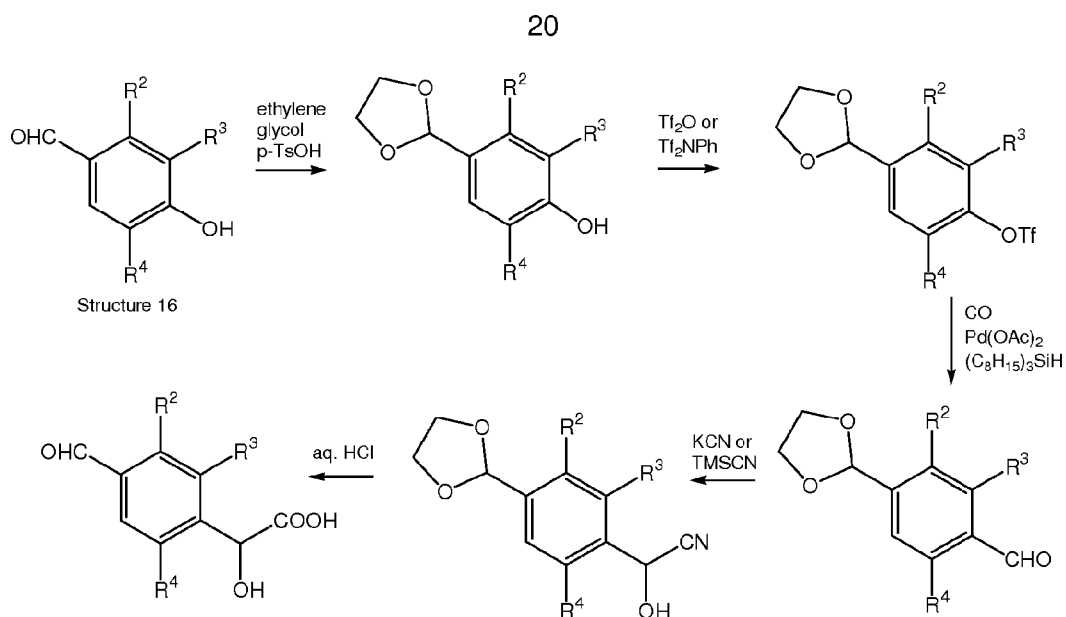


The following schemes illustrate synthetic routes to prepare compounds of Structure 3 and 4.

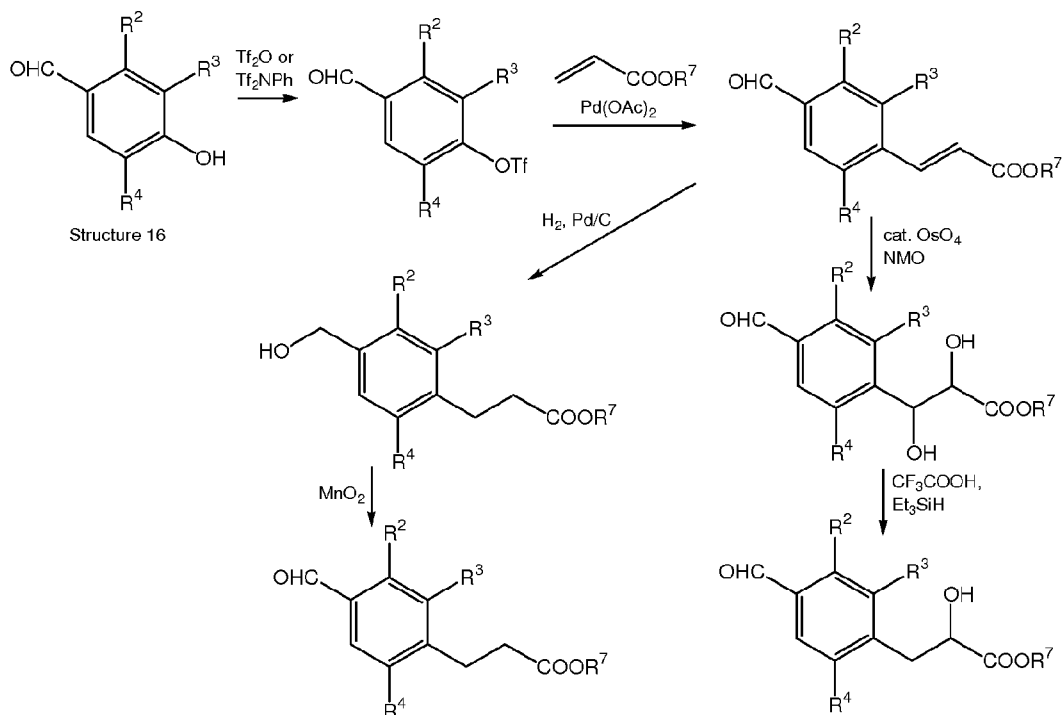
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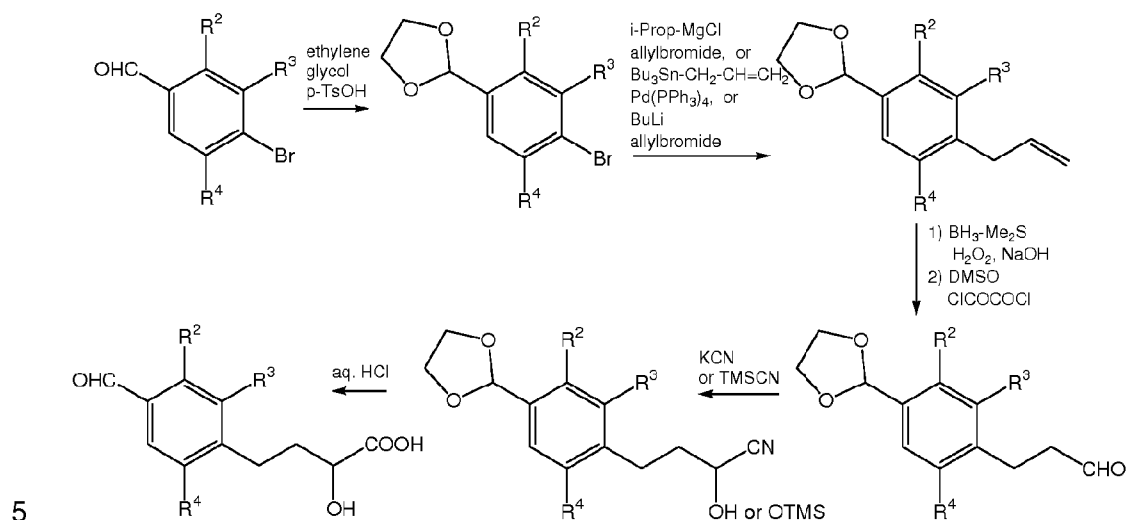
(Lit. e.g. F. Orsini, F. Pelizzoni, *Synthetic Comm.* **17** (1987), 1389-1402)



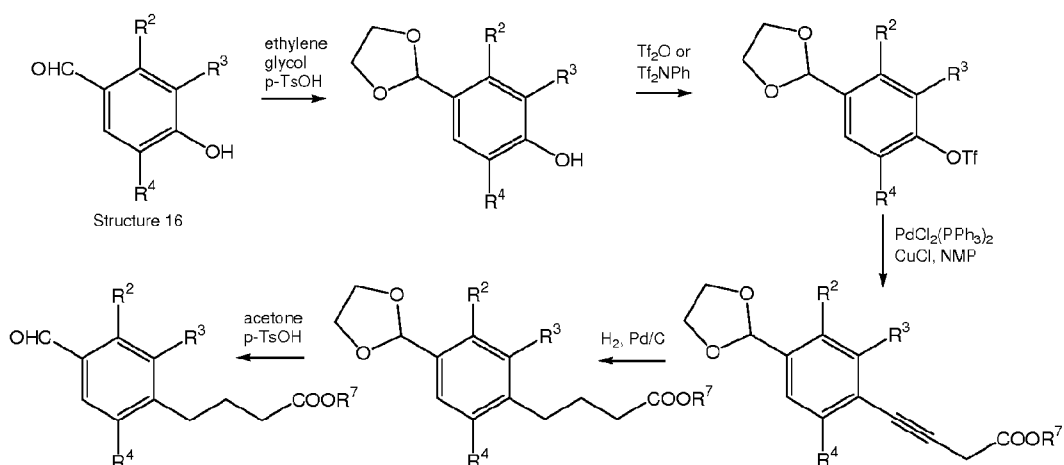
- (Lit. e.g. H. Kotsuki, P. K. Datta, H. Suenaga, *Synthesis* **1996**, 470-472; for bromide or iodide instead of triflate see e.g. V. P. Baillargeon, J. K. Stille, *J. Am. Chem. Soc.* **108** (1986), 452-461; M. J. Gomez-Escalonilla, F. Langa, J.-M. Rueff, L. Oswald, J. F. Nierengarten, *Tetrahedron Lett.* **43** (2002), 7507-7511; H. Aust, D. Ickenroth, H. Meier, *J. Prakt. Chem.* **341** (1999), 523-528; Y. Li, B. He, B. Qin, X. Feng, G. Zhang, *J. Org. Chem.* **69** (2004), 7910-7913).



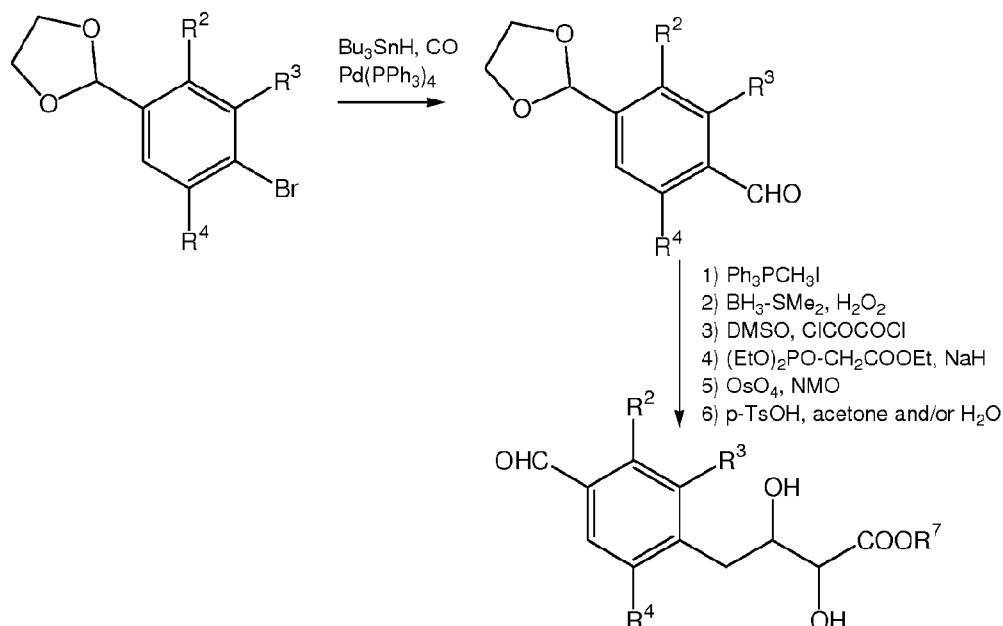
(Lit. e.g. G. Battistuzzi, S. Cacchi, G. Fabrizi, *Org. Lett.* **5** (2003), 777-780; N. J. Lawrence, S. Brown, *Tetrahedron* **58** (2002), 613-619; D. J. Wardrop, M. S. Burge, *Chem. Comm.* **2004**, 1230-1231)



(Lit. e.g. Y. Li, B. He, B. Qin, X. Feng, G. Zhang, *J. Org. Chem.* **69** (2004), 7910-7913; T. Azemi, M. Kitamura, K. Narasaka, *Tetrahedron* **60** (2004), 1339-1344; A. Krasovskiy, P. Knochel, *Angew. Chem. Int. Ed.* **43** (2004), 3333-3336; T. P. Zabawa, D. Kasi, S. R. Chemler, *J. Am. Chem. Soc.* **127** (2005), 11250-11251).



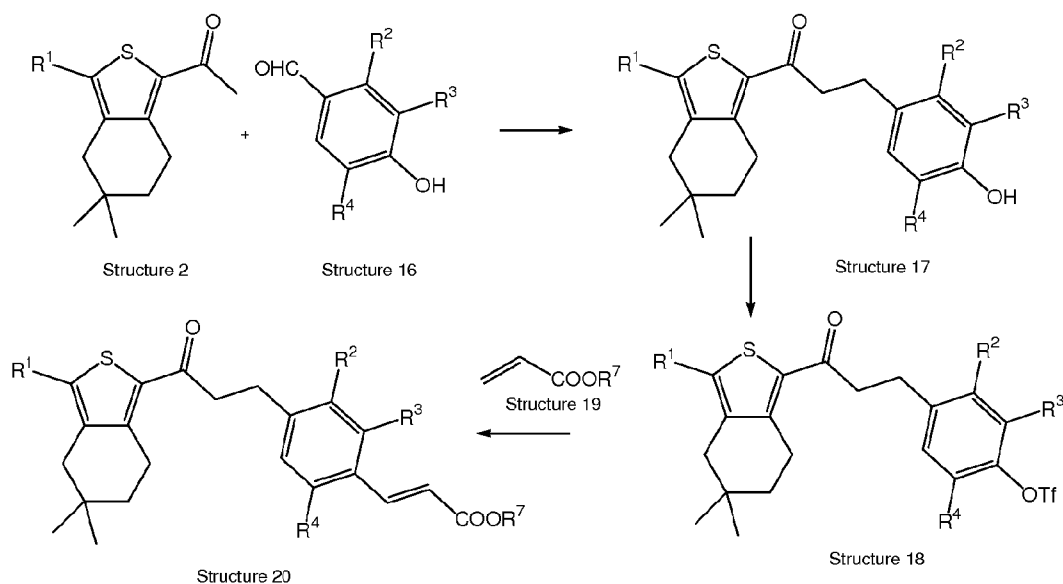
(Lit. e.g. W. P. Gallagher, R. E. Maleczka, *J. Org. Chem.* **68** (2003), 6775-6779, A.-Y. Peng, Y.-X. Ding, *J. Am. Chem. Soc.* **125** (2003), 15006-15007).



(Lit. e.g. R. A. Fernandes, M. S. Bodas, P. Kumar, *Tetrahedron* **58** (2002), 1223-1227; V. P. Baillargeon, J. K. Stille, *J. Am. Chem. Soc.* **108** (1986), 452-461).

An alternative route to prepare compounds of Structure 1 is given in the scheme below. The compounds of Structure 17 are obtained by condensing a compound of Structure 2 with a compound of Structure 16 under the either basic or acidic conditions mentioned above. The compounds of Structure 16 are either commercially available or are prepared following standard methodology known to a person skilled in the art. Treatment of a compound of Structure 17 with e.g. trifluoromethanesulfonic anhydride in the presence of a base such as triethylamine or pyridine affords the compounds of Structure 18. Pd-catalysed Heck-type coupling reaction of a compound of Structure 18 with a compound of Structure 19 gives the corresponding compound of Structure 20 (Lit. e.g. G. Battistuzzi, S. Cacchi, G. Fabrizi, *Org. Lett.* **5** (2003), 777-780). Depending on the reaction conditions applied, the alcohol functionality present in the case where R^6 represents a hydroxy group may require temporary protection. The double bond present in the compound of Structure 20 may then be further elaborated to the desired motif disclosed in Structure 1. These steps are in analogy to those outlined for the preparation of compounds of Structure 3 and 4 above and thus may include simple hydrogenation

to obtain the saturated derivative or dihydroxylation using e.g. KMnO_4 or a catalytic amount of OsO_4 in the presence of N-methyl morpholine-N-oxide (NMO) whereupon the reductive removal of the benzylic alcohol may follow (Lit. e.g. N. J. Lawrence, S. Brown, *Tetrahedron* **58** (2002), 613-619; D. J. Wardrop, M. S. Burge, *Chem. Comm.* **2004**, 1230-1231). The cross coupling reaction may also be carried out with an alkyne rather than an alkene (Sonogashira coupling, e.g. W. P. Gallagher, R. E. Maleczka, *J. Org. Chem.* **68** (2003), 6775-6779; A.-Y. Peng, Y.-X. Ding, *J. Am. Chem. Soc.* **125** (2003), 15006-15007). The such produced phenylacetylene derivative may then be hydrogenated in a sequential or a one-step fashion to the corresponding saturated compound.



15 Examples

The following examples illustrate the invention but do not at all limit the scope thereof.

All temperatures are stated in °C. Compounds are characterized by ^1H -NMR (300 MHz) or ^{13}C -NMR (75 MHz) (Varian Oxford; chemical shifts are given in ppm relative to the solvent used; multiplicities: s = singlet, d = doublet, t = triplet, p = pentuplet, hex = hexet, hept = heptet, m = multiplet, br = broad, coupling constants

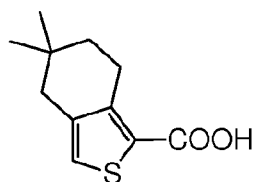
are given in Hz); by LC-MS (Finnigan Navigator with HP 1100 Binary Pump and DAD, column: 4.6x50 mm, Zorbax SB-AQ, 5 μ m, 120 Å, gradient: 5-95% acetonitrile in water, 1 min, with 0.04% trifluoroacetic acid, flow: 4.5 mL/min), t_R is given in min; by TLC (TLC-plates from Merck, Silica gel 60 F₂₅₄); or by melting point. Compounds are purified by preparative HPLC (conditions if not stated otherwise: column: X-terra RP18, 50x19 mm, 5 μ m, gradient: 10-95% acetonitrile in water containing 0.5 % of formic acid) or by MPLC (Labomatic MD-80-100 pump, Linear UVIS-201 detector, column: 350x18 mm, Labogel-RP-18-5s-100, gradient: 10% methanol in water to 100% methanol).

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Abbreviations (as used herein):

	aq.	aqueous
	atm	atmosphere
	BSA	bovine serum albumin
15	Bu	butyl
	cat.	catalytic
	CC	column chromatography
	d	day(s)
	DBU	1,8-diazabicyclo[5.4.0]undec-7-en
20	DCC	dicyclohexyl carbodiimide
	DCM	dichloromethane
	DIBAL	diisobutylaluminium hydride
	DIPEA	diisopropyl-ethylamine, Hünig's base, ethyl-diisopropylamine
	DMF	dimethylformamide
25	DMSO	dimethylsulfoxide
	EA	ethyl acetate
	EDC	N-(3-dimethylaminopropyl)-N'-ethyl-carbodiimide
	Et	ethyl
	h	hour(s)
30	HPLC	high performance liquid chromatography
	HV	high vacuum conditions
	i-Prop	isopropyl
	LC-MS	liquid chromatography – mass spectrometry

	LDA	lithium diisopropyl amide
	Me	methyl
	min	minute(s)
	MPLC	medium pressure liquid chromatography
5	NMO	N-methyl morpholine-N-oxide
	NMP	1-methyl-2-pyrrolidone
	OAc	acetate
	OTMS	trimethylsilyloxy
	Ph	phenyl
10	prep.	preparative
	p-TSOH	para-toluenesulfonic acid
	rt	room temperature
	sat.	saturated
	S1P	sphingosine 1-phosphate
15	TBTU	2-(1H-benzotriazole-1-yl)-1,2,3,3-tetramethyluronium tetrafluoroborate
	Tf	trifluoromethane sulfonyl
	TFA	trifluoroacetic acid
	THF	tetrahydrofuran
20	TLC	thin layer chromatography
	TMSCN	trimethylsilyl cyanide
	t _R	retention time

Scaffold A

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a) To a solution of 4,4-dimethyl-cyclohex-2-enone (50 g, 403 mmol) in EA (230 mL) a suspension of Pd/C (2.5 g, 10% Pd) in EA is added. The suspension is stirred at rt for 2 h under 1 bar H₂. The catalyst is filtered off and the solvent of the filtrate is carefully evaporated to give 4,4-dimethyl-cyclohexanone (50 g) as a colourless oil

which slowly crystallizes; ^1H NMR (CDCl_3): δ 2.34 (t, $J = 6.4$ Hz, 4H), 1.66 (t, $J = 6.4$ Hz, 4H), 1.09 (s, 6H).

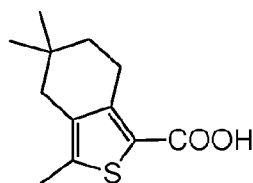
b) To an ice-cold solution of K-tert-butyrate (24.5 g, 109 mmol, 50% solution in tert-butanol) in THF (700 mL), ethylformate (120 mL, 123 mmol) is slowly added. The mixture is stirred at rt for 30 min before a solution of 4,4-dimethyl-cyclohexanone (50 g, 396 mmol) in ethylformate (50 mL) and THF (70 mL) is added over a period of 20 min. Upon complete addition, stirring is continued at 15-20°C for 30 min. The orange suspension is poured onto a 10% aq. citric acid solution (200 mL) and brine (200 mL) and extracted with EA (2x200 mL). The organic extracts are washed with 0.2 N aq. NaOH and brine, dried over Na_2SO_4 and evaporated to dryness to give 5,5-dimethyl-2-oxo-cyclohexanecarbaldehyde (52 g) as a yellow oil; LC-MS: $t_R = 0.89$ min, $[\text{M}+1+\text{CH}_3\text{CN}]^+ = 196.15$.

c) To a solution of 5,5-dimethyl-2-oxo-cyclohexanecarbaldehyde (51 g, 331 mmol) in chloroform (250 mL), oxalyl chloride (40 mL, 465 mmol) is rapidly added. After stirring for 3-4 min, ice followed by 2 N aq. NaOH (100 mL) is added. The organic phase is separated and the aq. phase is extracted once more with chloroform. The combined organic extracts are washed with water and dried over Na_2SO_4 . The solvent is removed *in vacuo* to give 2-chloromethylene-4,4-dimethyl-cyclohexanone (50 g) as a brown oil; LC-MS: $t_R = 0.96$ min.

d) To a part (300 mL) of a freshly prepared solution of sodium (21 g, 875 mmol) in ethanol (500 mL), mercaptoacetic acid ethyl ester (50 mL) is added. The resulting solution is added over a period of 10 min to a solution of 2-chloromethylene-4,4-dimethyl-cyclohexanone (50 g, 290 mmol) in THF (170 mL). The mixture becomes warm (50°C). Upon complete addition, the remaining part of the freshly prepared solution of sodium in ethanol (200 mL) is added to the reaction mixture. The mixture is stirred at rt for 15 min before 1 N aq. LiOH solution (300 mL) is added. The solution is refluxed for 3 h, then stirred at rt for 16 h. The THF and ethanol are removed under reduced pressure and the remaining dark solution is extracted with heptane/EA 3:1 (2x200 mL). The aq. phase is acidified by adding citric acid (30 g) and 2 N aq. HCl (200 mL) and then extracted three times with EA. The combined

organic extracts are washed three times with sat. aq. NaHCO_3 solution, dried over Na_2SO_4 and evaporated. The resulting dark brown oil is dissolved in acetonitrile at 60°C and crystallised at 5°C . The crystals are collected, washed with acetonitrile and dried to give 5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (31 g) as a slightly grey powder; LC-MS: $t_R = 0.95$ min, $[\text{M}+1+\text{CH}_3\text{CN}]^+ = 252.18$; ^1H NMR (CDCl_3): δ 7.15 (s, 1H), 3.05 (t, $J = 7.0$ Hz, 2H), 2.47 (s, 2H), 1.58 (t, $J = 7.0$ Hz, 2H), 0.97 (s, 6H).

Scaffold B



1) Via Scaffold A

At -78°C a solution of 5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (5 g, 23.8 mmol) in THF is treated with tert-butyllithium (41 mL, 1.5 M in pentane). The mixture is stirred at -78°C for 15 min before methyl iodide (17.1 g, 120 mmol) is added dropwise. Stirring is continued at -78°C for 30 min. The mixture is warmed to rt, diluted with water (400 mL), acidified with 10% aq. citric acid solution and extracted three times with EA. The combined organic extracts are dried over MgSO_4 and evaporated. The remaining solid is suspended in heptane/diethyl ether, filtered and dried under HV to give 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (4.01 g) as a beige powder; LC-MS: $t_R = 0.97$ min; $[\text{M}+1] = 225.13$; ^1H NMR ($\text{D}_6\text{-DMSO}$): δ 12.49 (s br, 1H), 2.87 (t, $J = 6.7$ Hz, 2H), 2.26 (s, 5H), 1.45 (t, $J = 6.7$ Hz, 2H), 0.91 (s, 6H).

2) Direct route starting from 4,4-dimethyl-cyclohexanone

a) To a suspension of NaH (2.88 g, 60% dispersion in mineral oil, 60 mmol) in toluene (25 mL), EA (6.5 mL, 66 mmol) is added. The mixture is stirred at rt for 5 min before a solution of 4,4-dimethyl-cyclohexanone (2.52 g, 20 mmol) in EA (6 mL) is added. The mixture is heated to 55°C where a vigorous reaction starts. The white to grey suspension turns orange and becomes clear. The clear solution is poured onto ice/water and is extracted with EA. The aq. phase is acidified to pH 4-5 and

extracted once more with EA. The combined organic extracts are dried over Na_2SO_4 and the solvent is removed *in vacuo* to give 2-acetyl-4,4-dimethyl-cyclohexanone (2.00 g) as a yellow oil; ^1H NMR (CDCl_3): δ 2.35 (t, $J = 7.0$ Hz, 2H), 2.12 (s, 2H), 2.10 (s, 1H), 1.48 (t, $J = 7.0$ Hz, 2H), 0.98 (s, 6H).

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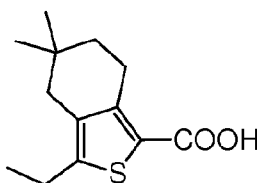
b) At 0°C , a solution of 2-acetyl-4,4-dimethyl-cyclohexanone (5.00 g, 29.7 mmol) in chloroform (15 mL) is treated with oxalyl chloride (7.54 g, 59.4 mmol). The mixture is heated to 60°C and stirred for 15 min before it is poured onto water. The organic phase is separated, washed with sat. aq. NaHCO_3 solution and brine, dried over
10 MgSO_4 and evaporated to dryness to give crude 2-(1-chloro-ethylidene)-4,4-dimethyl-cyclohexanone (3.2 g, containing regio-isomer) as a brown oil, LC-MS: $t_R = 1.00$ min.

c) To a mixture of NaOEt (10 mL of a 2.5 M solution in ethanol, 25 mmol) in THF
15 (10 mL), mercaptoacetic acid ethyl ester (3.09 g, 25.7 mmol) followed by a solution of the above 2-(1-chloro-ethylidene)-4,4-dimethyl-cyclohexanone (3.2 g, 17.14 mmol) is added. The resulting solution is stirred at 60°C for 45 min. The mixture is diluted with water and extracted with EA. The organic extract is dried over Na_2SO_4 , evaporated and purified by CC on silica gel eluting with heptane/toluene and then
20 heptane/EA to give 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[b]thiophene-2-carboxylic acid ethyl ester (3.1 g) as a brown oil containing the regio isomer 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[b]thiophene-2-carboxylic acid ethyl ester. An analytical sample is purified by prep. HPLC to give pure 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[b]thiophene-2-carboxylic acid ethyl ester as a colourless oil; LC-
25 MS: $t_R = 1.13$ min; $[M+1] = 252.99$; ^1H NMR (CDCl_3): δ 4.29 (q, $J = 7.0$ Hz, 2H), 3.00 (t, $J = 6.4$ Hz, 2H), 2.30 (s, 3H), 2.26 (s, 2H), 1.52 (t, $J = 6.4$ Hz, 2H), 1.34 (t, $J = 7.0$ Hz, 3H), 0.96 (s, 6H).

d) To a solution of 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[b]thiophene-2-carboxylic
30 acid ethyl ester (3.0 g, 11.9 mmol) in ethanol (100 mL), aq. 2 N LiOH (50 mL) is added. The reaction mixture is stirred at 65°C for 2 h before the ethanol is removed on a rotavapor. The remaining solution is extracted once with heptane, acidified with citric acid to pH 2 and extracte three times with EA. The EA extracts are

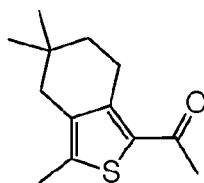
combined, dried over Na_2SO_4 , filtered, evaporated and dried to give 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[b]thiophene-2-carboxylic acid (1.6 g) as a beige solid containing the regio isomer 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[b]thiophene-2-carboxylic acid. LC-MS: $t_R = 0.98$ min, $[M+1] = 225.14$.

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Scaffold C

To a cooled solution (-78°C) of 5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (960 mg, 4.57 mmol) in THF (19 mL), tert-butyllithium (8 mL, 1.5 M solution in pentane) is added. The mixture is stirred at -78°C for 10 min before ethyl iodide (3.80 g, 24.37 mmol) is added. The reaction mixture is stirred at -78°C for 3 h. Water/methanol 1:1 (8 mL) followed by 10% aq. citric acid solution is added and the mixture is extracted with EA. The combined organic extracts are washed with brine, dried over Na_2SO_4 and evaporated. The remaining solid is suspended in acetonitrile (6 mL), heated to 60°C , cooled to rt, filtered and dried to give 3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (640 mg) as a slightly beige solid; LC-MS: $t_R = 1.01$ min, $[M+1+\text{CH}_3\text{CN}] = 280.10$.

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Scaffold D

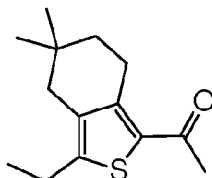
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To a suspension of 3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (4.10 g, 18.28 mmol) in diethyl ether (300 mL), methyllithium (23 mL, 1.6 M solution in diethyl ether) is slowly added at rt. The reaction mixture becomes clear, yellow and slightly warm (26°C), and is stirred for 15 min before it is quenched with water. The organic layer is separated, washed once more with water, dried over MgSO_4 and evaporated. The crude product is purified by CC on silica gel eluting with heptane:EA 4:1 to give 1-(3,5,5-trimethyl-4,5,6,7-tetrahydro-

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benzo[c]thiophen-1-yl)-ethanone (2.80 g) as a pale yellow crystalline solid; LC-MS: $t_R = 1.06$ min; $[M+1] = 223.17$; 1H NMR ($CDCl_3$): δ 3.00 (t, $J = 7.0$ Hz, 2H), 2.43 (s, 3H), 2.31 (s, 3H), 2.26 (s, 2H), 1.51 (t, $J = 7.0$ Hz, 2H), 0.95 (s, 6H).

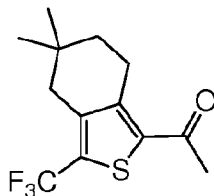
5 Scaffold E



To a solution of 3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (2.10 g, 8.81 mmol) in diethyl ether (100 mL), a solution of methyllithium (11 mL, 1.6 M solution in diethyl ether) is added at rt. The pale yellow solution is stirred at rt for 15 min before another portion of methyllithium (2 mL) is added. Stirring is continued for 15 min, a further portion of methyllithium (1 mL) is added, and the mixture is again stirred for 15 min at rt. The reaction is quenched with water. The organic layer is separated, washed once more with water, dried over $MgSO_4$ and evaporated. The crude product is purified by CC on silica gel eluting with heptane:EA 7:3 to give 1-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-ethanone (1.65 g) as a pale yellow solid; LC-MS: $t_R = 1.00$ min; $[M+1] = 237.15$; 1H NMR ($CDCl_3$): δ 3.03 (t, $J = 7.0$ Hz, 2H), 2.73 (q, $J = 7.6$ Hz, 2H), 2.47 (s, 3H), 2.31 (s, 2H), 1.55 (t, $J = 7.0$ Hz, 2H), 1.28 (t, $J = 7.6$ Hz, 3H), 0.97 (s, 6H).

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Scaffold F



a) To a solution of 5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid (20 g, 95 mmol) in DMSO (150 mL) is added N,O-dimethylhydroxylamine hydrochloride (12.06 g, 124 mmol) and DIPEA (65 mL, 380 mmol) followed by TBTU (33.59 g, 105 mmol, dissolved in DMF (70 mL)). The reaction mixture is stirred at rt for 2 h before it is poured into water/ice and extracted twice with diethyl

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ether (2x100 mL). The organic extracts are washed with sat. aq. NaHCO_3 solution, 10% aq. citric acid solution and brine, dried over Na_2SO_4 , filtered, evaporated and dried to give 5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid methoxy-methyl-amide (23 g) as a brown oil; LC-MS: $t_R = 1.01$ min, $[M+1] = 254.14$.

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b) To a solution of diisopropylamine (11.02 g, 109 mmol) in THF (400 mL) is added n-butyl lithium (72.7 mL, 109 mmol, 1.5 M in pentane) at 0-5°C. The solution is cooled to -78°C and a solution of 5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid methoxy-methyl-amide (23 g, 91 mmol) in THF (100 mL) is added. Upon complete addition, the mixture is stirred for 20 min at -78°C before a solution of iodine (30 g, 119 mmol) in THF (100 mL) is added. Stirring is continued at -78°C for 30 min. The reaction is quenched by slowly adding a 1:1 mixture of water/methanol (20 mL). The solution is diluted with water (400 mL) and extracted with diethyl ether (3x100 mL). The combined organic extracts are washed with 10% aq. citric acid solution and brine, dried over Na_2SO_4 , filtered and evaporated. The crude product is purified by CC on silica gel eluting with DCM to afford 3-iodo-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid methoxy-methyl-amide (18 g) as a brownish oil; LC-MS: $t_R = 1.09$ min, $[M+1] = 380.21$.

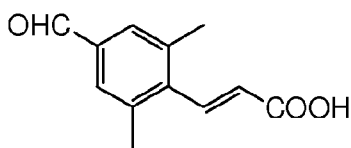
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c) 3-Iodo-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid methoxy-methyl-amide (18 g, 47 mmol), CuI (14.5 g, 76 mmol) and KF (4.4 g, 76 mmol) are dissolved in DMF (80 mL). The solution is heated to 134°C and methyl chlorodifluoroacetate (16.26 g, 113 mmol) is added via syringe pump over a period of 4 h. Gas evolution is observed. Upon complete addition, the mixture is cooled and poured into water/ice. The precipitate that forms is collected, suspended in DCM (600 mL), and filtered through a celite pad. The filtrate is washed with 0.5 N aq. HCl (250 mL), followed by sat. aq. NaHCO_3 solution, dried over Na_2SO_4 , filtered and evaporated to give 5,5-dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid methoxy-methyl-amide (14 g) as a brown oil; LC-MS: $t_R = 1.10$ min, $[M+1] = 322.20$.

30

- d) A solution of 5,5-dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophene-1-carboxylic acid methoxy-methyl-amide (14 g, 44 mmol) in diethyl ether (400 mL) is treated at rt with methyl lithium (80 mL, 1.6 M in diethyl ether). Upon complete addition, the mixture is stirred at rt for 15 min before it is poured onto water/ice and
- 5 neutralized with aq. HCl. The ether phase is separated and the aq. phase is extracted two more times with diethyl ether (2x100 mL). The organic extracts are washed with brine, dried over MgSO_4 , filtered and evaporated. The crude product is purified by CC on silica gel eluting with heptane containing 20-30% of DCM to give
- 10 1-(5,5-dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-ethanone (9.1 g) as a yellow oil; LC-MS: $t_R = 1.11$ min; $[M+1+\text{CH}_3\text{CN}] = 318.34$; ^1H NMR(CDCl_3): δ 3.04 (t, $J = 7.0$ Hz, 2H), 2.57 (d, $J = 1.2$ Hz, 2H), 2.53 (s, 3H), 1.58 (t, $J = 7.0$ Hz, 2H), 0.99 (s, 6H).

Building Block A



- 15 a) To a solution of 4-hydroxy-3,5-dimethyl-benzaldehyde (5.0 g, 33.3 mmol) in DCM (50 mL) and pyridine (8 mL), trifluoromethanesulfonic anhydride (6 mL, 36.6 mmol) is slowly added at 0°C. Upon complete addition, stirring is continued for 2 h at rt. The reaction mixture is diluted with EA and washed three times with water. The
- 20 separated organic layer is dried over MgSO_4 , filtered and evaporated. The crude product is purified by CC on silica gel eluting with heptane:EA 4:1 to give trifluoromethanesulfonic acid 4-formyl-2,6-dimethyl-phenyl ester (5.3 g) as a slightly yellow solid; LC-MS: $t_R = 1.04$ min; ^1H NMR (CDCl_3): δ 9.97 (s, 1H), 7.66 (s, 2H), 2.48 (s, 6H).
- 25 b) To a stirred solution of trifluoro-methanesulfonic acid 4-formyl-2,6-dimethyl-phenyl ester (4.7 g, 16.7 mmol) in dry DMF (75 mL) under argon is sequentially added at rt triethylamine (3.4 g, 33.3 mmol), methyl acrylate (14.3 g, 167 mmol), 1,3-bis-(diphenylphosphino)-propane (378 mg, 0.92 mmol) and $\text{Pd}(\text{OAc})_2$ (187 mg,
- 30 0.83 mmol). The mixture is heated to 115°C and stirred for 5 h. The mixture is diluted with diethyl ether (350 mL) and washed twice with aq. 1 N HCl and once

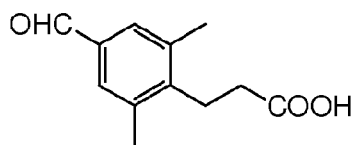
with sat. aq. NaHCO_3 . The organic extract is dried over MgSO_4 , filtered and evaporated. The residue is purified by CC on silica gel eluting with heptane:EA 5:1 to give 3-(4-formyl-2,6-dimethyl-phenyl)-acrylic acid methyl ester (2.9 g) as a slightly yellow solid; LC-MS: $t_R = 0.96$ min.

5

c) To a solution of 3-(4-formyl-2,6-dimethyl-phenyl)-acrylic acid methyl ester (2.9 g, 13.3 mmol) in methanol (70 mL), 2 N aq. NaOH (35 mL) is added. The suspension is stirred for 30 min at rt. Methanol is evaporated and the aq. solution is extracted twice with DCM. The aq. layer is acidified with 2 N aq. HCl and extracted twice with
10 EA. The combined EA extracts are dried over MgSO_4 , filtered and evaporated. The crude product is recrystallized from EA to give 3-(4-formyl-2,6-dimethyl-phenyl)-acrylic acid (2.2 g) as pale yellow crystals; LC-MS: $t_R = 0.83$ min; ^1H NMR (D_6 -DMSO): δ 12.65 (s br, 1H), 9.92 (s, 1H), 7.66 (d, $J = 16.4$ Hz, 1H), 7.61 (s, 2H), 6.12 (d, $J = 16.4$ Hz, 1H), 2.35 (s, 6H).

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Building Block B

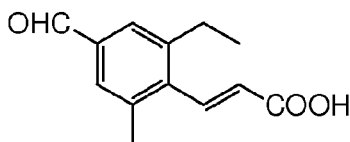


a) To a solution of 3-(4-formyl-2,6-dimethyl-phenyl)-acrylic acid (2.2 g, 10.8 mmol) and DIPEA (2.0 mL, 11.9 mmol) in ethanol (80 mL), Pd/C (200 mg, 10% Pd,
20 moistened with 50% water) is added. The suspension is vigorously stirred under 1 bar of H_2 for 1 h. The mixture is filtered over Celite and the filtrate is evaporated. The residue is poured onto 1 N aq. HCl/ice and extracted with EA. The organic extract is washed once with 1 N aq. HCl and once with brine, dried over MgSO_4 , filtered and evaporated to give 3-(4-hydroxymethyl-2,6-dimethyl-phenyl)-propionic
25 acid (2.2 g) as a pale yellow resin; LC-MS: $t_R = 0.71$ min.

b) To a solution of 3-(4-hydroxymethyl-2,6-dimethyl-phenyl)-propionic acid (960 mg, 4.6 mmol) in acetic acid (20 mL), MnO_2 (1440 mg, 16.6 mmol) is added. The mixture is stirred at 80°C for 4.5 h before it is filtered. The filtrate is evaporated and
30 the crude product is purified by CC on silica gel eluting with DCM containing 8% of methanol to give 3-(4-formyl-2,6-dimethyl-phenyl)-propionic acid (800 mg) as a

beige solid; LC-MS: t_R = 0.81 min; ^1H NMR (D_6 -DMSO): δ 12.2 (s br, 1H), 9.86 (s, 1H), 7.52 (s, 2H), 2.93-2.85 (m, 2H), 2.38-2.30 (m, 8H).

Building Block C

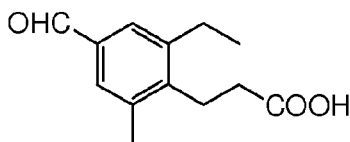


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3-(2-Ethyl-4-formyl-6-methyl-phenyl)-acrylic acid is prepared in analogy to Building Block A; LC-MS: t_R = 0.87 min; ^1H NMR (CDCl_3): δ 9.98 (s, 1H), 7.96 (d, J = 16.4 Hz, 1H), 7.62 (s, 1H), 7.59 (s, 1H), 6.13 (d, J = 16.4 Hz, 1H), 2.75 (q, J = 7.6 Hz, 2H), 2.42 (s, 3H), 1.25 (t, J = 7.6 Hz, 3H).

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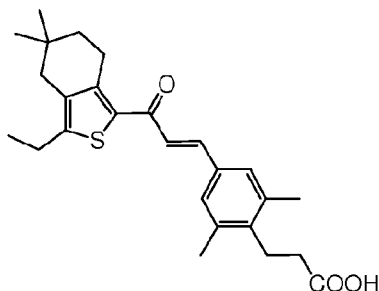
Building Block D



3-(2-Ethyl-4-formyl-6-methyl-phenyl)-propionic acid is prepared in analogy to Building Block B starting from Building Block C; LC-MS: t_R = 0.86 min; ^1H NMR (CDCl_3): δ 9.93 (s, 1H), 7.58 (s, 1H), 7.53 (s, 1H), 3.11-3.04 (m, 2H), 2.75 (q, J = 7.6 Hz, 2H), 2.56-2.50 (m, 2H), 2.43 (s, 3H), 1.28 (t, J = 7.6 Hz, 3H).

15

Intermediate 1

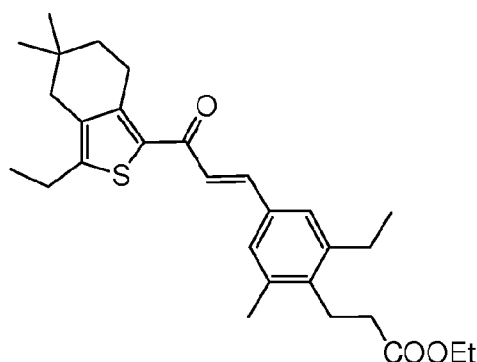


A solution of 1-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-ethanone (400 mg, 1.69 mmol), 3-(4-formyl-2,6-dimethyl-phenyl)-propionic acid (419 mg, 2.03 mmol) and NaOH (1.7 g, 42.5 mmol) in methanol (17 mL) is stirred at 75°C for 75 min before it is diluted with 1 N aq. HCl and extracted twice with EA. The organic extracts are dried over MgSO_4 , filtered and evaporated. The crude

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product is purified by CC on silica gel eluting with DCM containing 6% of methanol to give 3-{4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-2,6-dimethyl-phenyl}-propionic acid (620 mg) as a pale yellow solid; LC-MS: t_R = 1.17 min; $[M+1]$ = 425.34; 1H NMR($CDCl_3$): δ 7.68 (d, J = 15.8 Hz, 1H), 7.28 (s, 2H), 7.27 (d, J = 15.8 Hz, 1H), 3.18 (t, J = 7.0 Hz, 2H), 3.06-2.98 (m, 2H), 2.78 (q, J = 7.6 Hz, 2H), 2.54-2.48 (m, 2H), 2.39 (s, 6H), 2.34 (s, 2H), 1.58 (t, J = 7.0 Hz, 2H), 1.32 (t, J = 7.6 Hz, 3H).

Intermediate 2A



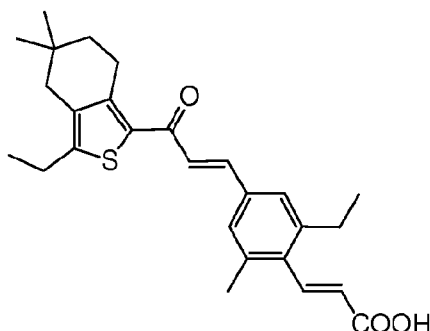
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A solution of 1-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-ethanone (143 mg, 0.606 mmol) and 3-(2-ethyl-4-formyl-6-methyl-phenyl)-propionic acid (200 mg, 0.908 mmol) in ethanol (15 mL) is treated with 5 N HCl in isopropanol (3 mL). The dark brown reaction mixture is stirred at rt for 3 h, then at 50°C for 48 h before DIPEA (4 mL) is added. The solvent is removed *in vacuo* and the crude product is purified by prep. HPLC (Grom-Sil 120 ODS-4-HE, 30x75 mm, 10 μ m, acetonitrile/water (0.5% HCOOH), 10% to 95% acetonitrile) to give 3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-6-methyl-phenyl}-propionic acid ethyl ester (157 mg) as a yellow oil; LC-MS: t_R = 1.27 min, $[M+1]$ = 467.43.

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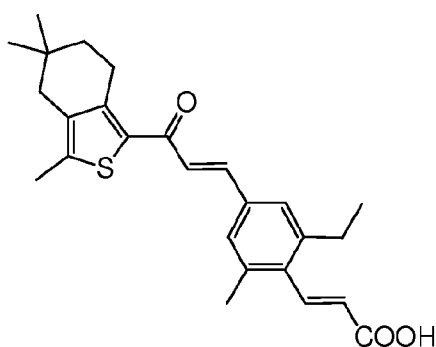
Intermediate 2B

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A solution of 1-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-ethanone (200 mg, 0.846 mmol) and 3-(2-ethyl-4-formyl-6-methyl-phenyl)-acrylic acid (203 mg, 0.931 mmol) in methanolic NaOH (8 mL, 10 g NaOH in 100 mL methanol) is stirred at rt for 3 h before it is carefully acidified to pH 1 by adding 2 N aq. HCl. The mixture is extracted twice with DCM and the organic extracts are washed with water and brine, dried over MgSO₄, filtered and evaporated. The crude product is crystallised from acetonitrile (40 mL) to give 3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-6-methyl-phenyl}-acrylic acid (222 mg) as yellow crystals. From the mother liquor a second crop (29 mg) of product can be obtained after purification by prep. HPLC (Grom-Sil 120 ODS-4-HE, 30x75 mm, 10 µm, acetonitrile/water (0.5% HCOOH), 20% to 95% acetonitrile); LC-MS: t_R = 1.20 min, $[M+1]$ = 437.31.

15 Intermediate 3

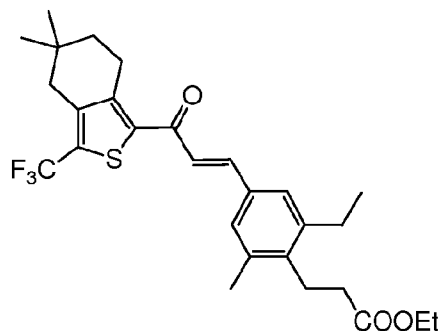


3-{2-Ethyl-6-methyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propenyl]-phenyl}-acrylic acid is prepared from 1-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-ethanone and 3-(2-ethyl-4-formyl-6-methyl-phenyl)-acrylic acid in analogy to Intermediate 2B; LC-MS: t_R = 1.17 min; $[M+1]$ = 423.34; ¹H NMR (CDCl₃): δ 7.97 (d, J = 16.4 Hz, 1H), 7.68 (d, J = 15.2 Hz, 1H),

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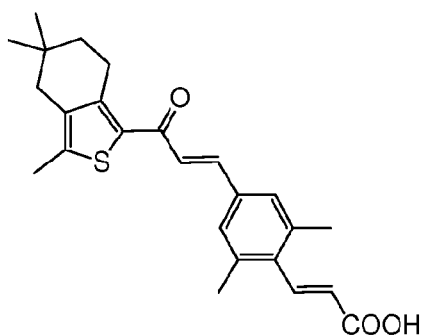
7.33 (s, 2H), 7.28 (d, J = 15.8 Hz, 1H), 6.13 (d, J = 15.8 Hz, 1H), 3.16 (t, J = 7.0 Hz, 2H), 2.77 (q, J = 7.6 Hz, 2H), 2.41 (s, 3H), 2.39 (s, 3H), 2.32 (s, 2H), 1.57 (t, J = 6.4 Hz, 2H), 1.24 (t, J = 7.6 Hz, 3H), 1.00 (s, 6H).

5 Intermediate 4



3-{4-[3-(5,5-Dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-2-ethyl-6-methyl-phenyl}-propionic acid ethyl ester is prepared in analogy to Intermediate 2A starting from Scaffold F and Building Block D; LC-MS: t_R = 1.29 min, $[M+1] = 506.68$.

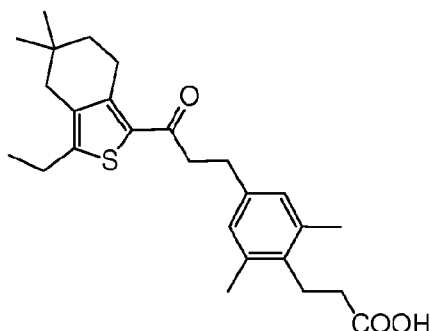
Intermediate 5



3-{2,6-Dimethyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propenyl]-phenyl}-acrylic acid (570 mg) is obtained by condensing Scaffold D (415 mg, 1.87 mmol) with Building Block B (381 mg, 1.87 mmol) in analogy to Intermediate 2B; LC-MS: t_R = 1.17 min, $[M+1] = 409.21$.

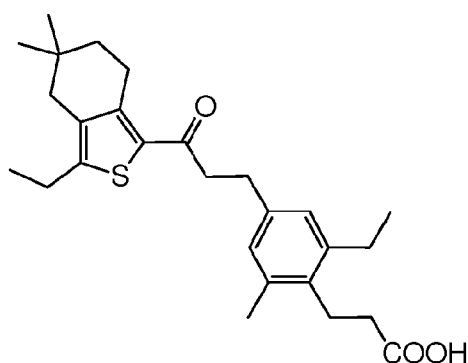
Example 1

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To a solution of 3-{4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-2,6-dimethyl-phenyl}-propionic acid (610 mg, 1.44 mmol) and DIPEA (204 mg, 1.58 mmol) in ethanol (30 mL) is added Pd/C (300 mg, 10% Pd, moistened with 50% water). The slurry is stirred at rt for 18 h under 1 atm H₂. The mixture is filtered and the filtrate is evaporated. The crude product is purified by prep. HPLC (Grom-Sil 120 ODS-4-HE, 30x75 mm, 10 μm, acetonitrile/water (0.5% HCOOH), 20% to 95% acetonitrile) to give 3-{4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-2,6-dimethyl-phenyl}-propionic acid (460 mg) as a colourless lyophilisate; LC-MS: t_R = 1.15 min; [M+1] = 427.40; ¹H NMR (CDCl₃): δ 6.91 (s, 2H), 3.10-2.90 (m, 8H), 2.73 (q, J = 7.6 Hz, 2H), 2.53-2.46 (m, 2H), 2.32 (s, 6H), 2.30 (s, 2H), 1.54 (t, J = 7.0 Hz, 2H), 1.28 (t, J = 7.6 Hz, 3H), 0.97 (s, 6H).

15 Example 2

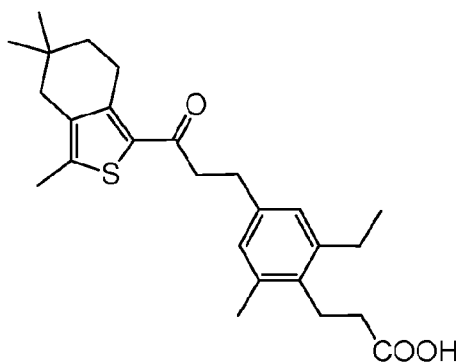


a) To a solution of 3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propenyl]-6-methyl-phenyl}-propionic acid ethyl ester (153 mg, 0.328 mmol) in ethanol, Pd/C (80 mg, 10% Pd, moistened with 50% water) is added and the resulting slurry is stirred at rt for 72 h under 1 bar of H₂. The reaction mixture is filtered and the filtrate is evaporated. The crude product is

purified by prep. HPLC (Grom-Sil 120 ODS-4-HE, 30x75 mm, 10 μ m, acetonitrile/water (0.5% HCOOH), 20% to 95% acetonitrile) to give 3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-6-methyl-phenyl}-propionic acid ethyl ester (95 mg) as an amorphous solid; LC-MS: t_R = 1.26 min, $[M+1] = 469.40$.

b) A solution of 3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-6-methyl-phenyl}-propionic acid ethyl ester (92 mg, 0.196 mmol) in ethanol (2 mL) is treated with 2 N aq. NaOH (2 mL). The solution is stirred at rt for 1 h before the solvent is removed *in vacuo*. The residue is dissolved in 2 N aq. HCl, and extracted with EA. The organic extract is washed with brine, dried over Na₂SO₄, filtered and evaporated to give 3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-6-methyl-phenyl}-propionic acid as an amorphous solid; LC-MS: $t_R = 1.16$ min; $[M+1] = 441.36$; ¹H NMR (CDCl₃): δ 6.95 (s, 1H), 6.93 (s, 1H), 3.12-2.94 (m, 8H), 2.74 (q, J = 7.6 Hz, 2H), 2.66 (q, J = 7.6 Hz, 2H), 2.56-2.48 (m, 2H), 2.36 (s, 3H), 2.32 (s, 2H), 1.56 (t, J = 7.0 Hz, 2H), 1.29 (t, J = 7.6 Hz, 3H), 1.24 (t, J = 7.6 Hz, 3H).

Example 3



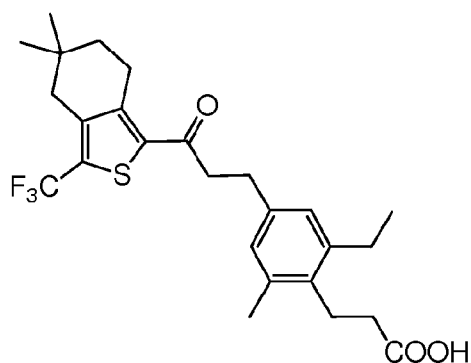
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To a solution of 3-{2-ethyl-6-methyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propenyl]-phenyl}-acrylic acid (Intermediate 3; 340 mg, 0.805 mmol) and DIPEA (182 mg, 1.41 mmol) in ethanol, Pd/C (340 mg, 10% Pd, moistened with 50% water) is added and the resulting slurry is stirred at 50 °C for 72 h under 10 bar of H₂. Another portion of Pd/C is added and stirring is continued for 16 h at 50 °C under 10 bar of H₂. The reaction mixture is filtered and the filtrate is evaporated. The crude product is purified by prep. HPLC (Grom-Sil 120 ODS-4-HE,

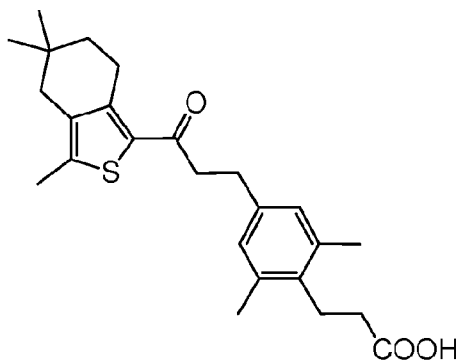
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30x75 mm, 10 μ m, acetonitrile/water (0.5% HCOOH), 20% to 95% acetonitrile) to give 3-{2-ethyl-6-methyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propyl]-phenyl}-propionic acid (154 mg) as a colourless foam; LC-MS: t_R = 1.15 min, $[M+1]$ = 427.30.

5

Example 4

3-{4-[3-(5,5-Dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-propyl]-2-ethyl-6-methyl-phenyl}-propionic acid is prepared in analogy to
10 Example 2 starting from Intermediate 4; LC-MS: t_R = 1.17 min, $[M+1]$ = 481.36.

Example 5

3-{2,6-Dimethyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propyl]-phenyl}-propionic acid (430 mg) is obtained starting from Intermediate 5
15 (548 mg, 1.34 mmol) in analogy to Example 3; LC-MS: t_R = 1.13 min; $[M+1]$ = 413.34; 1H NMR ($CDCl_3$): δ 0.97 (s, 6 H), 1.53 (t, J = 6.7 Hz, 2 H), 2.28 (s, 2H), 2.32 (s, 6H), 2.33 (s, 3H), 2.45-2.54 (m, 2 H), 2.89-2.99 (m, 4 H), 2.99-3.10 (m, 4 H), 6.91 (s, 2 H).

20

Example 6: GTP γ S assay to determine EC₅₀ values

GTP γ S binding assays are performed in 96 well microtiter plates (Nunc, 442587) in a final volume of 200 μ l, using membrane preparations of CHO cells expressing recombinant human S1P1 receptor. Assay conditions are 20 mM Hepes (Fluka, 54461), 100 mM NaCl (Fluka, 71378), 5 mM MgCl₂ (Fluka, 63064), 0.1% BSA (Calbiochem, 126609), 1 μ M GDP (Sigma, G-7127), 2.5% DMSO (Fluka, 41644), 50 pM ³⁵S-GTP γ S (Amersham Biosciences, SJ1320). The pH is 7.4. Test compounds are dissolved and diluted in 100% DMSO and pre-incubated at room temperature for 30 min in 150 μ l of the above assay buffer, in the absence of ³⁵S-GTP γ S. After addition of 50 μ l of ³⁵S-GTP γ S, the assay is incubated for 1 h at rt. The assay is terminated by transfer of the reaction mixture to a Multiscreen plate (Millipore, MAHFC1H60) using a cell harvester from Packard Biosciences, and the plates are washed with ice-cold 10 mM Na₂HPO₄/NaH₂PO₄ (70%/30%), dried, sealed at the bottom and, after addition of 25 μ l MicroScint20 (Packard Biosciences, order no. 6013621), sealed on the top. Membrane-bound ³⁵S-GTP γ S is measured with a TopCount from Packard Biosciences.

EC₅₀ is the concentration of agonist inducing 50 % of the maximal specific ³⁵S-GTP γ S binding. Specific binding is determined by subtracting non-specific binding from maximal binding. Maximal binding is the amount of cpm bound to the Multiscreen plate in the presence of 10 μ M of S1P. Non-specific binding is the amount of binding in the absence of an agonist in the assay.

Table 1 shows the EC₅₀ value of a compound of the present invention. The EC₅₀ value was determined according to the method described above.

Table 1:

Compound of Example	EC ₅₀ [nM]
4	4.0

Example 7: Assessment of *In vivo* Efficacy

The efficacy of the compounds of Formula (I) is assessed by measuring the circulating lymphocytes after oral administration of 3 to 30 mg/kg of a compound of

Formula (I) to normotensive male Wistar rats. The animals are housed in climate-controlled conditions with a 12 h-light/dark cycle, and have free access to normal rat chow and drinking water. Blood is collected before and 3, 6 and 24 h after drug administration. Full blood is subjected to hematology using Advia Hematology system (Bayer Diagnostics, Zürich, Switzerland).

All data are presented as mean $\pm$ SEM. Statistical analyses are performed by analysis of variance (ANOVA) using Statistica (StatSoft) and the Student-Newman-Keuls procedure for multiple comparisons. The null hypothesis is rejected when $p < 0.05$.

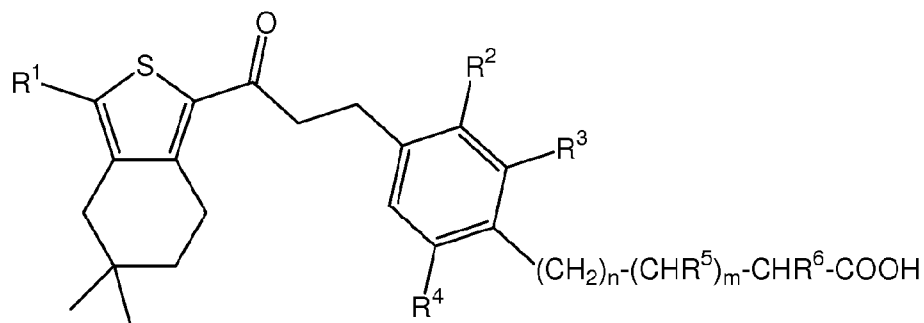
As an example, Table 2 shows the effect on lymphocyte counts 6 h after oral administration of 10 mg/kg of a compound of the present invention to normotensive male Wistar rats as compared to a group of animals treated with vehicle only.

Table 2:

Compound of Example	Lymphocyte counts
1	-61 $\pm$ 5%

Claims

1. A compound selected from the group consisting of thiophenes of the Formula (I),



Formula (I)

wherein

R¹ represents methyl, trifluoromethyl, or ethyl;

R² represents hydrogen, C₁₋₄-alkyl, methoxy, or halogen;

R³ represents hydrogen, C₁₋₄-alkyl, C₁₋₄-alkoxy, or halogen;

R⁴ represents hydrogen, C₁₋₄-alkyl, or halogen;

R⁵ represents hydrogen;

R⁶ represents hydrogen or hydroxy;

in case **R⁶** represents hydroxy, **R⁵** can in addition represent hydroxy;

n represents 0;

m represents 0 or 1; and

in case **m** represents 1, **n** can in addition represent 1;

and salts as well as solvent complexes of such compounds.

2. A compound according to claim 1, wherein **R**¹ represents an ethyl group.

5 3. A compound according to claim 1, wherein **R**¹ represents a methyl group.

4. A compound according to claim 1, wherein **R**¹ represents a trifluoromethyl group.

10 5. A compound according to any one of claims 1 to 4, wherein **R**² represents a methoxy group, and **R**³ and **R**⁴ represent hydrogen.

6. A compound according to any one of claims 1 to 4, wherein **R**² represents hydrogen, and **R**³ and **R**⁴ represent C₁₋₄-alkyl.

15 7. A compound according to claim 6, wherein **R**³ and **R**⁴ represent a methyl group.

8. A compound according to claim 6, wherein **R**³ and **R**⁴ represent an ethyl group.

20 9. A compound according to claim 6, wherein **R**³ represents a methyl group, and **R**⁴ represents an ethyl group.

10. A compound according to any one of claims 1 to 4, wherein **R**² represents hydrogen, **R**³ represents a methoxy group, and **R**⁴ represents a chlorine atom.

25 11. A compound according to any one of claims 1 to 4, wherein **R**² represents hydrogen, **R**³ represents a methyl group, and **R**⁴ represents a chlorine atom.

12. A compound according to any one of claims 1 to 11, wherein **R**⁵ and **R**⁶ represent hydrogen.

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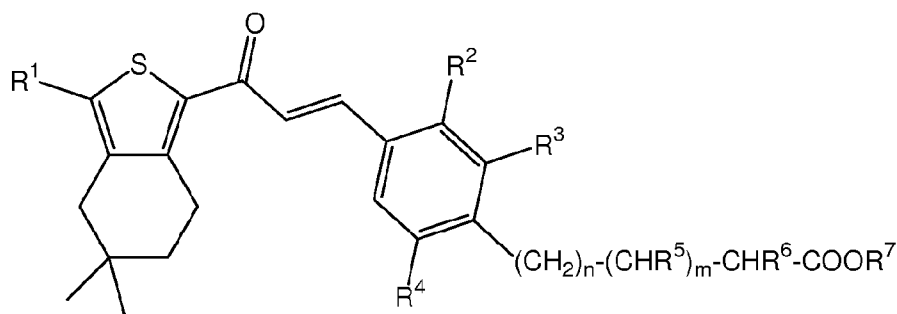
13. A compound according to claim 12, wherein **n** represents 0, and **m** represents 1.

14. A compound according to claim 12, wherein **n** represents 1, and **m** represents 1.
15. A compound according to any one of claims 1 to 11, wherein **m** represents 1,
5 and **R⁵** and **R⁶** represent hydroxy.
16. A compound according to claim 15, wherein **n** represents 0.
17. A compound according to any one of claims 1 to 11, wherein **R⁵** represents
10 hydrogen, and **R⁶** represents hydroxy.
18. A compound according to claim 1 selected from the group consisting of:
3-{4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-3-oxo-
propyl]-2,6-dimethyl-phenyl}-propionic acid;
15 3-{4-[3-(5,5-dimethyl-3-trifluoromethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-
yl)-3-oxo-propyl]-2-ethyl-6-methyl-phenyl}-propionic acid;
3-{2-ethyl-6-methyl-4-[3-oxo-3-(3,5,5-trimethyl-4,5,6,7-tetrahydro-
benzo[c]thiophen-1-yl)-propyl]-phenyl}-propionic acid; and
3-{2-ethyl-4-[3-(3-ethyl-5,5-dimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-
20 yl)-3-oxo-propyl]-6-methyl-phenyl}-propionic acid.
19. A compound according to claim 1 which is 3-{2,6-dimethyl-4-[3-oxo-3-(3,5,5-
trimethyl-4,5,6,7-tetrahydro-benzo[c]thiophen-1-yl)-propyl]-phenyl}-propionic acid.
- 25 20. A pharmaceutical composition comprising a compound according to any one of
claims 1 to 19 and a pharmaceutically acceptable carrier.
21. A compound according to any one of claims 1 to 19, or a pharmaceutical
composition according to claim 20, for use as a medicament.
- 30 22. Use of a compound according to any one of claims 1 to 19 for the preparation
of a pharmaceutical composition for the prevention or treatment of diseases or
disorders associated with an activated immune system.

23. The use according to claim 22 for the prevention or treatment of diseases or disorders selected from the group consisting of rejection of transplanted organs such as kidney, liver, heart, lung, pancreas, cornea, and skin; graft-versus-host diseases brought about by stem cell transplantation; autoimmune syndromes including rheumatoid arthritis, multiple sclerosis, inflammatory bowel diseases such as Crohn's disease and ulcerative colitis, psoriasis, psoriatic arthritis, thyroiditis such as Hashimoto's thyroiditis, uveo-retinitis; atopic diseases such as rhinitis, conjunctivitis, dermatitis; asthma; type I diabetes; post-infectious autoimmune diseases including rheumatic fever and post-infectious glomerulonephritis; solid cancers and tumor metastasis.

24. Use of a compound according to any one of claims 1 to 19 for the preparation of a pharmaceutical composition for use in combination with one or several agents selected from the group consisting of immunosuppressants, corticosteroids, NSAID's, cytotoxic drugs, adhesion molecule inhibitors, cytokines, cytokine inhibitors, cytokine receptor antagonists and recombinant cytokine receptors, for the prevention or treatment of diseases or disorders associated with an activated immune system.

25. A compound selected from the group consisting of thiophenes of Formula (II)



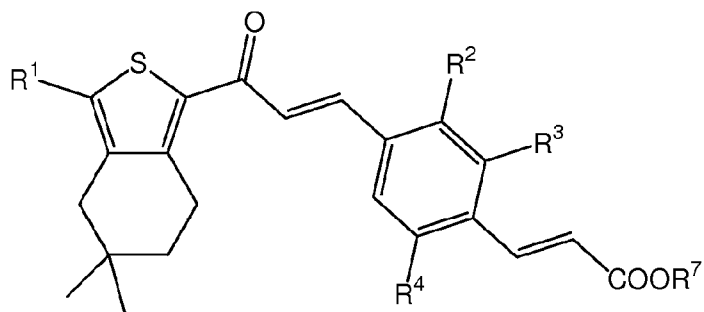
Formula (II)

25 wherein **R¹**, **R²**, **R³**, **R⁴**, **R⁵**, **R⁶**, **n** and **m** are as defined in claim 1 for Formula (I), and **R⁷** represents hydrogen, methyl, ethyl, or tert-butyl;

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and salts as well as solvent complexes of such compounds.

26. A compound selected from the group consisting of thiophenes of Formula (III)



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Formula (III)

wherein **R¹**, **R²**, **R³**, and **R⁴** are as defined in claim 1 for Formula (I), and **R⁷** represents hydrogen, methyl, ethyl, or tert-butyl;

10 and salts as well as solvent complexes of such compounds.