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(54) Title: TRYPSIN-LIKE SERINE PROTEASE INHIBITORS, AND THEIR PREPARATION AND USE

(57) Abstract: The invention provides compounds that are effective as inhibitors of human plasmin and plasma kallikrein, and that are useful for the prevention of blood loss and as components of fibrin adhesives. The invention further provides methods of making and using the compounds.



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Trypsin-Like Serine Protease Inhibitors, and Their Preparation and Use

FIELD OF THE INVENTION

[0001] The invention relates to the fields of organic chemistry, serine proteases (particularly plasmin and plasma kallikrein), and hemostasis, and to therapeutic modulation of the blood coagulation cascade and fibrinolysis.

BACKGROUND OF THE INVENTION

[0002] Plasmin (EC 3.4.21.7, fibrinolysin) is a trypsin-like serine protease which effects protein cleavage at arginine or lysine residues; its principal substrates are fibrin and extracellular matrix (ECM) proteins like fibronectin. Other plasmin substrates include various proteins of the basal membrane, for example, laminin and type IV collagen, and zymogens such as the proforms of urokinase and matrix metalloproteases. In blood, plasmin is responsible in particular for fibrinolysis, as it cleaves fibrin into soluble fragments. Plasmin is activated by cleavage from its precursor zymogen, plasminogen, by the action of plasminogen activators, principally serine proteases such as urokinase, tPA, and plasma kallikrein (EC 3.4.21.34; kininogenin, PK).

[0003] Endogenous plasmin inhibitors such as α_2 -macroglobulin and α_2 -antiplasmin, by moderating the anticoagulant effects of plasminogen activators, play key roles in regulating fibrinolysis. Certain pathological conditions (hyperplasminemias) are characterized by dysregulation of plasmin and spontaneous activation of fibrinolysis. The resulting degradation of wound-closing fibrin is exacerbated by the anticoagulant properties of the fibrinogen degradation products, leading to a serious impairment of hemostasis.

[0004] Antifibrinolytic drugs are used clinically to treat such conditions; among the commonly used agents are synthetic amino-substituted carboxylic acids such as *p*-aminomethylbenzoic acid, ϵ -aminocaproic acid, and *trans*-4-(aminomethyl)-cyclohexanecarboxylic acid (tranexamic acid). These compounds block the binding of plasminogen to fibrin, and thus inhibit the generation of plasmin, but they are not direct inhibitors of plasmin and do not inhibit the activity of already-formed plasmin. A direct antifibrinolytic is aprotinin (TRASYLOL™, Bayer AG, Leverkusen), a 58 amino acid polypeptide obtained from bovine lung. Aprotinin inhibits plasmin with an inhibition constant of 1 nM, but is relatively nonspecific: it effectively inhibits trypsin ($K_i = 0.1$ nM), plasma kallikrein ($K_i = 30$ nM) and, to a lesser extent, a variety of other enzymes.

[0005] The principal use of aprotinin was for reduction of blood loss, especially in cardiac surgical procedures with cardiopulmonary bypass (CPB), where it distinctly reduced the need for perioperative blood transfusions (Sodha *et al.*, *Expert Rev. Cardiovasc. Ther.*, **4**, 151-160, 2006). Aprotinin was also employed to inhibit blood loss in other operations, for example in organ transplants; it is also used in conjunction with fibrin adhesives.

[0006] The use of aprotinin has several disadvantages. Since it is isolated from bovine organs, there is in principle the risk of pathogenic contamination and allergic reactions. The risk of anaphylactic shock is relatively low with the first administration of aprotinin (< 0.1%), but increases on repeated administration within 200 days to 4-5%. It has been reported that administration of aprotinin, in direct comparison with ϵ -aminocaproic acid or tranexamic acid, induces an increased number of side effects (Mangano *et al.*, *New Engl. J. Med.*, **354**, 353-365, 2006). Administration of aprotinin led to a doubling of the number of cases of kidney damage requiring dialysis, and the incidence of myocardial infarction and apoplectic stroke was increased in comparison with the control groups. After the Blood Conservation Using Antifibrinolytics in a Randomized Trial (BART) study had shown an increased risk of mortality associated with aprotinin use compared to lysine analogues in high-risk cardiac surgery patients (Fergusson *et al.*, *New Engl. J. Med.*, **358**, 2319-2331, 2008), the drug was withdrawn from the market.

[0007] A number of synthetic inhibitors of plasmin have been disclosed. Sanders (Sanders and Seto, *J. Med. Chem.*, **42**, 2969-2976, 1999) has described 4-hetero cyclohexanone derivatives with relatively weak activity, with inhibition constants of $\geq 50 \mu\text{M}$ for plasmin. Xue (Xue and Seto, *J. Med. Chem.*, **48**, 6908-6917, 2005) has reported on peptidic cyclohexanone derivatives with IC_{50} values $\geq 2 \mu\text{M}$, but no further development has been reported. Okada (Okada *et al.*, *Chem. Pharm. Bull.*, **48**, 1964-1972, 2000; Okada *et al.*, *Bioorg. Med. Chem. Lett.*, **10**, 2217-2221, 2000) and Tsuda (Tsuda *et al.*, *Chem. Pharm. Bull.*, **49**, 1457-1463, 2001) described derivatives of 4-aminomethyl-cyclohexanoic acid which inhibit plasmin with IC_{50} values $\geq 0.1 \mu\text{M}$, but clinical use of these inhibitors has not been reported.

[0008] Stürzebecher *et al.* have described a series of N-terminal sulfonylated benzamidine peptidomimetics having various effects on serine proteases. Included within this class are factor Xa inhibitors, useful as anticoagulants and antithrombotics (US Pat. No. 6841701); urokinase inhibitors, useful as tumor suppressors (US Pat. Application Publication No. 2005/0176993, US Pat. No. 6624169); inhibitors of plasma kallikrein (PK), factor XIa and

factor XIIa, useful as anticoagulants and antithrombotics (US Pat. Application Publication No. 2006/0148901); and matriptase inhibitors, useful as tumor suppressors (US Pat. Application Publication No. 2007/0055065).

[0009] Inhibition constants for some compounds affecting plasmin activity have been published in several studies on inhibitors of coagulation proteases. The compounds in question, however, were being investigated as antithrombotics, and therefore a low level of plasmin inhibition was preferred. For example, the thrombin inhibitor melagatran inhibits plasmin with a K_i value of 0.7 μM , and the structurally related compound H317/86 has an inhibition constant of 0.22 μM (Gustafsson *et al.*, *Thromb. Haem.*, **79**, 110-118, 1998). However, because both compounds inhibit the protease thrombin much more strongly ($K_i \leq 2 \text{ nM}$), the net effect of administration is inhibition of coagulation. The possibility of using such compounds as pro-coagulants, *e.g.* for reducing blood loss in cardiac surgical procedures, was not mentioned in any of these papers.

[0010] As noted above, aprotinin inhibits not only plasmin but also plasma kallikrein (PK). PK is a multifunctional, trypsin-like serine protease for which several physiological substrates are known. Thus, by proteolytic cleavage, PK is able to release the vasoactive peptide bradykinin from high molecular weight kininogen, and to activate zymogens such as coagulation factor XII, pro-urokinase, plasminogen and pro-MMP 3. It is therefore assumed that the PK/kinin system plays an important role in many pathological conditions, for example in thromboembolic situations, disseminated intravascular coagulation, septic shock, allergies, the postgastrectomy syndrome, arthritis and ARDS (adult respiratory distress syndrome) (Tada *et al.*, *Biol. Pharm. Bull.*, **24**, 520-524, 2001).

[0011] Accordingly, aprotinin, via its inhibitory effect on PK, inhibits the release of the peptide hormone bradykinin, which in turn has various effects via activation of the bradykinin B2 receptor. The bradykinin-induced release of tPA, NO and prostacyclin from endothelial cells (Schmaier, *J. Clin. Invest.*, **109**, 1007-1009, 2002) influences fibrinolysis, blood pressure and inflammatory events. It has been suggested that systemic inflammatory processes which may occur as a side effect in surgical operations can be reduced by inhibiting bradykinin release.

[0012] Various bisbenzamidines, such as pentamidine and related compounds, and esters of ω -amino- and ω -guanidinoalkylcarboxylic acids, have been described as PK inhibitors with micromolar K_i values (Asghar *et al.*, *Biochim Biophys Acta*, **438**, 250-264, 1976; Muramatu and Fuji, *Biochim. Biophys. Acta*, **242**, 203-208, 1971; Muramatu and Fuji, *Biochim. Biophys.*

Acta, **268**, 221-224, 1972; Ohno *et al.*, *Thromb. Res.*, **19**, 579-588, 1980; Muramatsu *et al.*, *Hoppe-Seyler's Z. Physiol. Chem.*, **363**, 203-211, 1982; Satoh *et al.*, *Chem. Pharm. Bull.*, **33**, 647-654, 1985; Teno *et al.*, *Chem. Pharm. Bull.*, **39**, 2930-2936, 1991).

[0013] The first selective competitive PK inhibitors to be reported (Okamoto *et al.*, *Thromb. Res.*, Suppl. **VIII**, 131-141, 1988) were derived from arginine or phenylalanine, and inhibit PK with K_i values around 1 μ M. Several papers on the development of competitive PK inhibitors have been published by the Okada group, with the most active compounds, derived from trans-4-aminomethylcyclohexanecarbonyl-Phe-4-carboxymethylanilide, having inhibition constants around 0.5 μ M (Okada *et al.*, *Biopolymers*, **51**, 41-50, 1999; Okada *et al.*, 2000, Tsuda *et al.*, 2001). It is characteristic of these PK inhibitors that they have a relatively high K_i value.

[0014] Aliagas-Martin *et al.*, in US Pat. No. 6472393, described a wide variety of 4-amidinoanilides which are potent PK inhibitors, having inhibition constants around 1 nM. Antonsson *et al.* likewise described a wide range of amidine and guanidine PK inhibitors in US Pat. No. 5602253. Stürzebecher *et al.* have described 4-amidino- and 4-guanidino-benzylamines as PK inhibitors, some of which are Factor Xa inhibitors (US Pat. Application Publication. No. 2005/0119190), some of which have a slight inhibitory effect on plasmin (US Pat. Application Publication. No. 2006/0148901), and some of which are dual plasmin/PK inhibitors (PCT Publication No. 2008/049595). These inhibitors are related to, but differ structurally from, the inhibitors described in the present application.

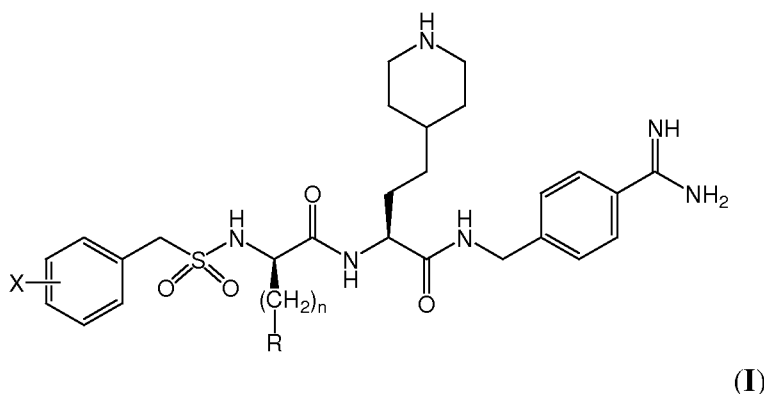
[0015] Dyax Corp. has developed a selective plasma kallikrein inhibitor, DX-88 (ecallantide, Kalbitor™), for the treatment of acute attacks in hereditary angioedema. Ecallantide is a recombinant small protein that has been identified utilizing a phage display technology based on the first Kunitz domain of human tissue factor pathway inhibitor (TFPI). Ecallantide is also undergoing phase II clinical testing for the reduction of blood loss during on-pump cardiothoracic surgery (Lehmann, *Expert Opin. Biol. Ther.*, **8**, 1187-1199, 2008).

[0016] There remains a need for low-molecular-weight substances, suitable for therapeutic applications, which reversibly and competitively inhibit plasmin and plasma kallikrein with high activity and specificity, and the present invention provides such compounds. The compounds of the present invention, accordingly, are suitable for modulating and/or maintaining hemostasis in various situations, particularly during and after surgeries with cardiopulmonary bypass, organ transplants, and other major surgical interventions. It is expected that the compounds of the present invention, as inhibitors of plasma kallikrein, will also lower kinin release, thereby suppressing both kinin-mediated inflammatory reactions and

kinin-induced release of tPA from endothelial cells. The latter effect provides an additional mechanism for downregulation of fibrinolysis.

BRIEF DESCRIPTION OF THE INVENTION

[0017] It has been found that compounds of general formula **I**,



wherein X, R, and n are as defined below, are effective and selective inhibitors of plasmin and plasma kallikrein. The invention accordingly provides compounds of formula **I**, methods for the preparation of compounds of formula **I**, and pharmaceutical compositions comprising compounds of formula **I**. The invention also provides methods of inhibiting plasmin and/or PK in a patient, methods for therapeutic modulation of the blood coagulation cascade and fibrinolysis, especially methods for prevention and treatment of blood loss in a patient, by administration of the compounds of formula **I**.

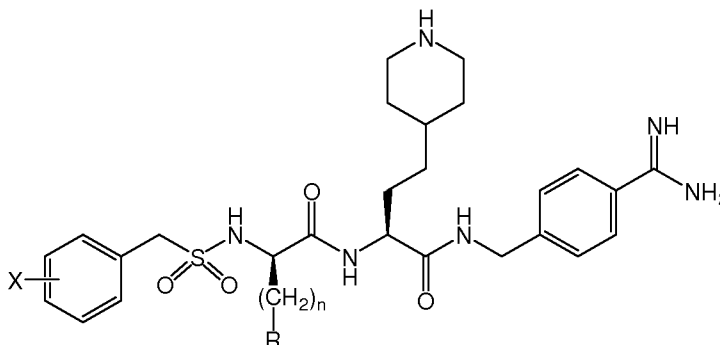
[0018] The invention further provides methods for the use of these compounds in manufacturing medicaments for inhibiting plasmin and/or PK in a patient, medicaments for therapeutic modulation of the coagulation cascade and fibrinolysis, especially for prevention and treatment of blood loss in a patient. Subjects who may be treated with the compositions of the invention include, but are not limited to, patients experiencing hyperfibrinolytic conditions, organ transplants, and cardiac surgical procedures, especially those involving cardiopulmonary bypass.

[0019] In the above formula **I**, X is selected from the group consisting of H, CO₂H, and CO₂R'; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidiny; wherein R may be unsubstituted or may be substituted by one or more substituents, as described in detail below.

[0020] The present invention also provides fibrin adhesives comprising the compounds of the invention, and methods for the use of the compounds of the invention in the manufacture of a fibrin adhesive.

DETAILED DESCRIPTION OF THE INVENTION

[0021] The invention provides compounds having the following formula (I)

**I**

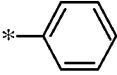
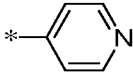
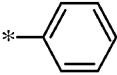
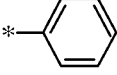
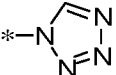
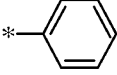
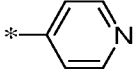
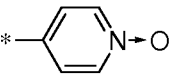
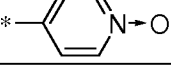
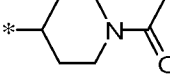
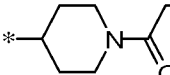
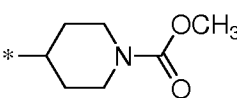
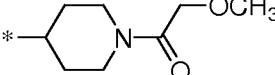
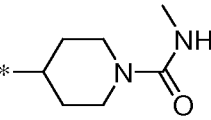
and pharmaceutically acceptable salts thereof; wherein X is selected from the group consisting of H, CO₂H, and CO₂R'; n ranges from 0 to 3; and R is phenyl, pyridyl, tetrazolyl, or piperidinyl. The moiety R may be unsubstituted or may be substituted by one or more of halogen, R', OR', SR', S(=O)R', S(=O)₂R', S(=O)₂NHR', S(=O)₂NR'₂, CN, NH₂, NHR', NR'₂, NHS(=O)₂R', NHC(=O)R', NHC(=O)OR', NHC(=O)NHR', NHC(=O)NR'₂, C(=O)R', C(=O)CH₂OR', CO₂R', C(=O)NHR', or C(=O)NR'₂; and where R is pyridyl, it may be a pyridine N-oxide. In all of the above-described compounds, each R' is independently C₁ to C₄ branched or unbranched lower alkyl or CF₃. As used herein the terms "phenyl", "pyridyl", tetrazolyl, and "piperidinyl" refer to both the unsubstituted and substituted systems, unless specifically identified as being unsubstituted.

[0022] In preferred embodiments, n is 2 or 3. R is preferably phenyl, 4-pyridyl, or 4-piperidinyl. Particularly preferred are compounds wherein R is unsubstituted phenyl, unsubstituted 4-pyridyl, unsubstituted 4-pyridyl N-oxide, 1-acetyl-4-piperidinyl, 1-tetrazolyl, 1-isopropionyl-4-piperidinyl, or 1-cyclopropanecarbonyl-4-piperidinyl.

[0023] In another preferred embodiment, n is 0 and R is unsubstituted phenyl. In other embodiments, n is 2 or 3, R is 4-piperidinyl; and the nitrogen of the piperidinyl bears a substituent selected from the group consisting of C(=O)R', C(=O)CH₂OR', CO₂R', C(=O)NHR', and C(=O)NR'₂.

[0024] Representative examples of the compounds of the invention are set out in Table 1.

Table 1

Compound No.	X	n	R
1.1	H	3	
1.2	H	3	
1.3	3-CO ₂ H	3	
1.4	3-CO ₂ Me	3	
1.5	H	3	
1.6	H	0	
1.7	H	2	
1.8	H	3	
1.9	H	2	
2.1	H	2	
2.2	H	2	
2.3	H	2	
2.4	H	2	
2.5	H	2	

2.6	H	2	
2.7	H	3	
2.8	H	3	
2.9	H	2	
2.10	H	2	
2.11	H	2	
2.12	H	2	
2.13	H	3	
2.14	H	3	

[0025] The pharmaceutically acceptable salts of the compounds of the invention are preferably formed by addition of any acid known to be useful in the formation of pharmaceutical salts. Preferred acids for salt formation include HCl, HBr, sulfuric acid, phosphoric acid, acetic acid, citric acid, methanesulfonic acid, trifluoroacetic acid, and p-toluenesulfonic acid.

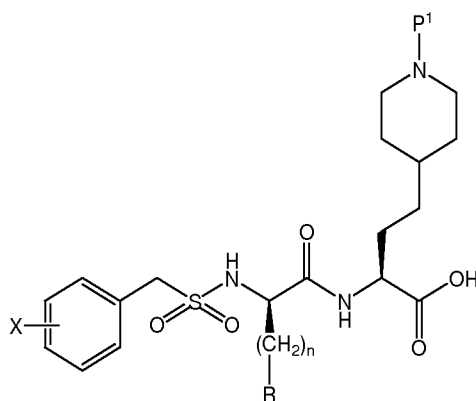
[0026] Substituents on the aromatic or heteroaromatic rings R include, but are not limited to, one or more of F, Cl, Br, I, CF₃, R', phenyl, OH, OR', OCF₃, CO₂H, CO₂R', CONHR', CONR'₂, NH₂, NHR', NR'₂, NHSO₂', NR'SO₂R', NO₂, SOR', SO₂R', SO₂NH₂, SO₂NHR', SO₂NR'₂, CN, OCO₂R', OCONHR', OCONR'₂, NHCOR', NHCO₂R', NHCONHR', NHCONR'₂, NHCO₂R', NR'CO₂R', NR'CONHR', and NR'CONR'₂, where each R' is independently C₁ to C₄ branched or unbranched lower alkyl, and cycloalkyl.

[0027] The compounds of the general formula **I** can be prepared by sequential coupling of amino acids to 4-amidinobenzylamine, which is N-protected at the amidino group. It will be understood that any suitable N-protecting group known in the art may be employed at the amidino group. Suitable N-protecting groups for the amidino group include, but are not limited to, 1,2,4-oxadiazol-5-one, N-Boc, N-Cbz, N-benzyloxy, and N-acetoxy. The 1,2,4-oxadiazol-5-one, N-benzyloxy and N-acetoxyamidino groups are preferred, because they are easily prepared from the corresponding nitrile.

[0028] The compounds of the invention may be prepared in several ways. Preferred synthetic approaches involve the formation of amide and sulfonamide bonds between pre-synthesized components. The methods and procedures described in PCT Publication No. 2008/049595, which is incorporated herein by reference in its entirety, may be readily adapted to the synthesis of the compounds of the present invention.

[0029] As used herein, the expression “an activated carboxylic acid derived from” a given acid refers to derivatives of carboxylic acids that are reactive toward amines, including but not limited to active esters, mixed anhydrides, and acyl halides, as are well-known in the art of peptide synthesis. Suitable examples include, but are not limited to, N-hydroxybenzotriazole esters, O-acylated isoureas, pentachloro- and pentafluoro-phenyl esters, acyl chlorides, and mixed anhydrides with carbonic acid monoesters. Preferred activated carboxylic acids are the mixed anhydride obtained by reaction with isobutyl chloroformate, or the N-hydroxybenzotriazole ester.

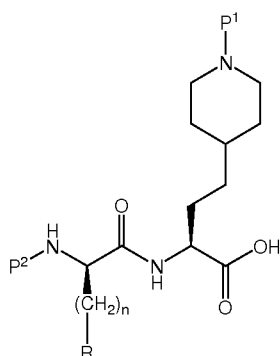
[0030] In a first representative synthesis, an amidino-protected 4-(aminomethyl)-benzamidine, such as 4-(aminomethyl)-N-acetoxybenzamidine (**i**), is obtained from the commercially available 4-cyanobenzylamine (Showa Denko K.K., Japan) by the method described in the supplement to Schweinitz *et al.*, *J. Biol. Chem.*, **279**:33613-33622 (2004). Alternative amidino-protected 4-(methylamino)benzamidines include (**ii**), (**iii**), or (**iv**) as described below. This material is N-acylated with an activated carboxylic acid derived from compound **A**



(A)

wherein P^1 is an amino protecting group, and X, n, and R are as described above. P^1 may be any amino protecting group known in the art, including but not limited to Fmoc, Alloc, Boc, benzyloxycarbonyl (Cbz), 4-nitrobenzyloxycarbonyl (4-NO₂-Cbz), trifluoroacetyl, trityl, and benzhydryl. The Boc and the Cbz group are preferred. Following the acylation, cleavage of the amino protecting group P^1 and cleavage of the protecting group from the benzamidine are carried out, in any order. If P^1 is a benzyloxycarbonyl or benzhydryl group, both protecting groups may be removed in a single hydrogenolysis step. On a small scale, final purification of the inhibitors is preferably carried out by preparative reversed-phase HPLC. Larger preparations are purified by recrystallization of the compound, or a suitably crystalline salt thereof, as is routine in the art.

[0031] A second representative synthesis comprises the acylation of 4-(aminomethyl)-N-acetoxymethylbenzamidinium (**i**) (or, alternatively, (**ii**), (**iii**), or (**iv**)) with an activated carboxylic acid derived from compound **B**,

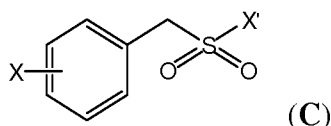


(B)

wherein P^1 and P^2 are amino protecting groups and n and R are as described above. Again, P^1 and P^2 may be any amino protecting group known in the art, including but not limited to Fmoc, Alloc, Boc, benzyloxycarbonyl (Cbz), 4-nitrobenzyloxycarbonyl (4-NO₂-Cbz),

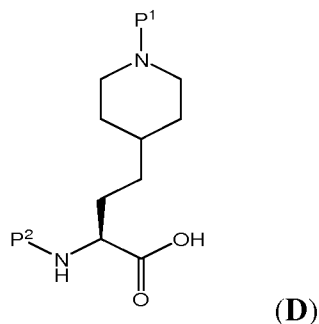
trifluoroacetyl, trityl, and benzhydryl. In this scheme, however, P^1 and P^2 are preferably orthogonal, so that P^2 may be cleaved without affecting P^1 .

[0032] After the acylation, the amino protecting group P^2 is cleaved, and the resulting deprotected α -amino group is sulfonylated with a sulfonylating agent of formula **C**:



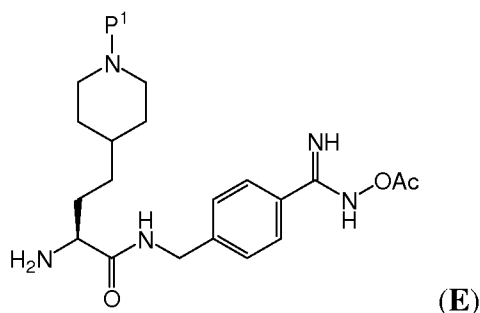
wherein X' is a leaving group, preferably Cl, and X is as defined above. After sulfonylation, the amino protecting group P^1 and the protecting group on the benzamidine are cleaved as described above, simultaneously or in any order.

[0033] A third, and preferred, synthetic approach comprises the acylation of 4-(aminomethyl)-N-acetoxybenzamidine (**i**) (or, alternatively, (**ii**), (**iii**), or (**iv**)) with an activated carboxylic acid derived from compound **D**

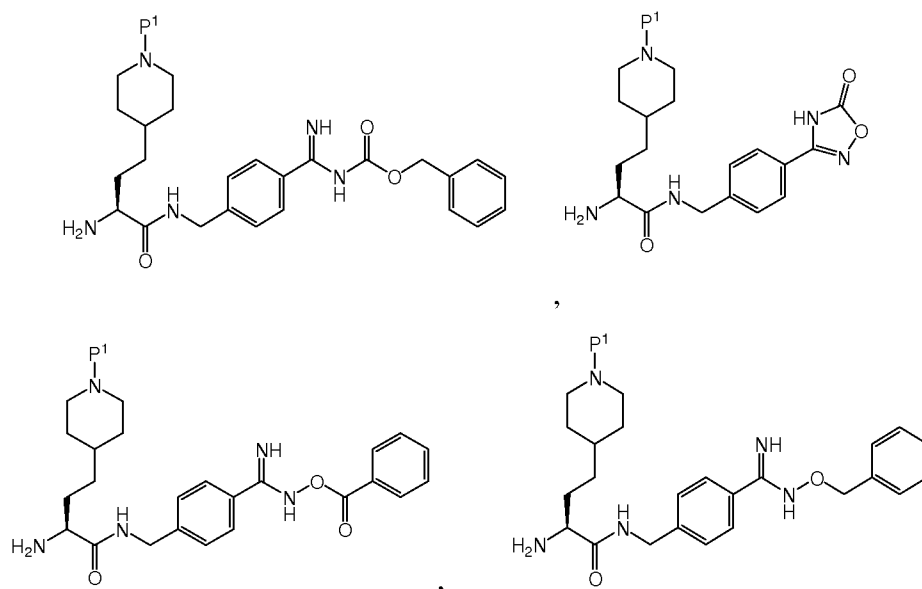


wherein P^1 and P^2 are amino protecting groups as described above.

[0034] Again, P^1 and P^2 are preferably orthogonal, so that P^2 may be cleaved without affecting P^1 . After the acylation, the amino protecting group P^2 is cleaved, to generate an intermediate such as **E** shown below:

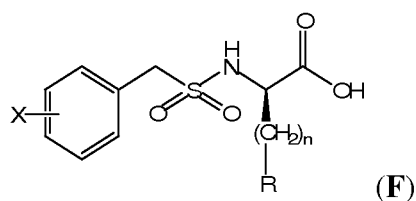


[0035] In this manner, using the starting materials (ii) – (v) described above, the invention also provides compounds analogous to E, such as the following:



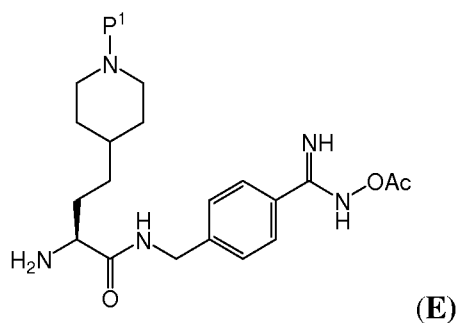
where P^1 is an amino protecting group as described above.

[0036] The intermediate **E** is then acylated with an activated carboxylic acid derivative derived from compound **F**

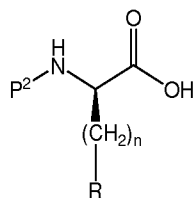


where X, n, and R are as defined above. Removal of P^1 and the amidine protecting group, as described above, provides a compound of structure **I**.

[0037] A fourth method comprises acylation of an N-acylated amidino-protected 4-(aminomethyl)benzamidine, such as structure **E**



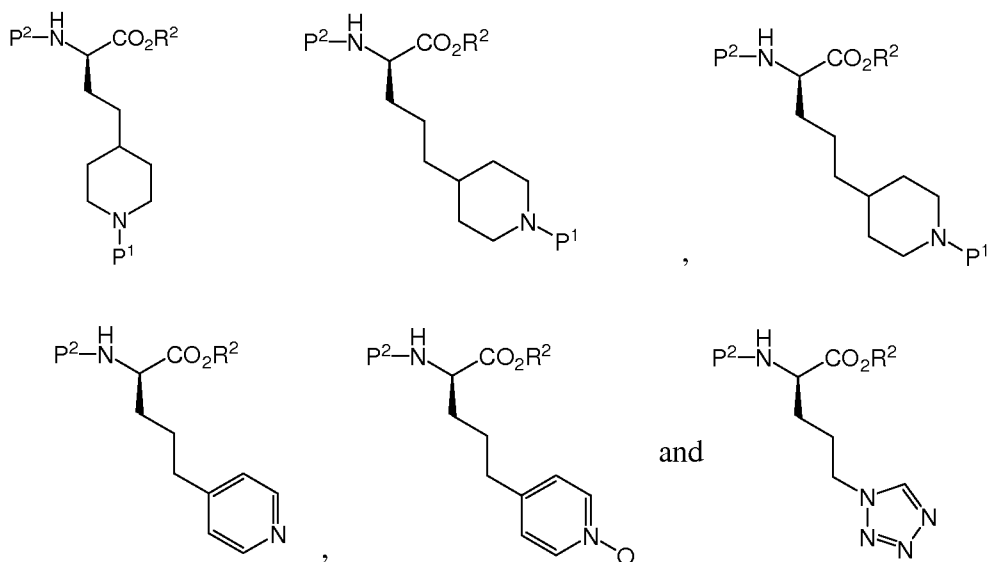
with an activated carboxylic acid derived from structure **G**



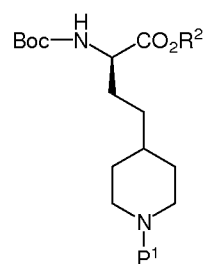
(G)

where P^1 , P^2 , n and R are as defined above.

[0038] The invention provides a variety of compounds of formula **G**, and precursors thereof, including but not limited to the following examples:

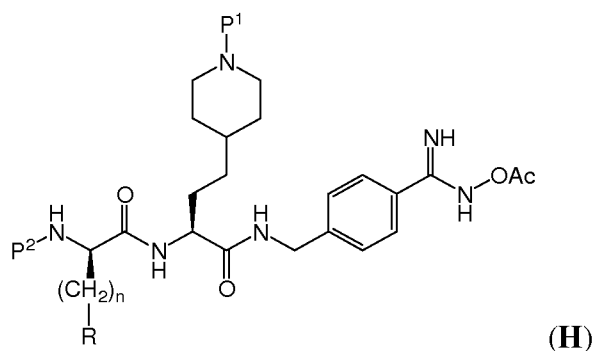


wherein P^1 and P^2 are independently H or amino protecting groups, such as Boc, Fmoc, Cbz, and trifluoroacetyl, and R^2 may be H, methyl, ethyl, t-butyl, or benzyl. Preferably, P^1 and P^2 are orthogonal, so that P^2 can be removed in the presence of P^1 . Particularly useful as intermediates are compounds of formula



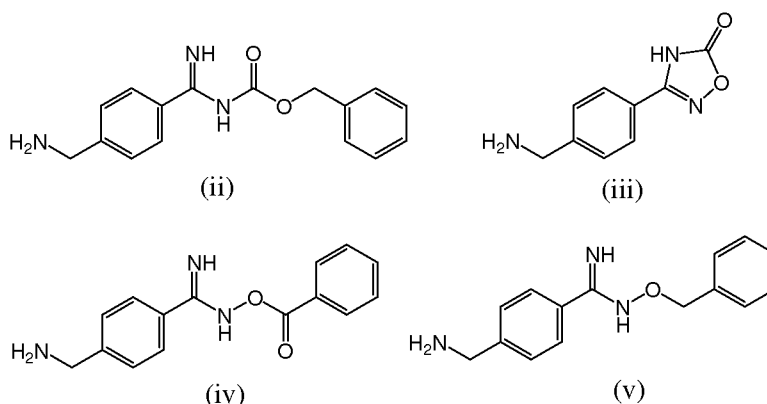
where P^1 is H, benzyloxycarbonyl, or 4-nitrobenzyloxycarbonyl, and R^2 is H, methyl, ethyl, t-butyl, or benzyl.

[0039] Acylation of a compound **E** with an activated acid derived from structure **G** yields intermediates such as structure **H**



[0040] The amino protecting group P^2 , which is preferably orthogonal to P^1 , is then cleaved from intermediate **H**, and the resulting deprotected α -amino group is sulfonylated with a sulfonylating agent of formula **C** as described above. After sulfonylation, the amino protecting group P^1 , any protecting group on R, and the protecting group on the benzamidine are cleaved as described above, simultaneously or in any order.

[0041] In additional embodiments of the invention, any of the above methods of preparation are carried out using alternative protecting groups for the amidine functionality. Suitable protecting groups include, but are not limited to, substituted and unsubstituted N-benzyloxy, N-benzoyloxy and N-benzyloxycarbonyl groups, and the 1,2,4-oxadiazol-5-one heterocyclic ring, which are readily introduced by the substitution for (i) of alternative starting materials such as (ii)-(v) shown below:



[0042] The compounds of the invention are useful for the therapeutic modulation of the blood coagulation cascade and fibrinolysis. As used herein, “therapeutic modulation” includes both pro- and anti-coagulant activities, and the *in vivo* stabilization or promotion of innate hemostatic or fibrinolytic activities. In particular, the compounds are useful for the prevention or treatment of blood loss. Patients in need of such treatment include those undergoing surgery (especially those procedures, such as cardiac surgery, which involve cardiopulmonary bypass), and those suffering from an acquired or inborn derangement of hemostasis or fibrinolysis.

[0043] The invention also provides pharmaceutical composition comprising one or more compounds of the invention, in combination with one or more pharmaceutically acceptable carriers or excipients. Such excipients include, but are not limited to, fillers, binding agents, lubricants, preservatives, water, buffers, and disintegrants. The compositions may be in the form of solids or liquids, compounded for oral administration, or solutions or suspensions suitable for parenteral administration. In particular, a buffered saline solution suitable for parenteral administration is provided, as are powdered or lyophilized compositions suitable for reconstitution into a buffered saline solution.

[0044] Also provided are fibrin adhesives comprising, in at least one component of the fibrin adhesive, one or more compounds of formula I. Methods and compositions for fibrin adhesives are well-known in the art; see Sierra, *J. Biomater. Appl.*, **7**:309-352 (1993). Fibrin adhesives generally consist of a physiological two-component adhesive which comprises as a first component fibrinogen, factor XIII and aprotinin, and as a second component thrombin and calcium chloride for factor XIII activation. In such compositions, the prior art material aprotinin will be augmented or replaced by a suitable plasmin inhibitor of the present invention. Methods and materials for preparing fibrin adhesives are described in US Pat. 7572769, which is incorporated by reference in its entirety. Compositions without fibrinogen may also be prepared, as described in US Pat. 6410260, which is incorporated herein by reference in its entirety.

[0045] The invention also provides methods for preventing blood loss in a patient, which comprise administering to a patient in need thereof an effective amount of at least one compound of formula I. Such patients include, but are not limited to, individuals with hyperfibrinolytic conditions, or undergoing organ transplants or cardiac surgical procedures, in particular those procedures involving cardiopulmonary bypass. Preferably the compound or compounds are administered in the form of a pharmaceutical composition as described above. Those skilled in the art will appreciate that suitable doses will vary with the particular compound, the route of administration, the condition to be treated, and the hemostatic status of the patient. In general, daily doses in the range of 1 mg to 500 mg will be effective. Effective dosing levels can be determined by dose-ranging studies, which are routine and well within the ability of those skilled in the art. Dosing may be continuous (*e.g.*, via an intravenous line), or unit doses can be administered one or more times daily, as needed to maintain an effective concentration *in vivo*. Preferably, dosing is adjusted so as to maintain a mean blood level ranging from 0.01 to 10 µg/ml during the period for which prevention of blood loss is desired.

[0046] The invention further provides methods for inhibiting human plasmin and/or PK, in a patient in need thereof, comprising administering to said patient an effective amount of one or more compounds of formula I. Effective doses are determined as described above.

[0047] The invention also provides for the use of a compound of formula I in the manufacture of medicaments for the prevention of blood loss, the inhibition of plasmin, and/or the inhibition of PK, and in the manufacture of a fibrin adhesive.

[0048] The following examples are presented by way of example, and are intended to illustrate and explain the invention in detail. The scope of the invention is not limited to the examples presented.

EXAMPLES

[0049] Analytical HPLC

Variable	Parameters
Device	Shimadzu LC-10A system
Column	Phenomenex Luna C ₁₈ 100 Å, 5 µm column, 4.6 × 250 mm
Mobile phase	A: TFA, 0.1%(v/v) in water; B: TFA, 0.1 %(v/v) in methanol
Method	Linear gradient of 1 % B per min
Flow rate	1.0 mL/min
Detection wavelength	UV 220 nm
Column temperature	25°C
Injection volume	30 µl

[0050] Preparative HPLC

Variable	Parameters
Device	Shimadzu LC-8A system
Column	Phenomenex Luna C ₈ (2) 100 Å , 5 µm column, 30 × 250 mm
Mobile phase	A: TFA, 0.1%(v/v) in H ₂ O; B: TFA, 0.09%(v/v) in methanol
Method	Linear gradient of 45 % B in 120 min
Flow rate	20.0 mL/min
Detection wavelength	UV 220 nm
Column temperature	30°C

[0051] Chiral HPLC

Variable	Parameters
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Device	HP Agilent 1100 system
Column	Chiralpak AD-H 5 μ m column, 4.6 x 250 mm
Mobile phase	A: heptane; B: isopropanol
Method	isocratic 85 % A / 15 % B 45 min
Flow rate	1.0 mL/min
Detection wavelength	UV 220 nm
Column temperature	25°C
Injection volume	30 μ l

[0052] Thin layer chromatography

[0053] Thin layer chromatography (TLC) of final inhibitors was performed on silica gel plates (silica gel 60 F₂₅₄, Merck, Darmstadt, Germany) using the following mobile phase systems (solvent ratios are by volume):

n-butanol / acetic acid / water	4/1/1
n-butanol / acetic acid / ethyl acetate/ water	1/1/1/1
dichloromethane / methanol (DCM/MeOH)	5/1
benzene / acetone / acetic acid (BAE)	27/10/05
petrol ether (PE) / ethyl acetate (EE)	1/1

[0054] Mass spectroscopy

[0055] Mass spectra were recorded on an Esquire HCT ESI-MS (Bruker Daltonics).

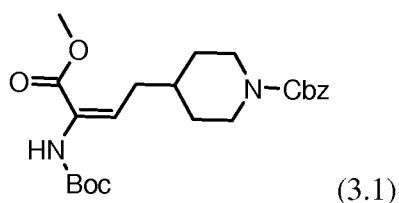
[0056] Abbreviations

4-Amba	4-amidinobenzylamide
Ac	acetyl
Boc	tert.-Butyloxycarbonyl
BSA	bovine serum albumin
Bzls	benzylsulfonyl
Cbz	benzyloxycarbonyl
Cbz(4-NO ₂)	(4-nitro)benzyloxycarbonyl
DCM	dichloromethane
DGly(Tzlpr)	(R)-2-amino-5-(1H-tetrazol-1-yl)pentanoic acid
DGly(4-Pippr)	(R)-2-amino-5-(piperidine-4-yl)pentanoic acid
DGly(4-Pyrpr)	(R)-2-amino-5-(pyridine-4-yl)pentanoic acid
DGly(4-Pyprren)	(R,E)-2-amino-5-(pyridine-4-yl)pent-4-enoic acid
DhAla(4-Pip)	(R)-2-amino-4-(piperidine-4-yl)butanoic acid

D/LhAla(4-Pyr)	(R,S)-2-amino-4-(pyridine-4-yl)butanoic acid
DPhg	(R)-2-amino-2-phenylacetic acid
DPpg	(R)-2-amino-5-phenylpentanoic acid
DIEA	diisopropylethylamine
DMF	N,N-dimethylformamide
DMSO	dimethyl sulfoxide
FC	flash chromatography
HPLC	high performance liquid chromatography
m-CPBA	3-chloroperoxybenzoic acid
MS	mass spectroscopy
NMM	N-Methylmorpholine
PyBop	benzotriazol-1-yl-oxytripyrrolidinophosphonium hexafluorophosphate
TEA	triethylamine
TFA	trifluoroacetic acid
THF	tetrahydrofuran
TLC	thin layer chromatography
TMS-Cl	trimethylsilyl chloride

[0057] Synthesis of precursors

[0058] (E)-methyl 2-(tert-butyloxycarbonylamino)-4-(1-benzyloxycarbonyl-piperidin-4-yl)but-2-enoate

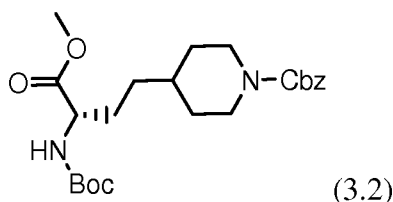


[0059] To a solution of Boc- α -phosphonoglycine trimethyl ester (20 g, 67 mmol) in THF (80 ml) was added 1,1,3,3-tetramethylguanidine (8 ml, 64 mmol) at -78 °C and stirring was continued for 20 min. 2-(4-benzyloxycarbonyl piperidine)-acetaldehyde (16 g, 61 mmol) was added and the mixture stirred at -78 °C for 1 h and at 0°C for 2 h. The solution was diluted with ethyl acetate, washed with aqueous 5 % KHSO₄ and brine. The organic layer was dried (Na₂SO₄) and evaporated in vacuo. The residue was purified by FC using silica gel 60 (40-63 μ m) and a gradient from 0 - 70% ethyl acetate in cyclohexane to afford the title compound.

Yield: 24.7 g (93 %, white solid).

Anal. HPLC: 79.8 % B; TLC: R_f = 0.58 (PE/EE 1:1); MS calc.: 432.2, found 455.0(M+Na)⁺

[0060] Boc-hAla(4-Pip[Cbz])-OMe



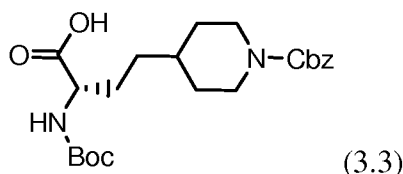
[0061] [Rh(COD)(S,S)-Et-duphos)]OTf (167 mg, 0.231 mmol) was placed in a 100 ml Schlenk flask previously set under argon. Degassed methanol (50 ml) was then added and the solution stirred for 5 min. Compound 3.1 (10.0 g, 23.1 mmol) was placed in a 1 L Schlenk flask, dissolved in methanol (450 ml) and stirred at room temperature for 10 min. Both the substrate and the catalyst solution were then transferred via canula into a 1 L stainless steel reactor previously set under argon. The reactor was sealed, purged with argon in three cycles (1 bar/20 bar) and finally, the argon replaced with hydrogen (4 cycles 1 bar/20bar). The reactor pressure was set to 4 bar hydrogen and stirring was started. After 18.5 h, the pressure was released and the solvent evaporated in vacuo. The residue was filtered through a short pad of SiO₂ (20 g; ethyl acetate / n-heptane = 1:3) and the solvent evaporated in vacuo to afford the title compound.

Yield: 9.7 g (97 %).

Anal. HPLC: 78.1 % B TLC: R_f = 0.74 (BAE); MS calc.: 434.2, found 435.0 (M+H)⁺

Enantiomeric purity (ee): > 99.5 % (chiral HPLC)

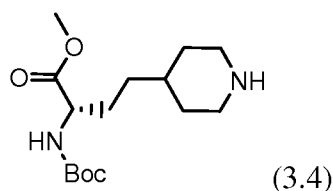
[0062] Boc-hAla(4-Pip-[Cbz])-OH



[0063] A mixture of methyl ester 3.2 (1.7 g, 3.9 mmol) in dioxane (10 ml) and aqueous 1 N LiOH (10 ml) was stirred at room temperature for 2 h and then neutralized by the addition of aqueous 1 N HCl. The solvent was evaporated in vacuo, the residue dissolved in ethyl acetate and the solution washed with aqueous 5 % KHSO₄ and brine. The organic layer was dried (Na₂SO₄) and evaporated in vacuo to afford the title compound.

Yield: 1.65 g (97%, white solid)

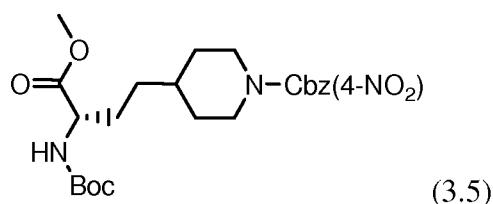
Anal. HPLC: 77.1 % B, TLC: R_f = 0.4 (BAE), MS calc.: 420.2, found: 419.1 (M-H)⁻

[0064] Boc-hAla(4-Pip)-OMe

[0065] To a solution of compound 3.2 (2.2 g, 5 mmol) in methanol (350 ml) 10 % Pd/C (20 mg) was added at room temperature under nitrogen. The nitrogen was replaced by hydrogen and the mixture stirred at room temperature for 2 h. The mixture was flushed with nitrogen, filtered through Celite™ and the solvent evaporated in vacuo to afford the title compound.

Yield: 1.5 g (99.8 %, oil)

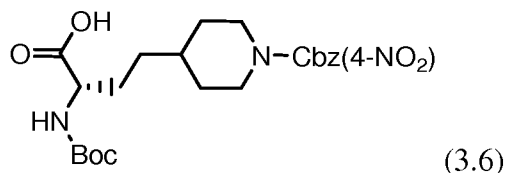
TLC: R_f = 0.49 (4:1:1); MS calc.: 300.2; found 301.0 (M+H)⁺

[0066] Boc-hAla(4-Pip-[Cbz-4-NO₂])-OMe

[0067] To a solution of compound 3.4 (1.5 g, 4.9 mmol) in THF (25 ml) was added 4-nitrobenzyloxycarbonyl-chloride (1.1 g, 4.9 mmol) and TEA (0.85 ml, 6 mmol) at room temperature and the mixture was stirred for 1.5 h while maintaining the pH of the reaction between 8-9 by addition of TEA. The solvent was evaporated in vacuo, the residue dissolved in ethyl acetate, washed with aqueous 5 % KHSO₄ and brine. The organic layer was dried (Na₂SO₄) and evaporated in vacuo to afford the title compound.

Yield: 2.35 g (100 %, oil).

Anal. HPLC: 76.7 % B; TLC: R_f = 0.89 (5:1); MS calc.: 479.2, found 480.0 (M+H)⁺

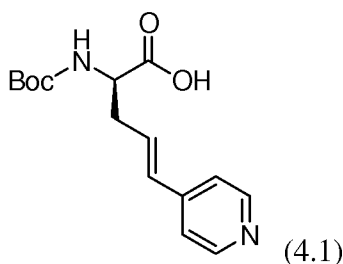
[0068] Boc-hAla(4-Pip-[Cbz-4-NO₂])-OH

[0069] Compound 3.5 (2.5 g, 5.2 mmol) was converted to the title compound according to the procedure described for compound 3.3.

Yield: 2.1 g (85 %)

Anal. HPLC: 73.8 % B; TLC: R_f = 0.6 (5:1); MS calc.: 465.2, found 465.9 (M+H)⁺

[0070] Boc-DGly(4-Pyrpren)-OH

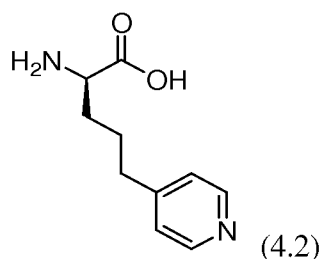


[0071] To a solution of Boc-allylglycine (1.65 g, 7.7 mmol) and 4-iodopyridine (1.38 g, 6.75 mmol) in DMF (40 ml) was added a solution of NaHCO₃ (1.7 g, 20.5 mmol) in water (20 ml) and the mixture was incubated at 70 °C for 10 min. Palladium acetate (160 mg, 0.7 mmol) was added and the mixture was stirred at 70 °C for 4h and at room temperature overnight. The catalyst was filtered off and the solvent evaporated in vacuo. Purification by FC using silica gel 60 (40-63 μm) and a gradient from 0 - 38 % methanol in DCM afforded the title compound.

Yield: 2.1 g (94.6 %, yellow solid).

Anal. HPLC: 36.1 % B; TLC: R_f = 0.45 (1:1:1:1); MS calc.: 292.1, found 292.9 (M+H)⁺

[0072] H-DGly(4-Pyrpr)-OH x AcOH

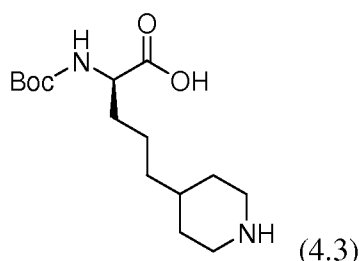


[0073] To a solution of compound 4.1 (5 g, 17 mmol) in 90 % acetic acid (300 ml) Pd/C (500 mg) was added under argon. The argon was replaced with hydrogen and the mixture stirred at room temperature overnight. The catalyst was filtered off and the solvent evaporated in vacuo. The oily intermediate was dissolved in 1 N HCl in acetic acid (5 ml) and stirred at room temperature for 1 h. The solvent was evaporated in vacuo and the residue dissolved in a small amount of methanol. Addition of diethyl ether and filtering afforded the title compound.

Yield: 3.8 g (83.1 %, white solid).

TLC: R_f = 0.12 (1:1:1:1); MS calc.: 194.2, found 194.6 (M+H)⁺

[0074] Boc-DGly(4-Pippr)-OH x AcOH (AW 3-34)

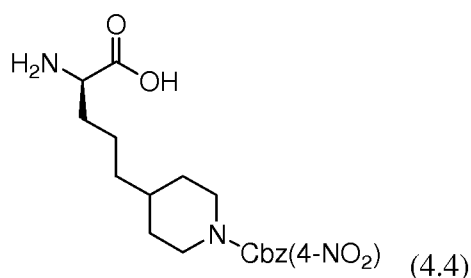


[0075] To a solution of compound 4.1 (2 g, 6.8 mmol) in 90 % acetic acid (50 ml) and ethanol (100 ml) was added 10 % Pt₂O (200 mg) under argon. The argon was replaced with hydrogen and the mixture stirred at room temperature overnight. The catalyst was filtered off, the solvent evaporated in vacuo and the residue dissolved in a small amount of methanol. Addition of diethyl ether and filtering afforded the title compound.

Yield: 1.5 g (62.1 %, amorphous solid)

TLC: R_f = 0.43 (1:1:1:1); MS calc.: 300.2; found 301.1 (M+H)⁺.

[0076] H-DGly(4-Pippr[Cbz-4-NO₂])-OH x HCl

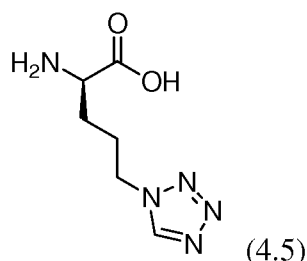


[0077] To a mixture of compound 4.3 (200 mg, 0.55 mmol) in aqueous 1 N NaOH (2 ml, 2 mmol), dioxane (8 ml) and water (5 ml) was added 4-nitrobenzyloxycarbonyl-chloride (120 mg, 0.55 mmol) at 0 °C with stirring. The pH was maintained at 8-9 by addition of aqueous 1M NaOH. Stirring was continued at room temperature for 2 h. The solvent was removed in vacuo and the residue portioned between ethyl acetate and aqueous 5 % KHSO₄. The organic layer was washed with aqueous 5 % KHSO₄ and brine, dried (Na₂SO₄), and evaporated in vacuo. The oily intermediate was dissolved in 1 N HCl in acetic acid (5 ml) and stirred at room temperature for 1 h. The solvent was evaporated in vacuo and the residue dissolved in a small amount of methanol. Addition of diethyl ether and filtering afforded the title compound.

Yield: 79 mg (41.3 %, white solid).

Anal. HPLC: 55.0 % B; MS calc.: 379.2, found 380.0 (M+H)⁺

[0078] H-DGly(Tzlpr)-OH

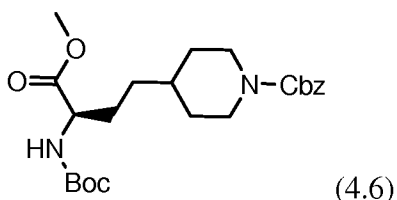


[0079] To a solution of Cbz-DOrn-OH (1.33 g, 5 mmol) in acetic acid (40 ml) was added sodium azide (1.5 g, 23 mmol) and trimethyl orthoformate (9.8 ml, 90 mmol) and the mixture was stirred at 80 °C for 2h. The solvent was evaporated in vacuo and the residue dissolved in ethanol (3 ml). Aqueous 2 N NaOH was added and the mixture stirred at room temperature for 15 min. The pH of the reaction mixture was adjusted to 3 by addition of aqueous 2 N HCl followed by extraction with ethyl acetate. The organic layer was separated, dried (NaSO₄), and the solvent evaporated in vacuo. The crude intermediate was dissolved in methanol (75 ml) and ethanol (75 ml) followed by addition of 10 % Pd/C (50 mg) under argon. The argon was replaced with hydrogen and the mixture was stirred at room temperature overnight. The catalyst was filtered off and washed with water. The organic solvent was evaporated in vacuo and the residue lyophilized to afford the title compound.

Yield: 740 mg (80 %, white powder)

MS calc.: 185.2, found 186.1 (M+H)⁺

[0080] Boc-DhAla(4-Pip-[Cbz])-OMe

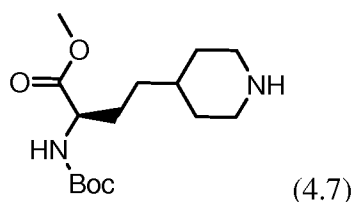


[0081] The title compound was prepared from compound 3.1 (10.0 g, 23.1 mmol) according to the procedure described for compound 3.2, using [Rh(COD)(R,R)-Et-duphos)]OTf as the catalyst.

Yield: 9.8 g (98 %, oil)

Anal. HPLC: 78.1 % B; TLC: R_f = 0.74 (BAE); MS calc.: 434.2, found 435.0 (M+H)⁺

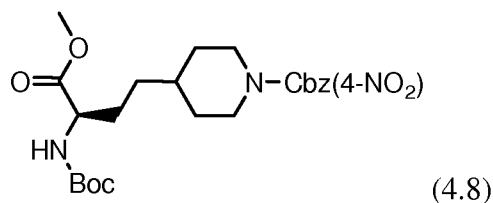
Enantiomeric purity (ee): > 99.5 % (chiral HPLC)

[0082] Boc-DhAla(4-Pip)-OMe

[0083] Compound 4.6 (3.2 g, 7.3 mmol) was converted to the title compound according to the procedure described for compound 3.4.

Yield: 2 g (92 %, oil).

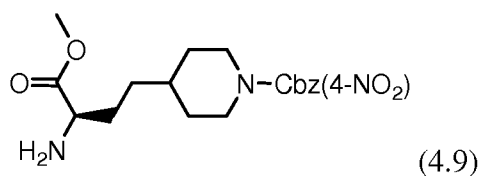
TLC: R_f = 0.67 (1:1:1:1); MS calc.: 300.2, found 301.1 (M+H)⁺

[0084] Boc-DhAla(4-Pip-[Cbz-4-NO₂])-OMe

[0085] Compound 4.7 (2 g, 6.7 mmol) was converted to the title compound according to the procedure described for compound 3.5.

Yield: 3.2 g (100 %).

Anal. HPLC: 76.5 % B; TLC: MS calc.: 479.2, found 478.6 (M-H)⁻

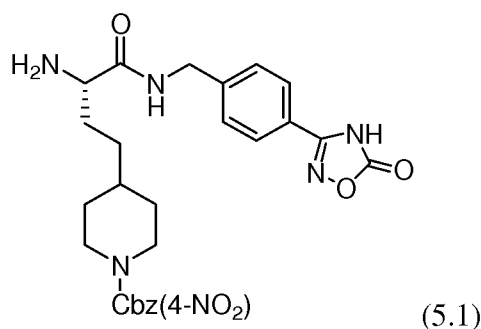
[0086] H-DhAla(4-Pip-[Cbz-4-NO₂])-OMe x HCl

[0087] To a solution of compound 4.8 (3.2 g, 6.7 mmol) in acetic acid (7 ml) 1N HCl in acetic acid (15 ml) was added and the mixture stirred at room temperature for 1 h. The solvent was partially evaporated in vacuo followed by addition of diethyl ether. The solid was filtered off, washed with diethyl ether, and dried in vacuo to afford the title compound.

Yield: 2.2 g (81 %, white solid).

Anal. HPLC: 52.8 % B; MS calc.: 379.2, found 380.0 (M+H)⁺

[0088] H-hAla(4-Pip-[Cbz-4-NO₂])-4-oxadiazolon-benzylamide x TFA



[0089] To a solution of compound 3.6 (1.7 g, 3.7 mmol) in DMF (10 ml) was added NMM (0.37 ml, 3.7 mmol) and isobutyl chloroformate (0.48 ml, 3.7 mmol) at -20 °C. The mixture was stirred for 10 min and 3-[4-(aminomethyl)phenyl]-1,2,4-oxadiazol-5-one HCl (1.2 g, 4.1 mmol; CAS 1097196-63-8, WO/2009/005076) and NMM (0.41 ml, 4.1 mmol) was added. The mixture was stirred at -15 °C for 1 h while maintaining the pH between 8-9 by addition of NMM. The reaction mixture was stirred at room temperature overnight and the solvent evaporated in vacuo. The residue was dissolved in ethyl acetate and consecutively washed with aqueous 5% KHSO₄, saturated aqueous NaHCO₃ and brine. The organic layer was dried (Na₂SO₄) and the solvent evaporated in vacuo. The product obtained was suspended in DCM (5 ml) and TFA (3 ml) was added and the mixture was stirred at room temperature for 1 h. The solvent was partially removed in vacuo followed by addition of diethyl ether. The product was filtered off, washed with diethyl ether, and dried in vacuo to afford the title compound.

Yield: 1.8 g (74 %, white solid).

Anal. HPLC: 59.2 % B; MS calc.: 538.2, found 539.0 (M+H)⁺

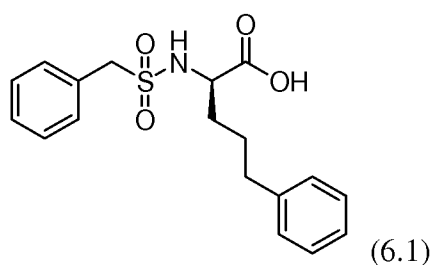
[0090] The compounds listed in Table 2 were prepared according to the procedure described for compound 5.1:

Table 2

#	Structure	Precursors	MS calculated/ found	Anal. HPLC % B
5.2		a) 3.3 and b) CAS 1097196-63-8	493.5/494.1 (M+H) ⁺	60.2

5.3	Chemical structure of compound 5.3: A piperidine ring with a Cbz(4-NO₂) group on the nitrogen is connected via a 2-aminopropyl chain to a chiral center. This chiral center is also bonded to an amino group and an amide group. The amide group is connected to a benzyl group, which is further connected to a benzene ring. The benzene ring has a 4-aminophenyl group and a 4-acetamidophenyl group.	a) 3.6 and b) CAS 380237-43-4	554.5/555.1 (M+H)⁺	52.8
5.4	Chemical structure of compound 5.4: A piperidine ring with a Cbz group on the nitrogen is connected via a 2-aminopropyl chain to a chiral center. This chiral center is also bonded to an amino group and an amide group. The amide group is connected to a benzyl group, which is further connected to a benzene ring. The benzene ring has a 4-aminophenyl group and a 4-acetamidophenyl group.	a) 3.3 and b) CAS 380237-43-4	509.6/510.1 (M+H)⁺	57.2

[0091] Bzls-DPpg-OH

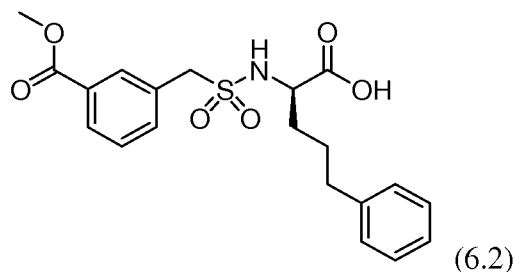


[0092] To a mixture of DPpg (3 g, 15 mmol) in aqueous 1M NaOH (15 ml, 15 mmol), dioxane (100 ml) and water (30 ml) was added in parallel a solution of Bzls-chloride (4.4 g, 23 mmol) in dioxane (10 ml) and aqueous 1M NaOH (25 ml, 25 mmol) at 0 °C over a period of 60 min. The pH was maintained between 8-9 by addition of aqueous 1M NaOH. The mixture was stirred at room temperature overnight. Additional Bzls-chloride (6 g, 31 mmol) and aqueous 1M NaOH (31 ml, 31 mmol) was added at 0 °C in portions and the pH maintained between 8-9 by addition of aqueous 1M NaOH. Stirring was continued until no more starting material was detected by TLC. The solvent was evaporated in vacuo and the residue portioned between ethyl acetate and aqueous 5 % KHSO₄. The organic layer was washed with aqueous 5 % KHSO₄ and brine, dried (Na₂SO₄), and evaporated in vacuo to afford the title compound.

Yield: 4 g (75 %, white solid).

Anal. HPLC: 69.3 % B; MS calc.: 347.1, found 346.3 (M-H)⁻

[0093] (3-MeOOC)Bzls-DPpg-OH



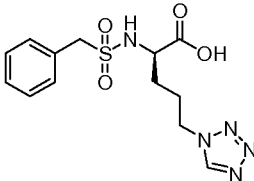
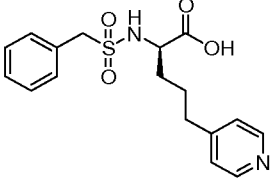
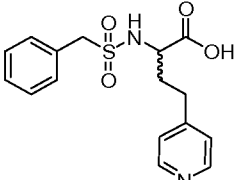
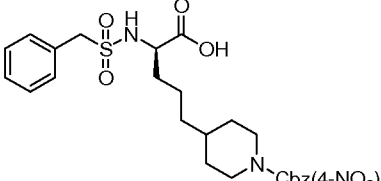
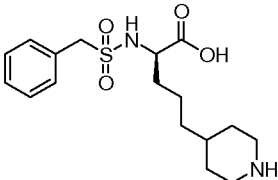
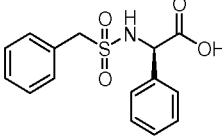
[0094] To a suspension of DPpg (1.3 g, 6.7 mmol) in dry DCM (90 ml) was added TMS-Cl (2 ml, 15.7 mmol) and DIEA (2.6 ml, 15 mmol) at room temperature and the mixture was refluxed for 1 h with stirring. The clear solution was cooled to 0°C and (3-MeOOC)Bzls-chloride (2 g, 8 mmol) and DIEA (2.6 ml) was added. The mixture was stirred at 0°C for 15 min and at room temperature for 1.5 h. The solvent was evaporated in vacuo and the residue dissolved in half-saturated aqueous NaHCO₃ (700 ml) followed by extraction with ethyl acetate. The aqueous layer was acidified with aqueous HCl (pH about 2-3) and extracted with ethyl acetate. The organic layer was washed with aqueous 5% KHSO₄ and brine, dried (Na₂SO₄), and evaporated in vacuo to afford the title compound.

Yield: 2.4 g (88 %, amorphous yellow solid).

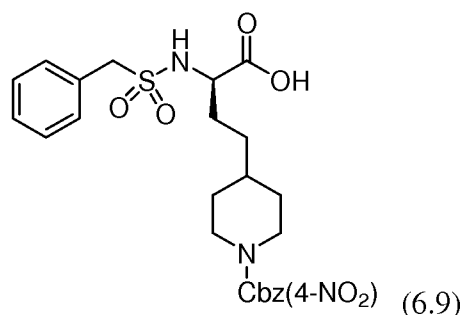
Anal. HPLC: 69.2 min % B; MS calc.: 405.1, found 404.3 (M-H)⁻

[0095] The compounds listed in Table 3 were prepared according to the procedure described for compound 6.1 or 6.2:

Table 3

#	Structure	Precursors/ remarks	MS calculated/ found	Anal. HPLC % B
6.3		Synthesized according to the procedure described for compound 6.1 using: a) Bzls-Cl and b) 4.5	339.1/ 340.2 (M+H) ⁺	38.6
6.4		Synthesized according to the procedure described for compound 6.1 using: a) Bzls-Cl and b) 4.2 purification by FC	348.1/ 348.9 (M+H) ⁺	33.6
6.5		Synthesized according to the procedure described for compound 6.1 using: a) Bzls-Cl and b) D,LhAla(4-Pyr) purification by FC	334.1/ 334.9 (M-H) ⁻	31.2
6.6		Synthesized according to the procedure described for compound 6.1 using: a) Bzls-Cl and b) 4.4	519.2/ 520.0 (M+H) ⁺	75.9
6.7		6.6 was hydrogenated according to the procedure described for compound 3.4	354.2/ 355.0 (M+H) ⁺	35.7
6.8		Synthesized according to the procedure described for compound 6.2 using: a) Bzls-Cl and b) DPhg	305.1/ 306.2(M+H) ⁺	64.1

[0096] Bzls-DhAla(4-Pip[Cbz-4-NO₂])-OH

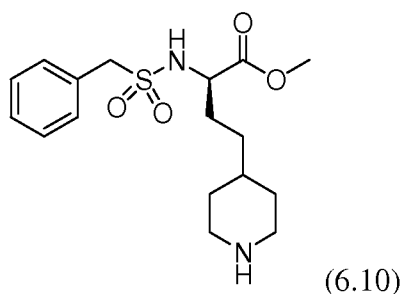


[0097] To a solution of compound 4.9 (2.2 g, 5.3 mmol) and DIEA (2 ml, 11.7 mmol) in DMF (40 ml) was added Bzls-chlorid (1.1 g, 5.8 mmol) at 0 °C with stirring and the pH was maintained between 8-9 by addition of DIEA. The mixture was stirred at room temperature overnight and the solvent evaporated in vacuo. The residue was portioned between ethyl acetate and aqueous 5 % KHSO₄, the organic layer was washed with aqueous 5 % KHSO₄ and brine, dried (Na₂SO₄) and evaporated in vacuo. The main part of the residue obtained was used for the synthesis of compound 6.10. A remaining part of the residue (100 mg) was hydrolyzed according to the procedure described for compound 3.3 to afford the title compound.

Yield: 80 mg

Anal. HPLC: 73.9 % B; MS calc.: 519.2, found 520.0 (M+H)⁺

[0098] Bzls-DhAla(4-Pip)-OMe



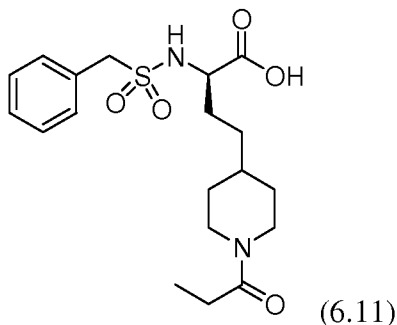
[0099] Hydrogenolysis of the main part of residue 6.9 was done according to the procedure described for compound 3.4 and in the presence aqueous 1N HCl (5 ml). The residue was dissolved in a small amount of methanol. Addition of diethyl ether and filtering afforded the title compound.

Yield: 2.3 g (> 100 %, light red solid)

Anal. HPLC: 39.8 % B; MS calc.: 354.2, found 355.0 (M+H)⁺

[00100] Crude 6.10 was used for further reactions with acid chlorides, isocyanates or anhydrides, e.g. as described for compound 6.11 and summarized in Table 4 below.

[00101] Bzls-DhAla(4-Pip[CO-Et])-OH



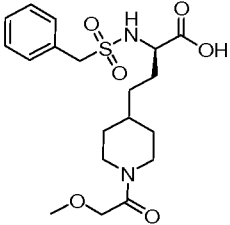
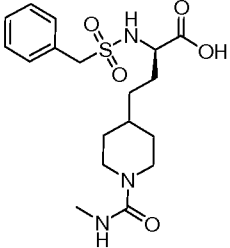
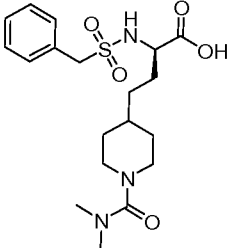
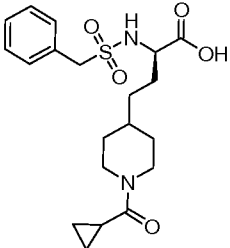
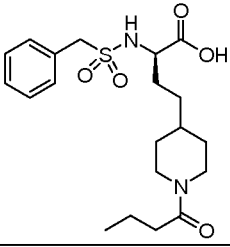
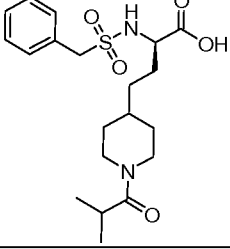
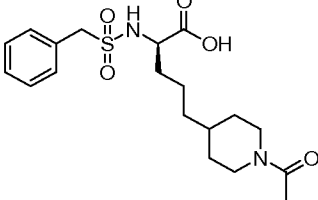
[00102] To a solution of compound 6.10 (100 mg, 0.21 mmol) and DIEA (0.08 ml, 0.46 mmol) in THF (5 ml) was added propionyl-chloride (0.02 ml, 0.23 mmol) at 0 °C with stirring and the pH was maintained between 8-9 by addition of DIEA. The mixture was stirred at room temperature for 3 h and the solvent evaporated in vacuo. The residue was portioned between ethyl acetate and 5 % KHSO₄-solution. The organic layer was washed with aqueous 5 % KHSO₄ and brine, dried (Na₂SO₄) and evaporated in vacuo. The title compound was obtained by hydrolysis of the crude intermediate according to the procedure described for compound 3.3.

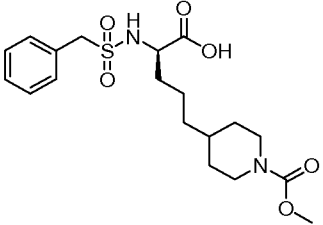
Yield: 74 mg (88 %, oil)

Anal. HPLC: 59.3 % B, MS calc.: 396.5, found 397.3 (M+H)⁺

Table 4:

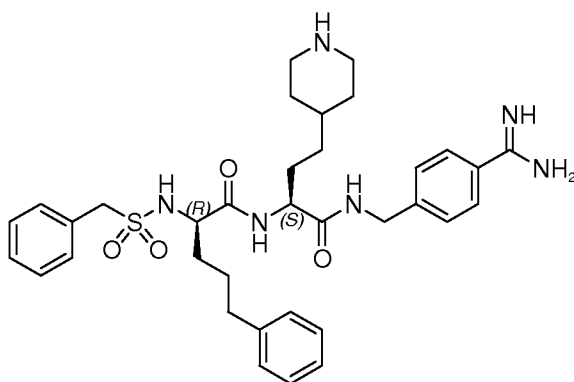
#	Structure	precursors/ remarks	MS calculated/ found	Anal. HPLC % B
6.12		a) 6.10 and b) acetic anhydride	382.2/381.0 (M-H) ⁻	60.2
6.13		a) 6.10 and b) methyl chloroformate	398.1/396.9 (M-H) ⁻	58.3

6.14		a) 6.10 and b) methoxyacetyl chloride	412.1/411.1 (M-H) ⁻	54.1
6.15		a) 6.10 and b) methyl isocyanate	397.2/398.2 (M+H) ⁺	55.3
6.16		a) 6.10 and b) dimethylcarbamoyl chloride	411.2/409.9 (M-H) ⁻	57.2
6.17		a) 6.10 and b) cyclopropanecarbonyl chloride	408.2/409.1 (M+H) ⁺	57.3
6.18		a) 6.10 and b) butanoyl chloride	410.2/409.1 (M-H) ⁻	63.7
6.19		a) 6.10 and b) isobutanoyl chloride	410.2/411.1 (M+H) ⁺	61.2
6.20		a) 6.7 and b) acetic anhydride	396.2/397.1 (M+H) ⁺	63.8

6.21		a) 6.7 and b) methyl chloroformate	411.4/412.2 (M-H) ⁻	71.1
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[0100] Synthesis of the inhibitors

[0101] BzIs-DPpg-hAla(4-Pip)-4-Amba x 2TFA



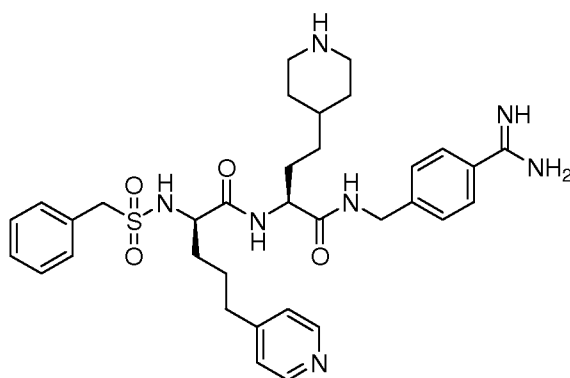
(1.1)

[0102] To a solution of compound 6.1 (160 mg, 0.46 mmol) and compound 5.2 (280 mg, 0.46 mmol) in dry DMF (4 ml) was added PyBop (265 mg, 0.5 mmol) and DIEA (220 μ l, 1.2 mmol) at 0 °C. The mixture was stirred at 0 °C for 15 min and at room temperature for 1.5 h. The solvent was evaporated in vacuo, the residue dissolved in ethyl acetate and consecutively washed with aqueous 5 % KHSO₄, saturated aqueous NaHCO₃, and brine. The organic layer was dried (Na₂SO₄) and the solvent evaporated in vacuo. The crude intermediate was dissolved in 90 % acetic acid (80 ml) and 10 % Pd/C (50 mg) was added under nitrogen. The nitrogen was replaced with hydrogen and the mixture stirred at room temperature overnight. The catalyst was filtered off and the solvent evaporated in vacuo. 1 N HBr in acetic acid (3 ml) was added and the mixture stirred at room temperature for 1 h. Diethyl ether was added, the crude product was isolated by filtration and purified by reversed phase HPLC. Lyophilization afforded the title compound.

Yield: 125 mg (31 %, white powder)

Anal. HPLC: 54.7 % B; MS calc.: 646.3, found 647.2 (M+H)⁺

[0103] Bzls-DGly(4-Pyrpr)-hAla(4-Pip)-4-Amba x 3TFA



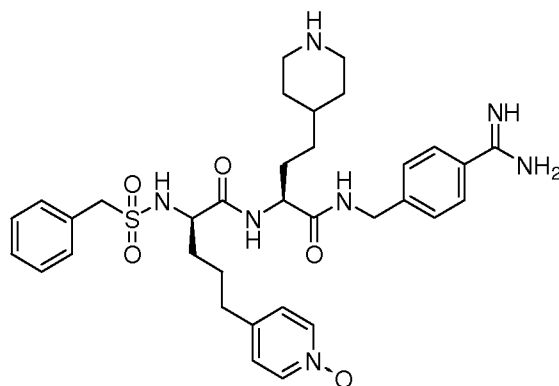
(1.2)

[0104] Coupling of compound 6.4 (260 mg, 0.56 mmol) and compound 5.1 (365 mg, 0.56 mmol) was done according the procedure described for compound 1.1. The crude intermediate was obtained after treatment with saturated aqueous NaHCO_3 and filtration. Hydrogenolysis according to the procedure described for compound 1.1 afforded the title compound

Yield: 215 mg (39 %, white powder)

Anal. HPLC: 31.6 min % B; MS calc.: 647.3, found 648.1 ($\text{M}+\text{H}$)⁺

[0105] Bzls-DGly(4-Pyrpr[NO])-hAla(4-Pip)-4-Amba x 2TFA



(1.8)

[0106] Coupling of compound 6.4 and compound 5.1 was done as described above. To a solution of the crude product (100 mg) in DCM (10 ml) was added m-CPBA (27 mg, 0.15 mmol) and the mixture was stirred at room temperature for 4h. Additional m-CPBA (15 mg, 0.075 mmol) was added and stirring was continued for 1h. Aqueous 39% sodium hydrogen sulphite (0.2 ml) was added and the solvent was evaporated in vacuo. The residue was dissolved in ethyl acetate and washed with saturated aqueous NaHCO_3 and brine. The organic layer was dried (Na_2SO_4) and the solvent evaporated in vacuo. The protected intermediate was hydrogenated and purified according the procedure described for 1.1. The crude product

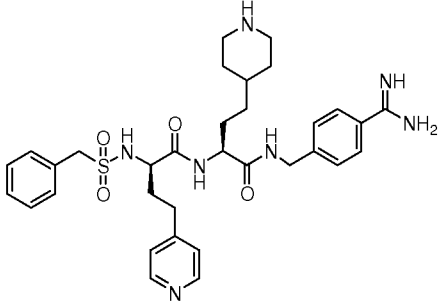
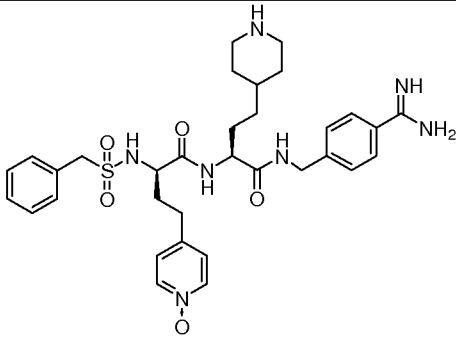
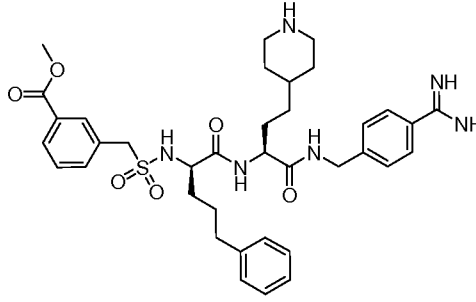
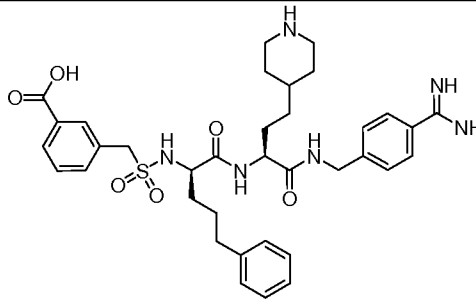
was isolated by filtration and purified by reversed phase HPLC. Lyophilization afforded the title compound.

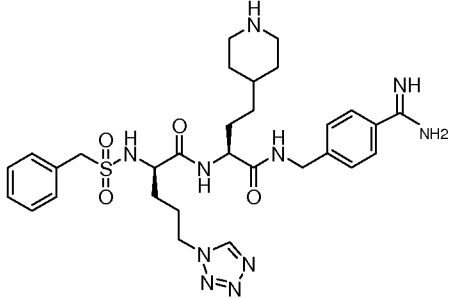
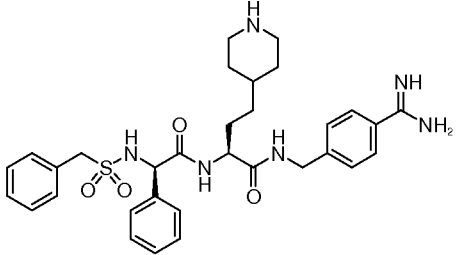
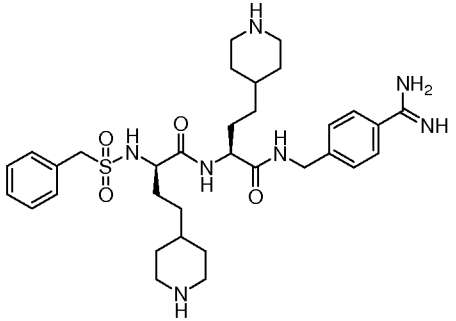
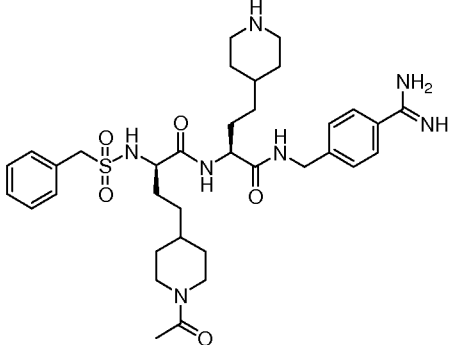
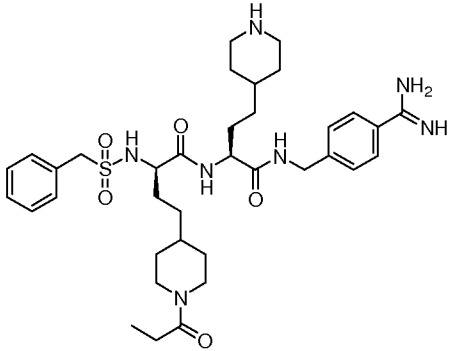
Yield: 7 mg

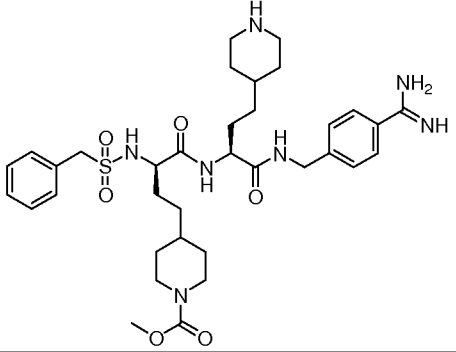
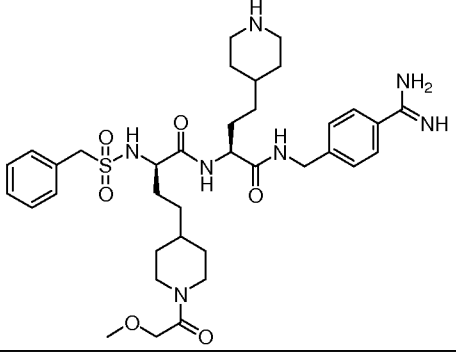
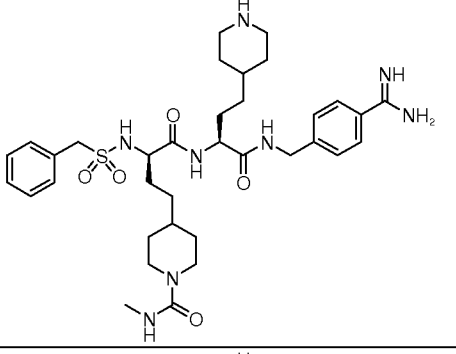
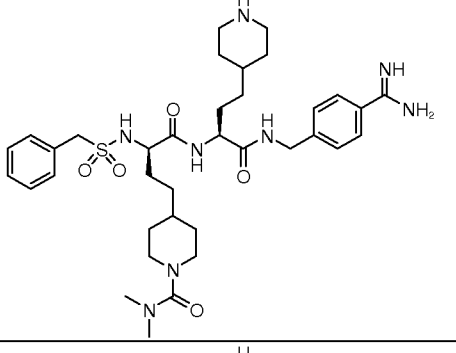
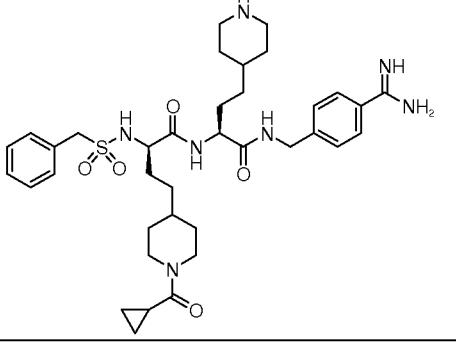
Anal. HPLC: 33.4 min % B; MS calc.: 663.3, found 664.1 (M+H)⁺

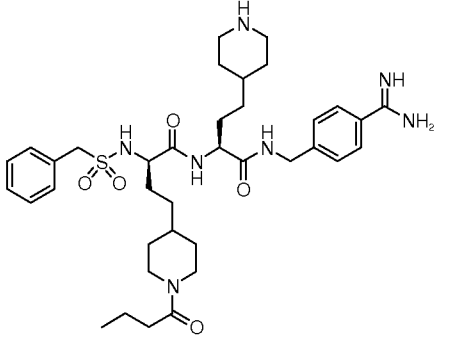
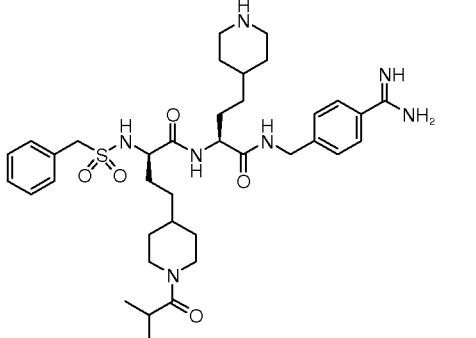
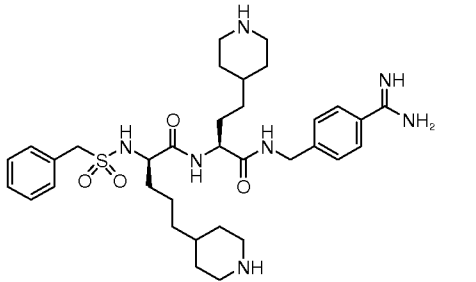
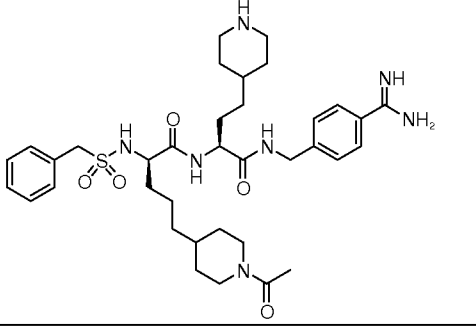
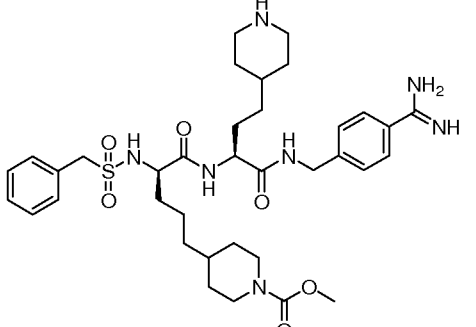
[0107] The compounds listed in Table 5 were prepared according to the procedure described for compound 1.1:

Table 5

#	Structure	precursors/ remarks	MS calculated/ found	HPLC % B
1.7		a) 5.1 and b) 6.5 Diastereomers were separated by preparative HPLC	633.3/634.1 (M+H) ⁺	29.7
1.9		Synthesized from compound 1.7 according to procedure described for compound 1.8	649.3/650.1 (M + H)	31.2
1.4		a) 5.1 and b) 6.2	704.3/705.2 (M+H) ⁺	51.5
1.3		Compound 1.4 was hydrolyzed according to procedure described for compound 3.3	690.3/691.2 (M+H) ⁺	47.1

1.5		a) 5.1 and b) 6.3	638.3/639.1 (M+H) ⁺	37.1
1.6		a) 5.1 and b) 6.8	604.7/605.2 (M+H) ⁺	41.9
2.9		a) 5.3 and b) 6.9	639.4/640.2 (M+H) ⁺	34.1
2.1		a) 5.4 and b) 6.12	681.4/682.1 (M+H) ⁺	43.3
2.2		a) 5.3 and b) 6.11	695.8/696.2 (M+H) ⁺	46.4

2.3		a) 5.1 and b) 6.13	697.4/698.2 (M+H) ⁺	44.7
2.4		a) 5.3 and b) 6.14	711.4/712.4 (M+H) ⁺	43.4
2.5		a) 5.1 and b) 6.15	696.4/697.7 (M+H) ⁺	42.6
2.6		a) 5.1 and b) 6.16	710.4/711.2 (M+H) ⁺	43.4
2.10		a) 5.3 and b) 6.17	707.4/708.2 (M+H) ⁺	44.5

2.12		a) 5.3 and b) 6.18	709.4/710.2 (M+H) ⁺	50.1
2.11		a) 5.2 and b) 6.19	709.4/710.2 (M+H) ⁺	50.5
2.8		a) 5.3 and b) 6.6	653.4/645.3 (M+H) ⁺	35.8
2.7		a) 5.3 and b) 6.20	695.4/696.0 (M+H) ⁺	45.7
2.13		a) 5.3 and b) 6.21	711.4/712.2 (M+H) ⁺	52.8

[0108] Determination of the inhibition constants for human plasmin (h plasmin) and human plasma kallikrein (h PK)

[0109] The inhibitory effect for the individual enzymes was determined in analogy to a previously disclosed method (Stürzebecher *et al.*, *J. Med. Chem.*, **40**, 3091-3099 (1997)). The reactions to determine the inhibition of human plasmin and human plasma kallikrein were carried out in the following mixture at 25°C:

[0110] 200 µl of TBS (0.05 M trishydroxymethylaminomethane; 0.154 M NaCl, 2% ethanol, pH 8.0)

[0111] 25 µl of substrate (4 mM, 2 mM and 1 mM tosyl-Gly-Pro-Lys-pNA = Chromozym PL from LOXO for plasmin and 3 mM, 1.5 mM and 1 mM H-D-Pro-Phe-Arg-pNA = S2302 from Chromogenix for PK, dissolved in H₂O)

[0112] 2 µL of a test compound solution in 50% v/v DMSO/water

[0113] 50 µl of enzyme solution (plasmin from Calbiochem: 1.7 mU/ml in 0.154 M NaCl + 0.1% BSA m/v; plasma kallikrein from Enzyme Research Lab.: 62 ng/ml in 0.154 M NaCl + 0.1% BSA m/v)

[0114] For zero order kinetics, the reaction was stopped after 20 min by adding 15 µl of acetic acid (80% v/v), and the absorption at 405 nm was determined using a Microplate Reader (Multiscan Ascent™, from Thermo). In the case of pseudo-first order kinetics, the reaction rates in the equilibrium state were determined by continuously recording the change in absorbance at 405 nm. The K_i values were calculated by parameter fitting in accordance with the rate equation for competitive inhibition using the GraFit software, version 4. The K_i values are the average of at least three determinations.

[0115] Determination of inhibition constants for reference enzymes

[0116] Human Activated Protein C (h aPC): Inhibition of human aPC was determined by the method described in [0092] – [0098] using human activated protein C from Enzyme Research Laboratories at 2.2 nM and H-D-Lys(Cbo)-Pro-Arg-pNA (Pefachrome PCa) at 2 mM, 1 mM, and 0.5 mM as substrate; results are reported as K_i values (nanomolar).

[0117] Human urinary kallikrein (h uKK): Inhibition of human uKK was determined by the method described in [0092] – [0098] using human urinary kallikrein from Lee Biosolutions at 7.5 nM and H-D-Val-Leu-Arg-pNA (S-2266) at 1 mM, 0.5 mM, and 0.25 mM as substrate; results are reported as K_i values (nanomolar).

[0118] Subcomponent “s” of Human Complement Component 1 (h C1s): Inhibition of human C1s was determined by the method described in [0092] – [0098] using native human activated C1s complement component from Calbiochem at 29 nM and Val-Ser-Arg-pNA (S2314) at 8 mM, 6 mM, and 4 mM as substrate; results are reported as K_i values (nanomolar).

[0119] Subcomponent “r” of Human Complement Component 1 (h C1r): Inhibition of human C1r was determined by the method described in [0092] – [0098] using native human activated C1r complement component from Calbiochem at 100 nM and Val-Ser-Arg-pNA (S2314) at 16 mM, 12 mM, and 8 mM as substrate; results are reported as K_i values (nanomolar).

[0120] Human Factor IIa (h FIIa): Inhibition of human FIIa was determined by the method described in [0092] – [0098] using human alpha-thrombin from Enzyme Research Laboratories at 0.1 NIH U/mL and Mes-d-Cha-Gly-Arg-pNA (Pefachrome tPA) at 2 mM, 1 mM, and 0.5 mM as substrate; results are reported as K_i values (nanomolar).

[0121] Human Factor Xa (h FXa): Inhibition of human FXa was determined by the method described in [0092] – [0098] using activated human Factor X from Enzyme Research Laboratories at 5 mIU/mL and MeOCO-d-Cha-Gly-Arg-pNA (Pefachrome FXa) at 2 mM, 1 mM, and 0.5 mM as substrate; results are reported as K_i values (nanomolar).

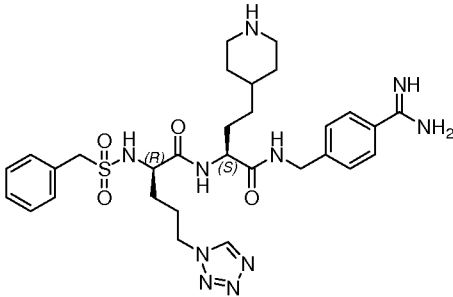
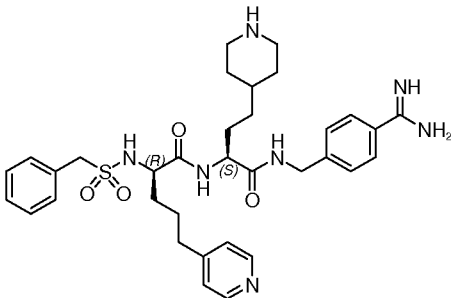
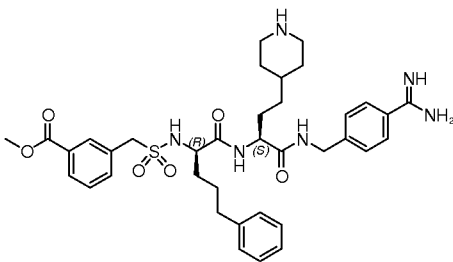
[0122] Human Factor XIa (h FXIa): Inhibition of human FXIa was determined by the method described in [0092] – [0098] using activated human Factor XI from Enzyme Research Laboratories at 96 ng/mL and H-D-Lys(Cbo)-Pro-Arg-pNA (Pefachrome PCa) at 5 mM, 4 mM, and 2 mM as substrate; results are reported as K_i values (nanomolar).

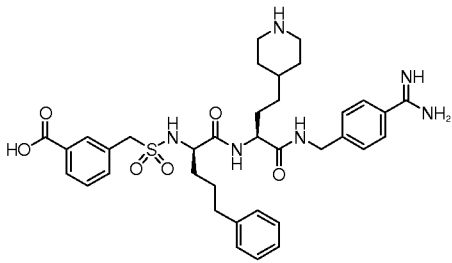
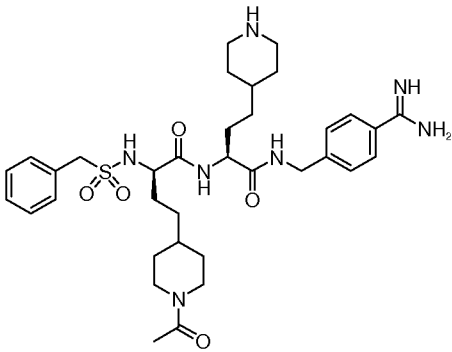
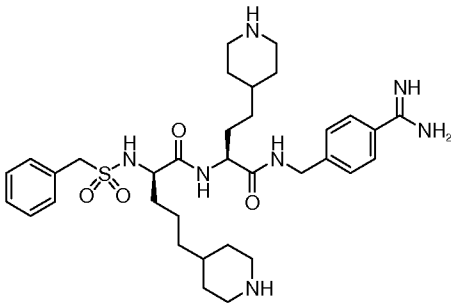
[0123] Human Factor XIIa (h FXIIa): Inhibition of human alpha-FXIIa was determined by the method described in [0092] – [0098] using activated human alpha-Factor XII (activated Hageman Factor) from Enzyme Research Laboratories at 50 mPEU/mL and CHA-Gly-Arg-pNA at 2 mM, 1 mM, and 0.5 mM as substrate; results are reported as K_i values (nanomolar).

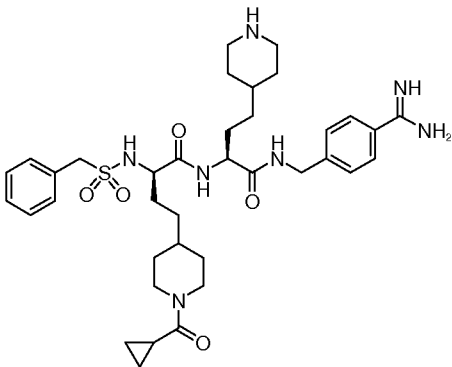
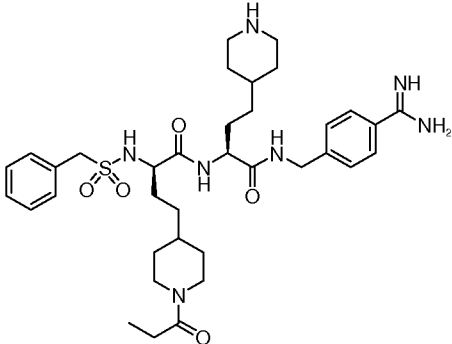
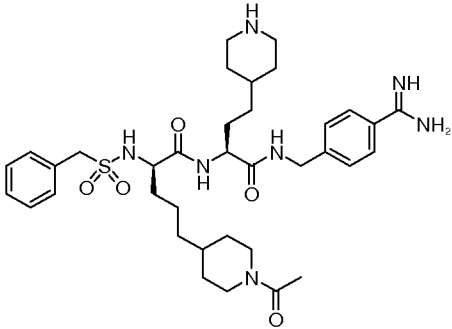
[0124] Human tissue-type plasminogen activator (h t-PA): Inhibition of human t-PA was determined by the method described in [0092] – [0098] using recombinant human tissue-type plasminogen activator (Actilyse®) from Boehringer Ingelheim at 290 U/mL and Mes-d-Cha-Gly-Arg-pNA (Pefachrome tPA) at 4 mM, 2 mM, and 1 mM as substrate; results are reported as K_i values (nanomolar).

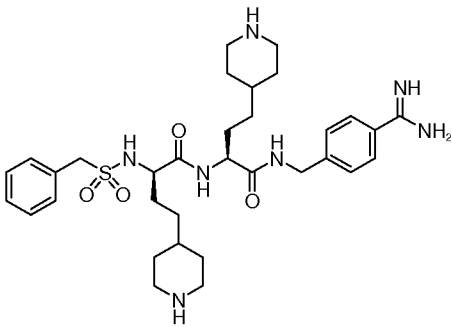
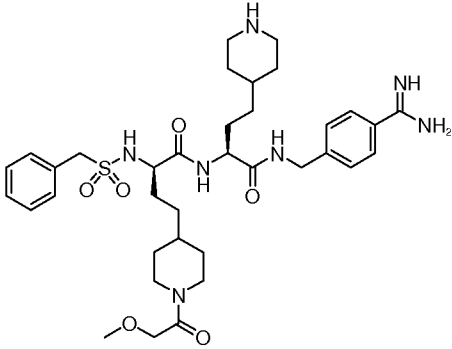
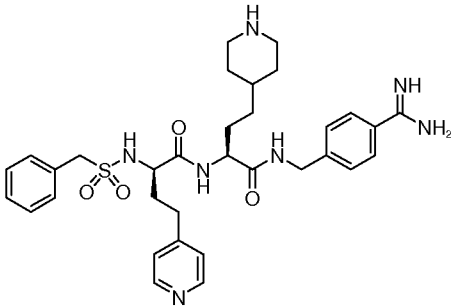
[0125] Results for exemplary compounds of the invention are shown in Table 6.

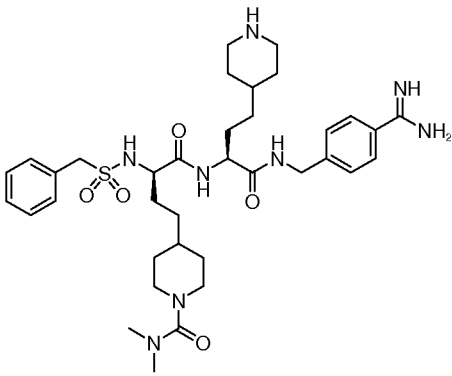
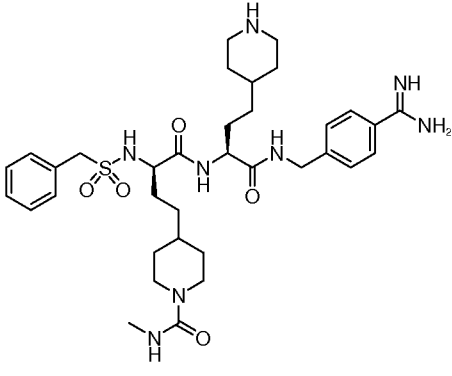
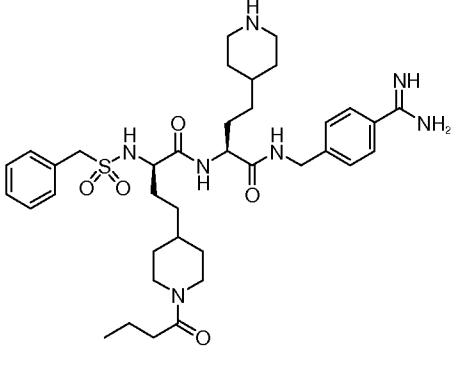
Table 6

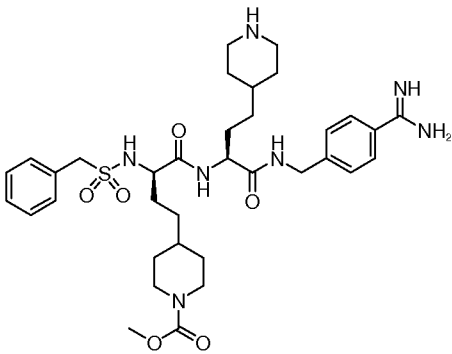
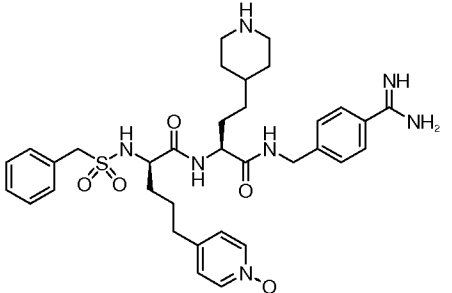
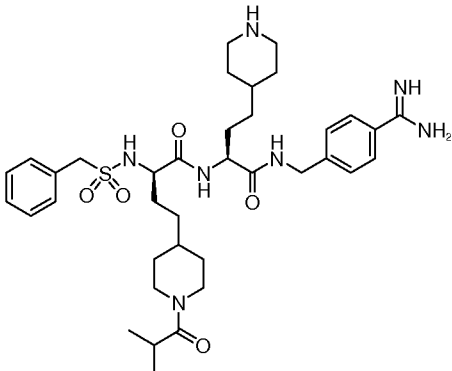
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	h PK	Ki; nM	5.3
	h aPC	Ki; nM	1,300
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	> 10,000
	h C1r	Ki; nM	n.d.
	h FIIa	Ki; nM	4,700
	h FXa	Ki; nM	2,400
	h FXIa	Ki; nM	1,400
	h FXIIa	Ki; nM	n.d.
	h t-PA	Ki; nM	n.d.
	h plasmin	Ki; nM	0.4
	h PK	Ki; nM	2.7
	h aPC	Ki; nM	600
	h uKK	Ki; nM	> 80,000
	h C1s	Ki; nM	4,950
	h C1r	Ki; nM	> 50,000
	h FIIa	Ki; nM	1,200
	h FXa	Ki; nM	850
	h FXIa	Ki; nM	500
	h FXIIa	Ki; nM	1,500
	h t-PA	Ki; nM	2,300
	h plasmin	Ki; nM	2.7
	h PK	Ki; nM	9.4
	h aPC	Ki; nM	570
	h uKK	Ki; nM	> 20,000
	h C1s	Ki; nM	4,800
	h C1r	Ki; nM	>30,000
	h FIIa	Ki; nM	920
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	h FXIa	Ki; nM	500
	h FXIIa	Ki; nM	> 10,000
	h t-PA	Ki; nM	3,900

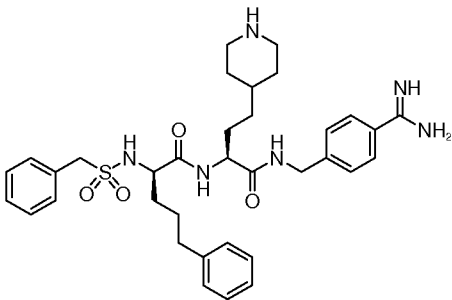
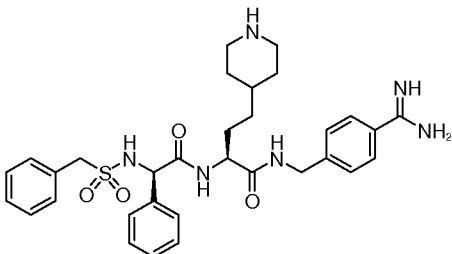
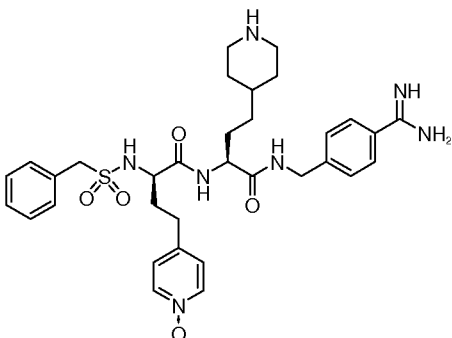
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	h PK	Ki; nM	3
	h aPC	Ki; nM	310
	h uKK	Ki; nM	> 20,000
	h C1s	Ki; nM	1,200
	h C1r	Ki; nM	> 20,000
	h FIIa	Ki; nM	4,400
	h FXa	Ki; nM	2,400
	h FXIa	Ki; nM	70
	h FXIIa	Ki; nM	n.d.
	h t-PA	Ki; nM	n.d.
	h plasmin	Ki; nM	1.8
	h PK	Ki; nM	5
	h aPC	Ki; nM	1,200
	h uKK	Ki; nM	> 20,000
	h C1s	Ki; nM	> 20,000
	h C1r	Ki; nM	> 40,000
	h FIIa	Ki; nM	8,000
	h FXa	Ki; nM	1,900
	h FXIa	Ki; nM	1,400
	h FXIIa	Ki; nM	530
	h t-PA	Ki; nM	4,800
	h plasmin	Ki; nM	2
	h PK	Ki; nM	7.5
	h aPC	Ki; nM	400
	h uKK	Ki; nM	> 50,000
	h C1s	Ki; nM	8,000
	h C1r	Ki; nM	> 50,000
	h FIIa	Ki; nM	800
	h FXa	Ki; nM	300
	h FXIa	Ki; nM	800
	h FXIIa	Ki; nM	n.d
	h t-PA	Ki; nM	n.d.

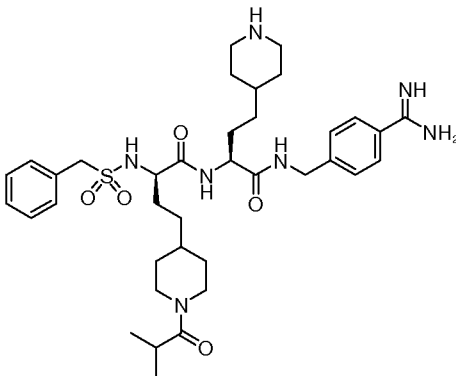
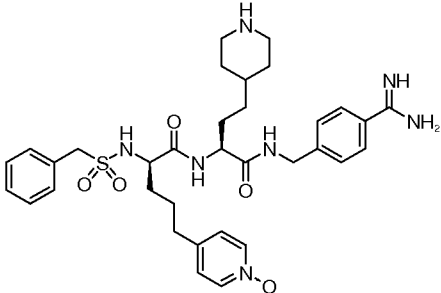
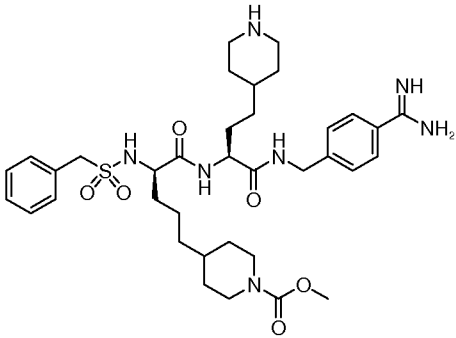
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	h aPC	Ki; nM	1,500
	h uKK	Ki; nM	> 50,000
	h C1s	Ki; nM	19,000
	h C1r	Ki; nM	> 50,000
	h FIIa	Ki; nM	8,500
	h FXa	Ki; nM	2,300
	h FXIa	Ki; nM	650
	h FXIIa	Ki; nM	1,100
	h t-PA	Ki; nM	6,100
	h plasmin	Ki; nM	0.8
	h PK	Ki; nM	0.9
	h aPC	Ki; nM	1,200
	h uKK	Ki; nM	> 60,000
	h C1s	Ki; nM	>25,000
	h C1r	Ki; nM	>35,000
	h FIIa	Ki; nM	5,600
	h FXa	Ki; nM	2,300
	h FXIa	Ki; nM	720
	h FXIIa	Ki; nM	650
	h t-PA	Ki; nM	5,100
	h plasmin	Ki; nM	1.5
	h PK	Ki; nM	2
	h aPC	Ki; nM	1,100
	h uKK	Ki; nM	> 500,000
	h C1s	Ki; nM	9,000
	h C1r	Ki; nM	> 100,000
	h FIIa	Ki; nM	3,800
	h FXa	Ki; nM	750
	h FXIa	Ki; nM	870
	h FXIIa	Ki; nM	630
	h t-PA	Ki; nM	3,000

	h plasmin	Ki; nM	3
	h PK	Ki; nM	7.5
	h aPC	Ki; nM	60
	h uKK	Ki; nM	> 100,000
	h C1s	Ki; nM	> 25,000
	h C1r	Ki; nM	> 100,000
	h FIIa	Ki; nM	4,200
	h FXa	Ki; nM	90
	h FXIa	Ki; nM	1,400
	h FXIIa	Ki; nM	n.d.
	h t-PA	Ki; nM	n.d.
	h plasmin	Ki; nM	1.2
	h PK	Ki; nM	1.3
	h aPC	Ki; nM	1,200
	h uKK	Ki; nM	> 100,000
	h C1s	Ki; nM	20,000
	h C1r	Ki; nM	> 50,000
	h FIIa	Ki; nM	4,500
	h FXa	Ki; nM	1,600
	h FXIa	Ki; nM	1,400
	h FXIIa	Ki; nM	680
	h t-PA	Ki; nM	4,700
	h plasmin	Ki; nM	1.5
	h PK	Ki; nM	9
	h aPC	Ki; nM	27
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	2,000
	h C1r	Ki; nM	> 20,000
	h FIIa	Ki; nM	3,900
	h FXa	Ki; nM	20
	h FXIa	Ki; nM	500
	h FXIIa	Ki; nM	n.d.
	h t-PA	Ki; nM	n.d.

	h plasmin	Ki; nM	0.8
	h PK	Ki; nM	4
	h aPC	Ki; nM	1,600
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	13,000
	h C1r	Ki; nM	> 50,000
	h FIIa	Ki; nM	13,000
	h FXa	Ki; nM	2,500
	h FXIa	Ki; nM	1,500
	h FXIIa	Ki; nM	2,000
	h t-PA	Ki; nM	8,300
	h plasmin	Ki; nM	1
	h PK	Ki; nM	2
	h aPC	Ki; nM	1,100
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	> 20,000
	h C1r	Ki; nM	> 20,000
	h FIIa	Ki; nM	4,800
	h FXa	Ki; nM	1,700
	h FXIa	Ki; nM	1,300
	h FXIIa	Ki; nM	550
	h t-PA	Ki; nM	5,300
	h plasmin	Ki; nM	0.6
	h PK	Ki; nM	2
	h aPC	Ki; nM	1,100
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	> 10,000
	h C1r	Ki; nM	> 15,000
	h FIIa	Ki; nM	5,500
	h FXa	Ki; nM	2,200
	h FXIa	Ki; nM	870
	h FXIIa	Ki; nM	800
	h t-PA	Ki; nM	6,100

	h plasmin	Ki; nM	0.7
	h PK	Ki; nM	2
	h aPC	Ki; nM	1,350
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	> 10,000
	h C1r	Ki; nM	> 20,000
	h FIIa	Ki; nM	13,000
	h FXa	Ki; nM	2,000
	h FXIa	Ki; nM	720
	h FXIIa	Ki; nM	1,600
	h t-PA	Ki; nM	6,600
	h plasmin	Ki; nM	1
	h PK	Ki; nM	4
	h aPC	Ki; nM	850
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	10,000
	h C1r	Ki; nM	> 30,000
	h FIIa	Ki; nM	4,900
	h FXa	Ki; nM	400
	h FXIa	Ki; nM	1,400
	h FXIIa	Ki; nM	870.
	h t-PA	Ki; nM	2,400
	h plasmin	Ki; nM	0.6
	h PK	Ki; nM	1.5
	h aPC	Ki; nM	1,700
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	> 25,000
	h C1r	Ki; nM	> 30,000
	h FIIa	Ki; nM	13,000
	h FXa	Ki; nM	3,200
	h FXIa	Ki; nM	920
	h FXIIa	Ki; nM	1,300
	h t-PA	Ki; nM	6,500

	h plasmin	Ki; nM	0.25
	h PK	Ki; nM	1.5
	h aPC	Ki; nM	555
	h uKK	Ki; nM	> 50,000
	h C1s	Ki; nM	> 5,000
	h C1r	Ki; nM	n.d.
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	h FXa	Ki; nM	1,100
	h FXIa	Ki; nM	135
	h FXIIa	Ki; nM	3,000
	h t-PA	Ki; nM	1,700
	h plasmin	Ki; nM	2.2
	h PK	Ki; nM	20
	h aPC	Ki; nM	210
	h uKK	Ki; nM	n.d.
	h C1s	Ki; nM	n.d.
	h C1r	Ki; nM	n.d.
	h FIIa	Ki; nM	1,700
	h FXa	Ki; nM	1,600
	h FXIa	Ki; nM	1,000
	h FXIIa	Ki; nM	n.d.
	h t-PA	Ki; nM	n.d.
	h plasmin	Ki; nM	5
	h PK	Ki; nM	20
	h aPC	Ki; nM	250
	h uKK	Ki; nM	> 100,000
	h C1s	Ki; nM	4,200
	h C1r	Ki; nM	> 50,000
	h FIIa	Ki; nM	9,000
	h FXa	Ki; nM	120
	h FXIa	Ki; nM	2,500
	h FXIIa	Ki; nM	n.d.
	h t-PA	Ki; nM	n.d.

	h plasmin	Ki; nM	0.6
	h PK	Ki; nM	1.5
	h aPC	Ki; nM	1,700
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	> 25,000
	h C1r	Ki; nM	> 30,000
	h FIIa	Ki; nM	13,000
	h FXa	Ki; nM	3,200
	h FXIa	Ki; nM	920
	h FXIIa	Ki; nM	1,300
	h t-PA	Ki; nM	6,500
	h plasmin	Ki; nM	1
	h PK	Ki; nM	4
	h aPC	Ki; nM	850
	h uKK	Ki; nM	> 200,000
	h C1s	Ki; nM	9,500
	h C1r	Ki; nM	> 30,000
	h FIIa	Ki; nM	4,900
	h FXa	Ki; nM	400
	h FXIa	Ki; nM	1,400
	h FXIIa	Ki; nM	870
	h t-PA	Ki; nM	2,400
	h plasmin	Ki; nM	1
	h PK	Ki; nM	1.5
	h aPC	Ki; nM	800
	h uKK	Ki; nM	> 100,000
	h C1s	Ki; nM	6,500
	h C1r	Ki; nM	> 100,000
	h FIIa	Ki; nM	3,600
	h FXa	Ki; nM	400
	h FXIa	Ki; nM	600
	h FXIIa	Ki; nM	400
	h t-PA	Ki; nM	n.d.

[0126] Additional References

[0127] The following references provide background information, which may be useful in understanding the state of the art prior to the present invention:

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US 5786328

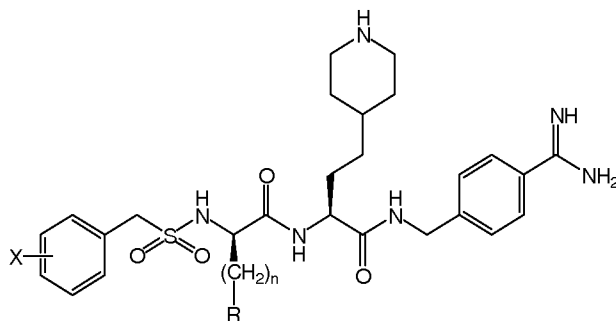
[0128] It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims.

[0129] All documents, papers and published materials referenced herein, including books, journal articles, manuals, patent applications, published patent applications and patents, are expressly incorporated herein by reference in their entireties.

CLAIMS

We claim:

1. A compound having the following formula

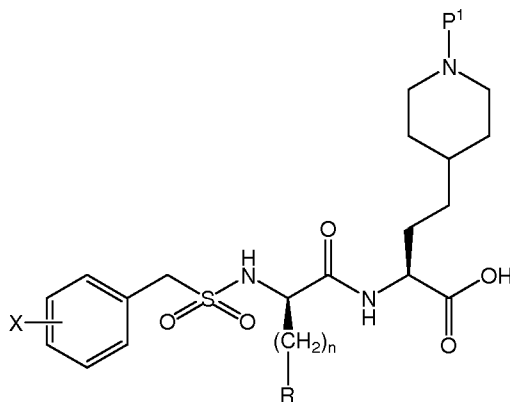


- or a pharmaceutically acceptable salt thereof; wherein X is selected from the group consisting of H, CO₂H, and CO₂R'; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidinyl; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R', OR', SR', S(=O)R', S(=O)₂R', S(=O)₂NHR', S(=O)₂NR'₂, CN, NH₂, NHR', NR'₂, NHS(=O)₂R', NHC(=O)R', NHC(=O)OR', NHC(=O)NHR', NHC(=O)NR'₂, C(=O)R', C(=O)CH₂OR', CO₂R', C(=O)NHR', and C(=O)NR'₂; wherein when R is pyridyl it may be a pyridine N-oxide; and wherein each R' is independently CF₃ or C₁ to C₄ lower alkyl or cycloalkyl.
2. A compound according to claim 1, wherein n is 2 or 3.
 3. A compound according to claim 2, wherein n is 3.
 4. A compound according to claim 1, wherein R is selected from the group consisting of phenyl, 4-pyridyl, 4-pyridyl N-oxide and 4-piperidinyl.
 5. A compound according to claim 2, wherein R is selected from the group consisting of phenyl, 4-pyridyl, 4-pyridyl N-oxide and 4-piperidinyl.
 6. A compound according to claim 3, wherein R is selected from the group consisting of phenyl, 4-pyridyl, 4-pyridyl N-oxide and 4-piperidinyl.

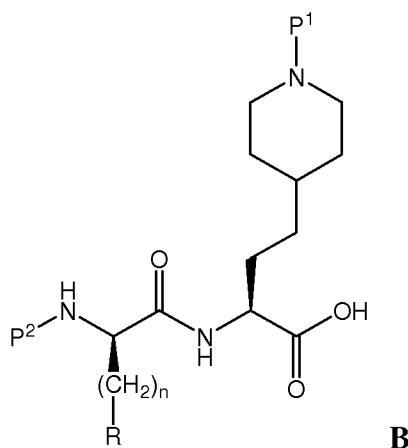
7. A compound according to claim 4, wherein R is selected from the group consisting of unsubstituted phenyl, unsubstituted 4-pyridyl, unsubstituted 4-pyridyl N-oxide and unsubstituted 4-piperidinyl.
8. A compound according to claim 5, wherein R is selected from the group consisting of unsubstituted phenyl, unsubstituted 4-pyridyl, unsubstituted 4-pyridyl N-oxide and unsubstituted 4-piperidinyl.
9. A compound according to claim 6, wherein R is selected from the group consisting of unsubstituted phenyl, unsubstituted 4-pyridyl, unsubstituted 4-pyridyl N-oxide and unsubstituted 4-piperidinyl.
10. A compound according to claim 1, wherein n is 0 and R is phenyl.
11. A compound according to claim 1, wherein n is 2 or 3 and R is 4-piperidinyl; wherein the nitrogen of said piperidinyl bears a substituent selected from the group consisting of $C(=O)R'$, $C(=O)CH_2OR'$, CO_2R' , $C(=O)NHR'$, and $C(=O)NR'_2$.
12. A pharmaceutical composition comprising one or more compounds according any one of claims 1-11, further comprising one or more pharmaceutically acceptable carriers or excipients.
13. A method for therapeutic modulation of the blood coagulation cascade or fibrinolysis, comprising administering to a patient in need thereof an effective amount of one or more compounds according to any one of claims 1-11.
14. A method for treating a hyperfibrinolytic condition in a patient, comprising administering to said patient an effective amount of one or more compounds according to any one of claims 1-11.
15. A method for controlling blood loss in a patient, comprising administering to said patient an effective amount of one or more compounds according to any one of claims 1-11.

16. The method of claim 15, wherein said patient is undergoing an organ transplant or cardiac surgical procedure.
17. The method of claim 15, wherein said patient is undergoing a surgical procedure with cardiopulmonary bypass.
18. A method for inhibiting human plasmin and/or plasma kallikrein in a patient, comprising administering to said patient an effective amount of one or more compounds according to any one of claims 1-11.
19. The use of a compound according to any one of claims 1-11 in the manufacture of a medicament for therapeutic modulation of the blood coagulation cascade or fibrinolysis.
20. The use of a compound according to any one of claims 1-11 in the manufacture of a medicament for the prevention of blood loss.
21. The use of a compound according to any one of claims 1-11 in the manufacture of a medicament for the treatment of a hyperfibrinolytic condition.
22. The use of a compound according to any one of claims 1-11 in the manufacture of a medicament for the prevention of blood loss during organ transplants or cardiac surgical procedures.
23. The use of a compound according to any one of claims 1-11 in the manufacture of a medicament for the prevention of blood loss during surgical procedures with cardiopulmonary bypass.
24. The use of a compound according to any one of claims 1-11 in the manufacture of a medicament for the inhibition of plasmin and/or plasma kallikrein.
25. A fibrin adhesive comprising at least one compound according to any one of claims 1-11.

26. The use of at least one compound according to any one of claims 1-11 for the manufacture of a fibrin adhesive.
27. A process for preparing a compound as claimed in any of claims 1-11, comprising the following steps:
- (a) acylation of an amidino-protected 4-(methylamino)benzamidine with an activated carboxylic acid derived from the acid of formula A

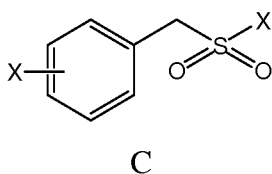
**A**

- wherein P^1 is an amino protecting group; X is H or $\text{CO}_2\text{R}'$; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidiny; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R' , OR' , SR' , $\text{S(=O)R}'$, $\text{S(=O)}_2\text{R}'$, $\text{S(=O)}_2\text{NHR}'$, $\text{S(=O)}_2\text{NR}'_2$, CN, NH_2 , NHR' , NR'_2 , $\text{NHS(=O)}_2\text{R}'$, $\text{NHC(=O)R}'$, $\text{NHC(=O)OR}'$, $\text{NHC(=O)NHR}'$, $\text{NHC(=O)NR}'_2$, $\text{C(=O)R}'$, $\text{C(=O)CH}_2\text{OR}'$, $\text{CO}_2\text{R}'$, $\text{C(=O)NHR}'$, or $\text{C(=O)NR}'_2$; wherein when R is pyridyl it may be a pyridine N-oxide; and wherein each R' is independently CF_3 or C_1 to C_4 lower alkyl; and, in any order,
- (b) cleavage of the amino protecting group P^1 ; and
- (c) cleavage of the protecting group from the benzamidine.
28. A process for preparing a compound as claimed in any of claims 1-11, comprising the following steps:
- (a) acylation of an amidino-protected 4-(methylamino)benzamidine with an activated carboxylic acid derived from the acid of formula B



wherein P^1 and P^2 are mutually orthogonal amino protecting groups; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidinyl; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R' , OR' , SR' , $S(=O)R'$, $S(=O)_2R'$, $S(=O)_2NHR'$, $S(=O)_2NR'_2$, CN , NH_2 , NHR' , NR'_2 , $NHS(=O)_2R'$, $NHC(=O)R'$, $NHC(=O)OR'$, $NHC(=O)NHR'$, $NHC(=O)NR'_2$, $C(=O)R'$, $C(=O)CH_2OR'$, CO_2R' , $C(=O)NHR'$, and $C(=O)NR'_2$; wherein when R is pyridyl it may be a pyridine N-oxide; and wherein each R' is independently CF_3 or C_1 to C_4 lower alkyl;

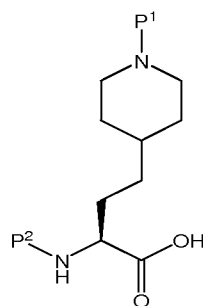
- (b) cleavage of the amino protecting group P^2 ;
- (c) sulfonylation of the resulting deprotected amino group with a sulfonylating agent of formula C:



wherein X' is a leaving group and X is H or CO_2R' ; and, in any order,

- (d) cleavage of the amino protecting group P^1 ; and
- (e) cleavage of the protecting group from the benzamidine.

29. A process for preparing a compound as claimed in any of claims 1-11, comprising the following steps:
- (a) acylation of an amidino-protected 4-(methylamino)benzamidine with an activated carboxylic acid derived from the acid of formula **D**

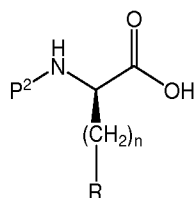
**D**

wherein P^1 and P^2 are mutually orthogonal amino protecting groups, and

- (b) cleavage of the protecting group P^2 .

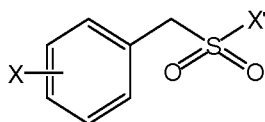
30. The process of claim 29, further comprising the steps of

- (c) acylation with an activated carboxylic acid derived from structure **G**

**G**

wherein P^2 is an amino protecting group; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidinyl; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R' , OR' , SR' , $S(=O)R'$, $S(=O)_2R'$, $S(=O)_2NHR'$, $S(=O)_2NR'_2$, CN , NH_2 , NHR' , NR'_2 , $NHS(=O)_2R'$, $NHC(=O)R'$, $NHC(=O)OR'$, $NHC(=O)NHR'$, $NHC(=O)NR'_2$, $C(=O)R'$, $C(=O)CH_2OR'$, CO_2R' , $C(=O)NHR'$, or $C(=O)NR'_2$; wherein when R is pyridyl it may be a pyridine N-oxide; and wherein each R' is independently CF_3 or C_1 to C_4 lower alkyl;

- (d) cleavage of the amino protecting group P^2 ;
 (e) sulfonylation of the resulting deprotected amino group with a sulfonylating agent of formula **C**:

**C**

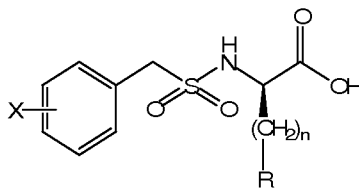
wherein X' is a leaving group and X is H or CO_2R' ; and, in any order,

- (f) cleavage of the amino protecting group P^1 ; and

(g) cleavage of the protecting group from the benzamidine.

31. The process of claim 29, further comprising the steps of

(c) acylation with an activated carboxylic acid derived from structure **F**



F

wherein n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidinyl; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R', OR', SR', S(=O)R', S(=O)₂R', S(=O)₂NHR', S(=O)₂NR'₂, CN, NH₂, NHR', NR'₂, NHS(=O)₂R', NHC(=O)R', NHC(=O)OR', NHC(=O)NHR', NHC(=O)NR'₂, C(=O)R', C(=O)CH₂OR', CO₂R', C(=O)NHR', or C(=O)NR'₂; wherein when R is pyridyl it may be a pyridine N-oxide; and wherein each R' is independently CF₃ or C₁ to C₄ lower alkyl; and, in any order,

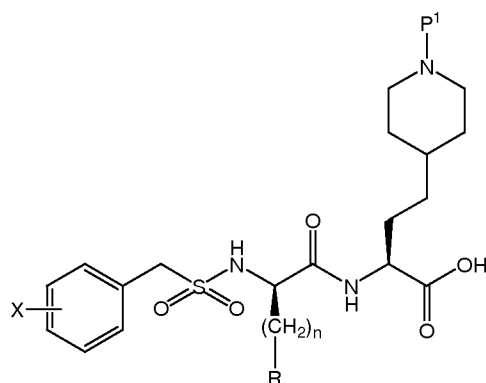
(d) cleavage of the amino protecting group P¹; and

(e) cleavage of the protecting group from the benzamidine.

32. The process of any one of claims 27-31, wherein the amidino protecting group is an N-acetoxy group.

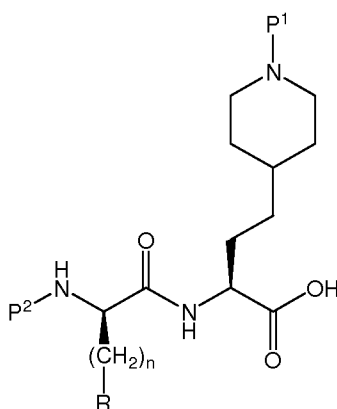
33. The process of any one of claims 27-31, wherein the amidino protecting group is a 1,2,4-oxadiazol-5-one ring.

34. A compound of formula



wherein P^1 is an amino protecting group; X is H or $\text{CO}_2\text{R}'$; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidiny; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R' , OR' , SR' , $\text{S}(\text{O})\text{R}'$, $\text{S}(\text{O})_2\text{R}'$, $\text{S}(\text{O})_2\text{NHR}'$, $\text{S}(\text{O})_2\text{NR}'_2$, CN, NH_2 , NHR' , NR'_2 , $\text{NHS}(\text{O})_2\text{R}'$, $\text{NHC}(\text{O})\text{R}'$, $\text{NHC}(\text{O})\text{OR}'$, $\text{NHC}(\text{O})\text{NHR}'$, $\text{NHC}(\text{O})\text{NR}'_2$, $\text{C}(\text{O})\text{R}'$, $\text{C}(\text{O})\text{CH}_2\text{OR}'$, $\text{CO}_2\text{R}'$, $\text{C}(\text{O})\text{NHR}'$, or $\text{C}(\text{O})\text{NR}'_2$; wherein when R is pyridyl it may be a pyridine N-oxide; and wherein each R' is independently CF_3 or C_1 to C_4 lower alkyl.

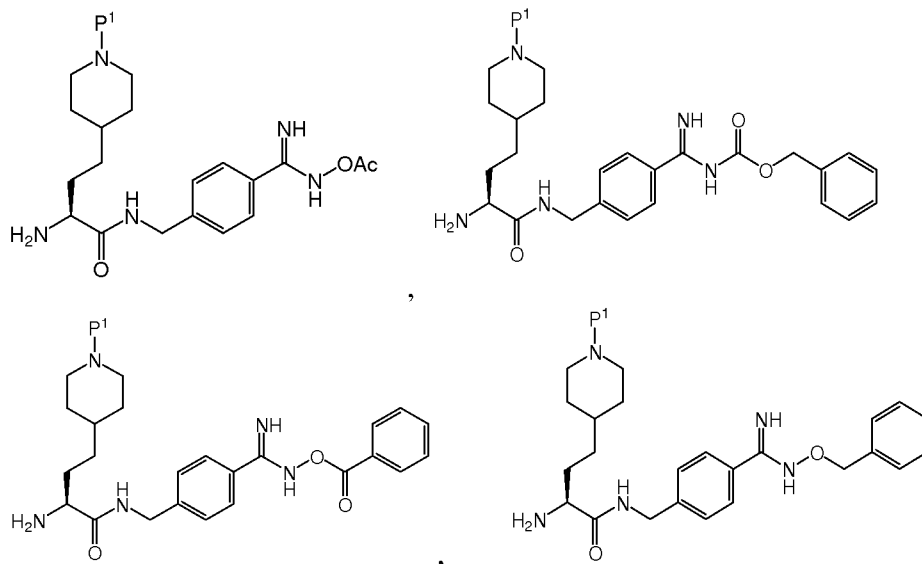
35. A compound of formula



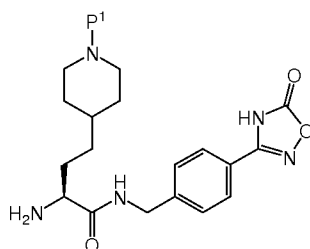
wherein P^1 and P^2 are mutually orthogonal amino protecting groups; n ranges from 0 to 3; and R is selected from the group consisting of phenyl, pyridyl, tetrazolyl, and piperidiny; wherein R may be unsubstituted or may be substituted by one or more substituents selected from the group consisting of halogen, R' , OR' , SR' , $\text{S}(\text{O})\text{R}'$, $\text{S}(\text{O})_2\text{R}'$, $\text{S}(\text{O})_2\text{NHR}'$, $\text{S}(\text{O})_2\text{NR}'_2$, CN, NH_2 , NHR' , NR'_2 , $\text{NHS}(\text{O})_2\text{R}'$, $\text{NHC}(\text{O})\text{R}'$, $\text{NHC}(\text{O})\text{OR}'$, $\text{NHC}(\text{O})\text{NHR}'$, $\text{NHC}(\text{O})\text{NR}'_2$, $\text{C}(\text{O})\text{R}'$, $\text{C}(\text{O})\text{CH}_2\text{OR}'$, $\text{CO}_2\text{R}'$, $\text{C}(\text{O})\text{NHR}'$, and $\text{C}(\text{O})\text{NR}'_2$; wherein when R is pyridyl it may

be a pyridine N-oxide; and wherein each R' is independently CF₃ or C₁ to C₄ lower alkyl.

36. A compound selected from the group consisting of

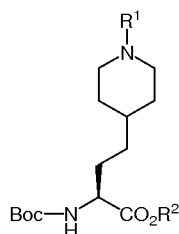


and



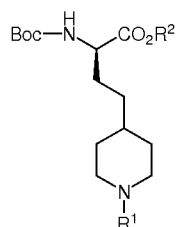
wherein P¹ is an amino protecting group.

37. A compound of formula



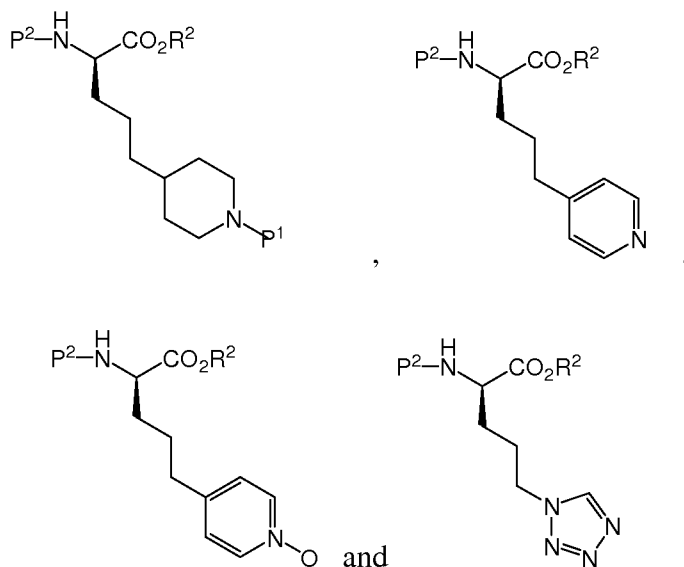
wherein R^1 is H, benzyloxycarbonyl, or 4-nitrobenzyloxycarbonyl, and R^2 is selected from the group consisting of H, methyl, ethyl, t-butyl, and benzyl.

38. A compound of formula



wherein R^1 is H, benzyloxycarbonyl, or 4-nitrobenzyloxycarbonyl, and R^2 is selected from the group consisting of H, methyl, ethyl, t-butyl, and benzyl.

39. A compound selected from the group consisting of



wherein P^1 and P^2 are each independently H or an amino protecting group, and R^2 is selected from the group consisting of H, methyl, ethyl, t-butyl, and benzyl.