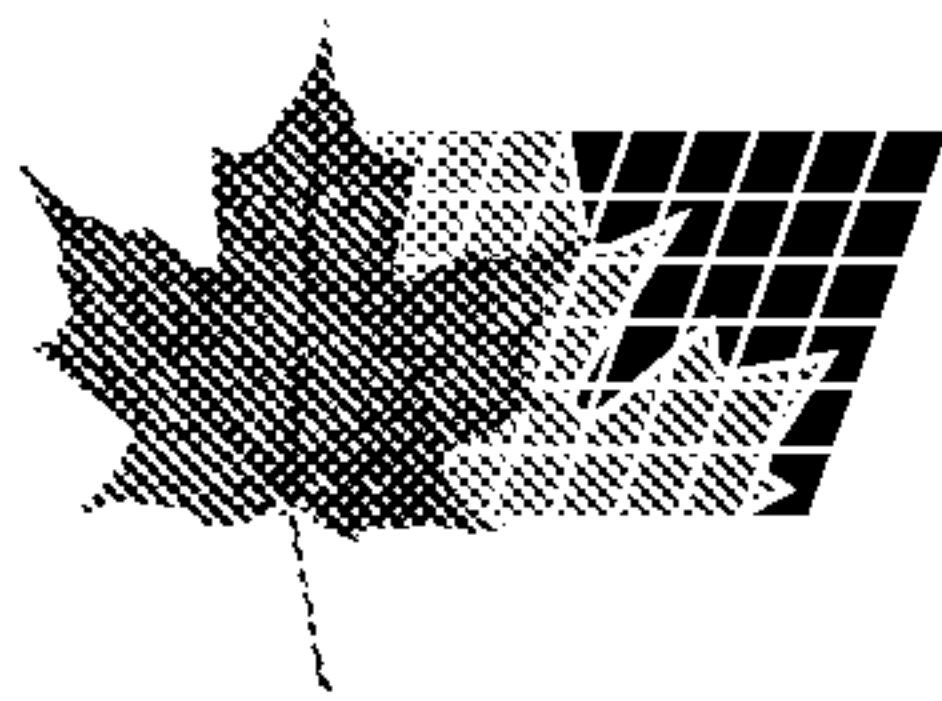




- (72) PETRIE, CHARLES, US
(72) MCKERNAN, PATRICIA A., US
(72) MOORE, EMMA E., US
(72) OSTRECH, JOHN M., US
(72) MEYER, JEAN-PHILIPPE, US
(72) HOUGHTEN, RICHARD A., US
(72) PINELLA, CLEMENCIA, US
(71) ZYMOGENETICS, INC., US
(71) TREGA BIOSCIENCES, INC., US
(51) Int.Cl.⁶ C07C 275/00
(30) 1998/01/21 (60/072,987) US
(54) **DIALKYLUREES UTILISEES EN TANT QUE SUBSTANCES
IMITANT LA CALCITONINE**
(54) **DIALKYL UREAS AS CALCITONIN MIMETICS**

(57) On décrit des composés de dialkylurée qui se comportent comme des substances imitant la calcitonine. Ces composés sont utiles dans le traitement de maladies qui sont associées à la résorption osseuse. Les substances imitant la calcitonine de la présente invention sont également utiles dans des dosages permettant de déterminer l'activité du récepteur de calcitonine.

(57) Dialkyl urea compounds are described which act as calcitonin mimetics. These compounds are useful in the treatment of diseases which are associated with bone resorption. The calcitonin mimetics of the present invention are also useful in assays for the determination of calcitonin receptor activity.

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C07C 275/00	A2	(11) International Publication Number: WO 99/37604 (43) International Publication Date: 29 July 1999 (29.07.99)
(21) International Application Number: PCT/US99/01151 (22) International Filing Date: 20 January 1999 (20.01.99) (30) Priority Data: 60/072,987 21 January 1998 (21.01.98) US (71) Applicants: ZYMOGENETICS, INC. [US/US]; 1201 Eastlake Avenue East, Seattle, WA 98102 (US). TREGA BIOSCIENCES, INC. [US/US]; 3350 General Atomics Court, San Diego, CA 92121 (US). (72) Inventors: PETRIE, Charles; 18459 N.E. 196th Place, Woodinville, WA 98072 (US). MCKERNAN, Patricia, A.; 18459 N.E. 196th Place, Woodinville, WA 98072 (US). MOORE, Emma, E.; 3507 30th Avenue West, Seattle, WA 98199 (US). OSTRECH, John, M.; 315 La Veta Avenue, Encinitas, CA 92024 (US). MEYER, Jean-Philippe; 2305 Hopkins Court, Holland, PA 18966 (US). HOUGHTEN, Richard, A.; 4939 Rancho Viejo, Del Mar, CA 92014 (US). PINELLA, Clemencia; 1656 Freda Lane, Cardiff, CA 92007 (US). (74) Agent: LINGENFELTER, Susan, E.; ZymoGenetics, Inc., 1201 Eastlake Avenue East, Seattle, WA 98102 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>Without international search report and to be republished upon receipt of that report.</i>
(54) Title: DIALKYL UREAS AS CALCITONIN MIMETICS (57) Abstract Dialkyl urea compounds are described which act as calcitonin mimetics. These compounds are useful in the treatment of diseases which are associated with bone resorption. The calcitonin mimetics of the present invention are also useful in assays for the determination of calcitonin receptor activity.		

5 DESCRIPTION
DIALKYL UREAS AS CALCITONIN MIMETICS

BACKGROUND OF THE INVENTION

Bone is a dynamic tissue, and homeostasis in the
10 adult skeleton requires a balance between bone resorption
and bone formation. Osteoclasts and osteoblasts play a
key role in this balance, with osteoclasts initiating bone
resorption and osteoblasts synthesizing and depositing new
bone matrix. Imbalances in bone homeostasis are
15 associated with such conditions as osteoporosis, Paget's
disease, and hyperparathyroidism.

The activities of osteoclasts and osteoblasts
are regulated by complex interactions between systemic
hormones and the local production of growth factors and
20 cytokines. Calcitonin, a peptide hormone secreted by the
thyroid and thymus of mammals, plays an important role in
maintaining bone homeostasis. Calcitonin inhibits bone
resorption through binding and activation of a specific
calcitonin receptor on osteoclasts (The Calcitonins-
25 Physiology and Pharmacology Azria (ed.), Karger, Basel,
Su., 1989), with a resultant decrease in the amount of
calcium released by bone into the serum. This inhibition
of bone resorption has been exploited, for instance, by
using calcitonin as a treatment for osteoporosis, a
30 disease characterized by a decrease in the skeletal mass
often resulting in debilitating and painful fractures.
Calcitonin is also used in the treatment of Paget's
disease where it provides rapid relief from bone pain,
which is frequently the primary symptom associated with
35 this disease. This analgesic effect has also been
demonstrated in patients with osteoporosis or metastatic
bone disease and has been reported to relieve pain
associated with diabetic neuropathy, cancer, migraine and

post-hysterectomy. Reduction in bone pain occurs before the reduction of bone resorption.

Salmon calcitonin has been shown to be considerably more effective in arresting bone resorption than human forms of calcitonin. Several hypotheses have been offered to explain this observation: 1) salmon calcitonin is more resistant to degradation; 2) salmon calcitonin has a lower metabolic clearance rate (MCR); and 3) salmon calcitonin may have a slightly different conformation, resulting in a higher affinity for bone receptor sites.

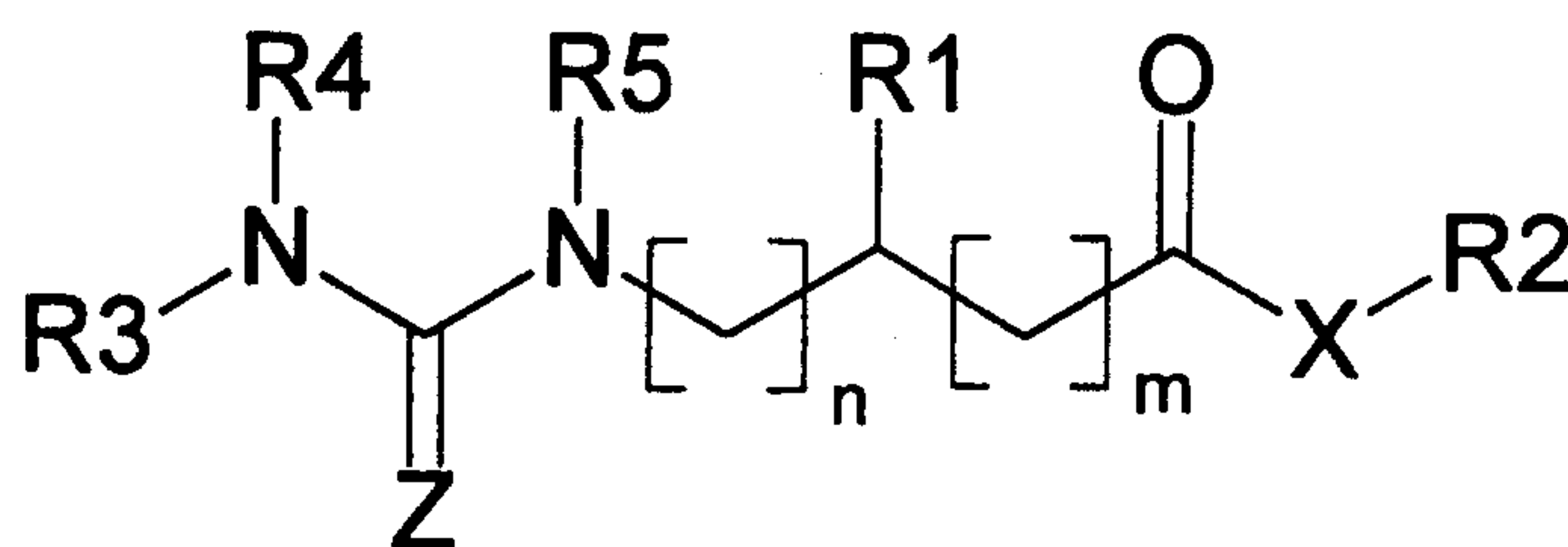
Despite the advantages associated with the use of salmon calcitonin in humans, there are also disadvantages. For treatment of osteoporosis, for instance, the average cost can exceed \$75 a week and involve daily prophylactic administration for 5 or more years. In the United States, calcitonin must be administered by injection, and since the disease indications for this drug are not usually life threatening, patient compliance can be low. Resistance to calcitonin therapy may occur with long-term use. What triggers this resistance or "escape phenomenon" is unknown (see page 1093, Principles of Bone Biology, Bilezikian et al., (eds.) Academic Press, NY; Raisz et al., Am. J. Med. 43:684-90, 1967; McLeod and Raisz, Endocrine Res. Comm. 8:49-59, 1981; Wener et al., Endocrinology. 90:752-9, 1972 and Tashjian et al., Recent Prog. Horm. Res. 34:285-303, 1978). Use of calcitonin mimetics, either in place of native calcitonins or in rotation with native calcitonins, would help avoid resistance to such treatment during long-term use. In addition, some patients develop antibodies to non-human calcitonin, calcitonin mimetics would be useful for such patients.

What is needed in the art are alternative methods of inhibiting bone resorption. The present invention fulfills these and other needs.

SUMMARY OF THE INVENTION

The present invention provides isolated compounds that are useful as calcitonin mimetics. As used herein, the term "calcitonin mimetic" refers to a compound with the ability to mimic the effects generated by calcitonin's interaction with its receptor and its signal transduction pathway and, by such interaction, stimulate G-protein-mediated activation by adenylyl cyclase.

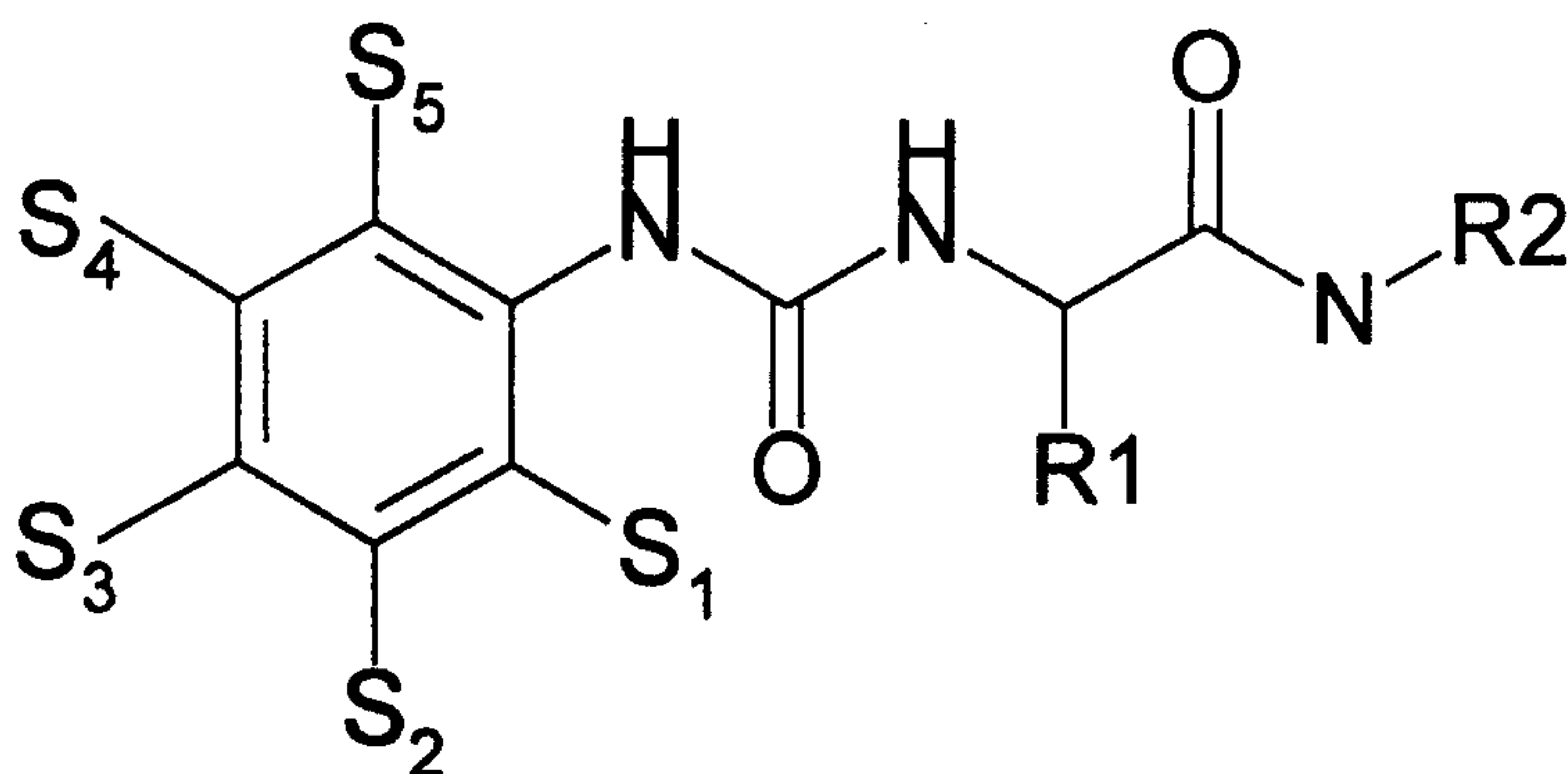
Within one aspect the invention provides a compound of formula I:



(I)

wherein R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; R3 is a 2,5 disubstituted aryl; R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6 carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings; Z and X are each independently selected from the group NH, O, S, or NR, wherein R is a lower alkyl group of from 1 to 6

carbon atoms; n and m are each independently an integer from 0 to 6. Within one embodiment R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl; R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl; wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and R4 and R5 are hydrogen; Z is O; and X is NH. Within a related embodiment R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-alloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and R2 is ethyl, allyl, benzyl or 2-naphthylmethyl. Within another embodiment the compound has the formula:



wherein, R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of

halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and S1, S3 and S4 are each independently selected from the group consisting of
5 hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl. S2 and S5 are each independently alkyl or aryl. Within one embodiment R1 is selected from the group consisting of phenyl, substituted
10 phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl; R2 is selected from the group consisting of alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, benzyl, substituted benzyl,
15 naphthylmethyl, and substituted naphthylmethyl; wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl and S2 and S5 are t-butyl. Within a
20 related embodiment R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; R2 is ethyl, allyl, benzyl or 2-naphthylmethyl; and S2 and S5 are t-
25 butyl.

Within another aspect, the invention provides a pharmaceutical composition comprising an effective amount of a compound as described above in a pharmaceutically acceptable carrier.

30 Within another aspect the invention provides a method for treating a bone-related disorder, comprising administering to a subject suffering from such disorder an effective amount of calcitonin mimetic compound as described above. Within a related embodiment the bone-
35 related disorder is selected from the group consisting of osteoporosis, Paget's disease, hyperparathyroidism,

osteomalacia, periodontal applications (bone loss), hypercalcemia of malignancy and hypercalcemia of infancy.

Within another aspect the invention provides a method of inhibiting bone resorption comprising
5 administering to a subject in need of such inhibition an effective amount of a calcitonin mimetic compound as described above.

Within yet another aspect the invention provides a method for providing an analgesic effect comprising
10 administering to a subject in need of such an effect an effective amount of a calcitonin mimetic compound as described above. Within a related embodiment the analgesic effect provides relief from bone pain.

Within another aspect the invention provides a
15 method for treating conditions associated with inhibiting gastric secretion comprising administering to a subject in need of such inhibition an effective amount of a calcitonin mimetic compound as described above. Within a related embodiment the conditions associated with
20 inhibiting gastric secretion is a gastrointestinal disorder.

These and other aspects of the invention will become evident upon reference to the following detailed description and the attached drawings.

25

DETAILED DESCRIPTION OF THE INVENTION

Abbreviations

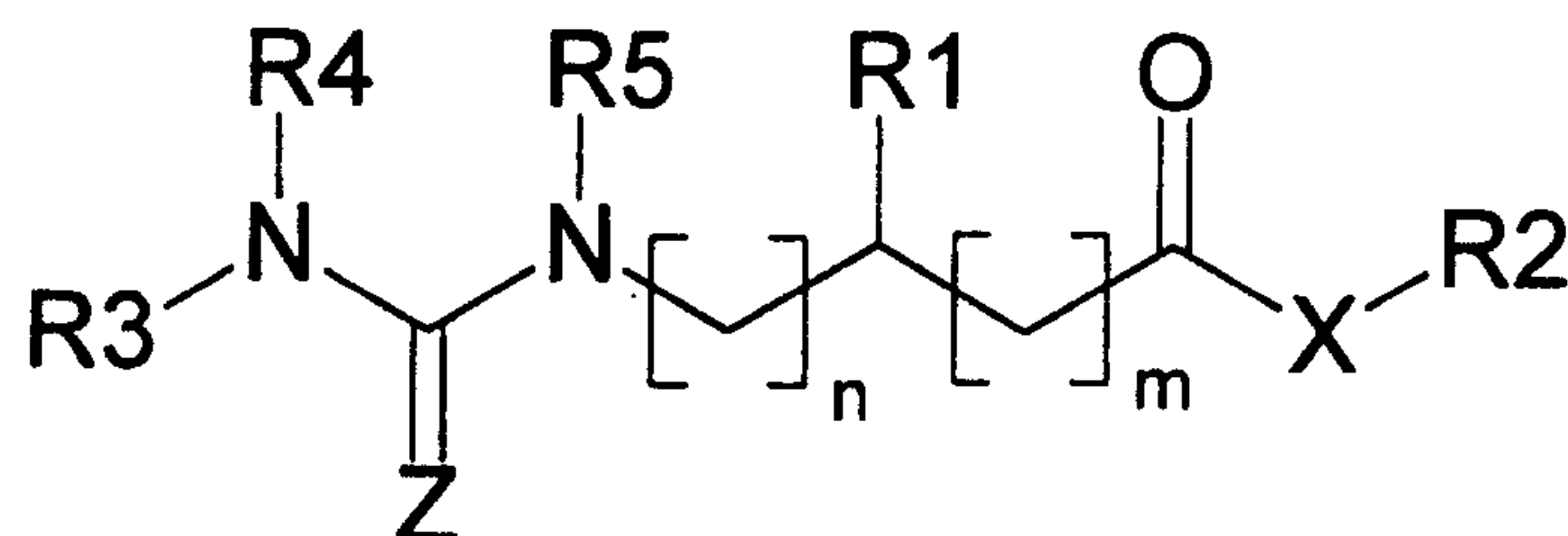
The following abbreviations are used herein:
Boc, t-butoxycarbonyl; DCM, dichloromethane; DME,
30 dimethoxyethane; DMF, dimethylformamide; EtOAc, ethyl acetate; Fmoc, fluorenylmethoxycarbonyl; TFA, trifluoroacetic acid.

All references cited herein are incorporated by reference in their entirety.

35 The calcitonin mimetics which are useful in the present invention are those compounds with the ability to mimic the interaction of calcitonin with its receptor and,

by such mimicry, to stimulate G-protein-mediated activation of adenyl cyclase or activation of CRE by an alternative signal transduction pathway. These mimetics are represented by the general formula:

5



(I)

In this formula, R1 and R2 are each
 10 independently hydrogen, alkyl groups having from 1 to 6 carbon atoms, alkenyl groups having from 1 to 6 carbon atoms, an aryl group, or alkylaryl groups, where the alkyl portion may have 1 to 6 carbon atoms and the aryl portion represents an aryl group, a substituted aryl group, a
 15 carbocyclic ring, a substituted carbocyclic ring, a heterocyclic ring, a substituted heterocyclic ring, or combinations thereof. The combinations can be fused or covalently linked. In certain preferred embodiments R1 is substituted or unsubstituted phenyl, benzyl,
 20 naphthylmethyl or indolymethyl. R2 is an alkyl or alkenyl having from 1 to 6 carbon atoms, substituted or unsubstituted benzyl or naphthylmethyl. In certain particularly preferred embodiments R1 is 4-ethoxybenzyl, 1-ethyl-indolymethyl, benzyl, 4-allyloxybenzyl, 1-allyl-
 25 indolymethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl. R2 is ethyl, allyl, benzyl, or 2-naphthylmethyl.

R3 represents substituted and unsubstituted aryl groups, carbocyclic rings, heterocyclic rings, or
 30 combinations thereof. The combinations can be fused or covalently linked. Within certain preferred embodiments R3 is a 2,5 disubstituted aryl. Preferably the

substitutions are aryl or alkyl. Within a preferred embodiment R3 is 2,6-di-t-butyl-phenyl.

R4 and R5 are each independently hydrogen, alkyl groups having from 1 to 6 carbon atoms. Within certain
5 embodiments R4 and R5 can be joined together to form a ring which is a four-, five-, six- or seven-member ring, saturated or unsaturated. For those embodiments in which the ring is unsaturated, the ring can be an heteroaromatic ring (e.g., pyrimidyl, imidazyl). Within
10 certain preferred embodiments R4 and R5 are hydrogen.

Z and X each independently represent either NH, NR, O, or S, in which R is a lower alkyl group of from one to six carbon atoms. In preferred embodiments, Z represents O and X represents NH. The symbols n and m
15 each represent independently, integers from zero to six.

As used herein, the term "alkyl" refers to a saturated hydrocarbon radical which may be straight-chain or branched-chain (for example, ethyl, isopropyl, or t-butyl), or cyclic (for example cyclobutyl, cyclopropyl or
20 cyclopentyl). Preferred alkyl groups are those containing 1 to 6 carbon atoms.

The term "alkenyl" refers to an unsaturated hydrocarbon radical which may be a straight-chain, branched-chain or cyclic. Examples of alkenyls include
25 vinyl, allyl, 2-butenyl, 3-butenyl, 2-pentenyl, 3-pentenyl, 3-pentenyl, 4-pentenyl, 2-hexenyl, 3-hexenyl, 4-hexenyl and 5-hexenyl, as well as dienes and trienes of straight, branched or cyclic chains and the like. Preferred alkenyl groups are those containing 1 to 6
30 carbon atoms.

The term "aryl" refers to an aromatic substituent which may be a single ring or multiple rings which are fused together, linked covalently or linked to a common group such as an ethylene or methylene moiety. The
35 aromatic rings may each contain heteroatoms, preferred heteroatoms are N, S or O. Examples of aryl groups include phenyl, benzyl, naphthyl, biphenyl,

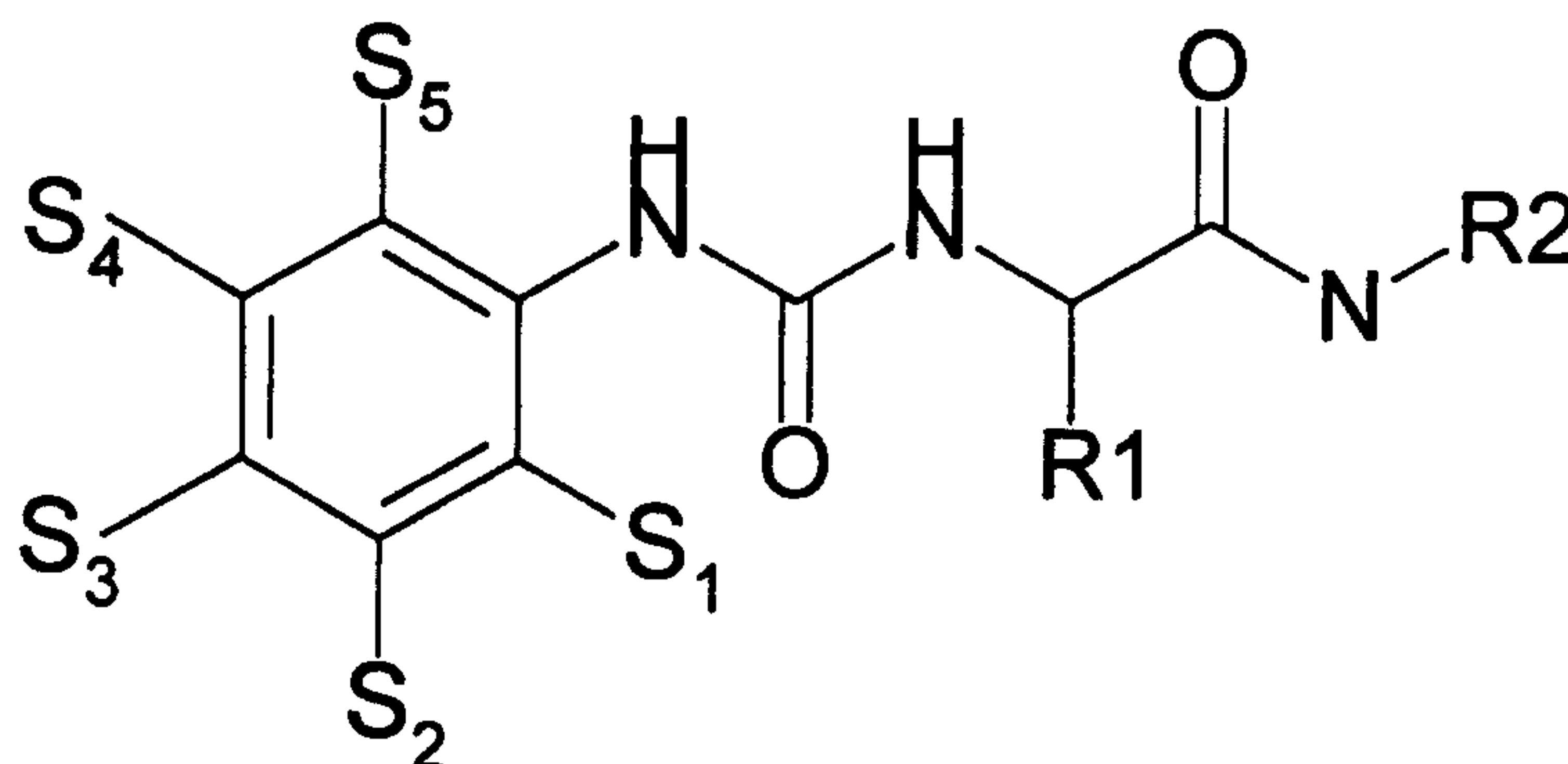
diphenylmethyl, 2,2-diphenyl-1-ethyl, thienyl, pyridyl and quinoxalyl. Additionally, the aryl groups may be attached to other parts of the molecule at any position on the aryl radical which would otherwise be occupied by a hydrogen
5 atom (such as, for example, 2-pyridyl, 3-pyridyl and 4-pyridyl).

Heterocyclic rings contain at least one heteroatom selected from N, O and S. Examples of carbocyclic and heterocyclic rings include cyclohexyl,
10 cyclohexenyl, piperazinyl, pyrazinyl, morpholinyl, imidazolyl, triazolyl and thiazolyl.

The terms "substituted alkyl", "substituted alkenyl", "substituted alkylaryl", "substituted aryl", "substituted carbocyclic ring", "substituted heterocyclic
15 ring" "substituted phenyl", "substituted benzyl", "substituted naphthylmethyl" and "substituted indolymethyl" refer to the above alkyl, alkenyl, alkylaryl, carbocyclic ring, heterocyclic ring, aryl, phenyl, benzyl, naphthylmethyl and indolymethyl groups
20 substituted by one or more, preferably one, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl. Examples include 4-ethoxybenzyl, 1-ethyl-indolymethyl, 4-allyloxybenzyl, 1-allyl-
25 indolymethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl or 2-naphthylmethyl.

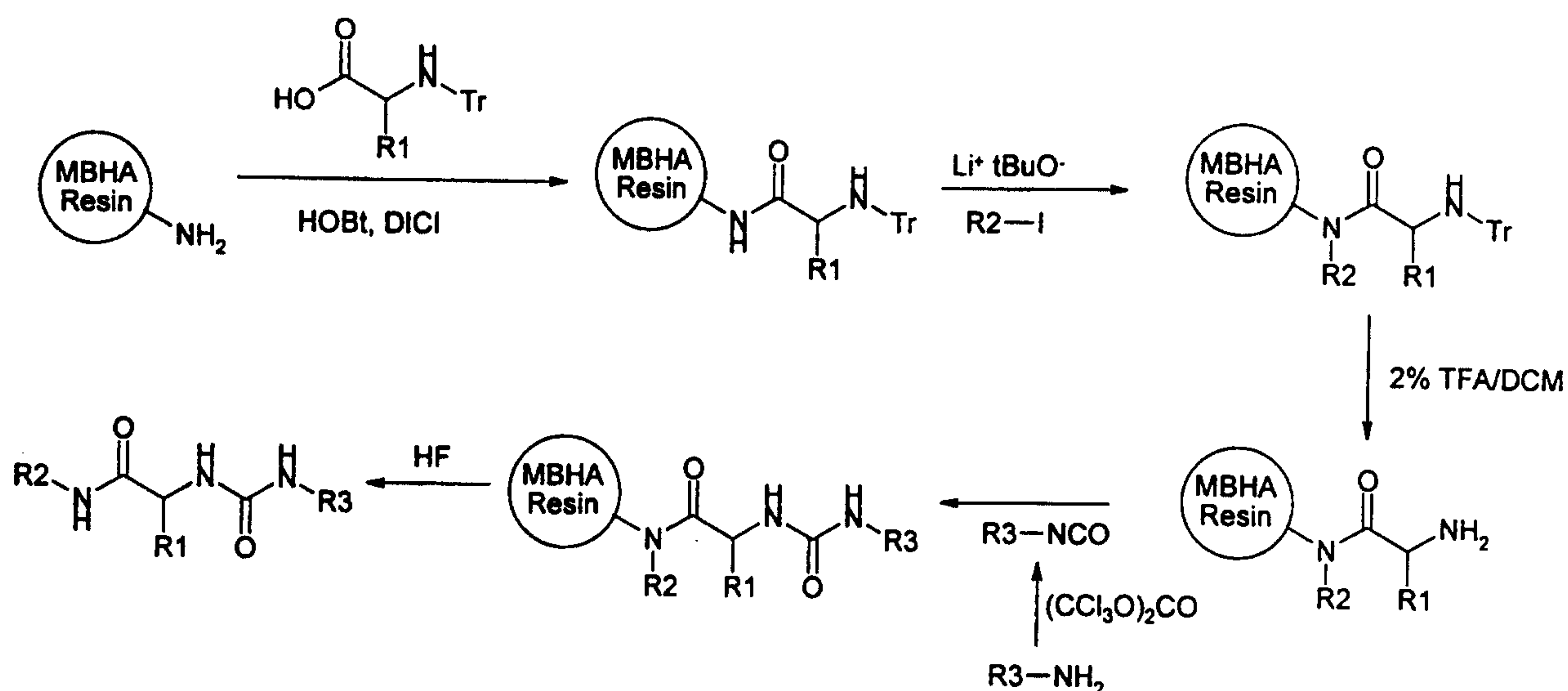
All numerical ranges in this specification and claims are intended to be inclusive of their upper and lower limits.

30 In one group of preferred embodiments, the calcitonin mimetics are represented by the formula:



In this formula, the symbols R1 and R2 have the meaning provided above. The symbols S1, S3 and S4 each independently represent a substituent on the attached aromatic ring which is hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl. The symbols S2 and S3 each represent an aryl or alkyl. In certain preferred embodiments R1 is substituted or unsubstituted phenyl, benzyl, naphthylmethyl or indolylmethyl. R2 is an alkyl or alkenyl having from 1 to 6 carbon atoms, substituted or unsubstituted benzyl or naphthylmethyl. In certain particularly preferred embodiments, S5 and S2 are t-butyl, R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl and R2 is ethyl, allyl, benzyl, or 2-naphthylmethyl.

The calcitonin mimetics used in the present invention can be prepared using commercially available materials. A general synthetic scheme for preparing molecules of Formula I wherein R4 and R5 are hydrogen, using methodologies known in the art, is provided herein.



In a typical preparation, 100 mg of p-5 methylbenzhydrylamine (MBHA) resin (0.81 meq/g, 100-200 mesh) was contained within a sealed polypropylene mesh packet. Following neutralization with 5% diisopropylethylamine (DIEA) in dichloromethane (DCM), the resin was washed with DCM. The first protected amino acid 10 was coupled using hydroxybenzotriazole (HOBt) and diisopropylcarbodiimide (DICl) in DMF. Following removal of the amino protecting group, the mesh packet was shaken overnight in a solution of 0.1 M trityl chloride in DCM/DMF (9:1) in the presence of DIEA. Completeness of 15 the trityl coupling was verified using the bromophenol blue color test as described in Krchnak et al., (Coll. Czech. Chem. Commun. 53:2542, 1988, and repeated as necessary.

N-alkylation was then performed by treatment of 20 the resin packet with 1 M lithium t-butoxide in THF (20X) for 15 min, as described by D'rner, et al., (Bioorg. Med. Chem. 4:709, 1996). Excess base was then removed by decantation, followed by addition of the individual alkylating agent in DMSO (20X, 0.1M). The solution was 25 vigorously shaken for 2 h at room temperature. This step is normally repeated three times for methyl iodide, and

five times for the other alkylating agents. Small aliquots of the resin can be cleaved to determine the completeness of this step. The trityl group was removed with 2% TFA in DCM (2 x 10 min).

5 The isocyanate of the incoming primary amine (or aniline) was performed by slowly adding a solution of the primary amine (0.3M in DCM, 24X over the resin substitution) and DIEA (48X) dropwise to solution of 0.1M triphosgene (8X) in DCM. It is known in the art that the
10 reaction does not proceed through the isocyanate for secondary amines. The packet was washed, neutralized and the isocyanate solution added and shaken for 1 hour at RT. Following decantation, the isocyanate solution was quenched with 10% NH₃ in DMF. The resin was washed with
15 DCM, 0.05% NH₃ in DMF, MeOH, DCM, and MeOH.

 The product was cleaved from the resin with anhydrous HF by the procedures of Houghten et al., (Int. J. Pep. Prot. Res. 27:673, 1986), in the presence of anisole. The product was extracted with 50% ACN/H₂O and
20 lyophilized, followed by relyophilization from 50% acetonitrile.

 The compounds of the invention can be administered to warm blooded animals, including humans, to mimic the interaction of calcitonin with its receptor in
25 vivo. Within one aspect, calcitonin mimetics of the present invention are contemplated to be advantageous for use in therapeutic defects for which calcitonin is useful. In particular, the calcitonin mimetics are useful for the regulation of bone metabolism and reduction of serum
30 calcium. The calcitonin mimetics of the invention can be administered to warm blooded animals, including humans, to mimic the interaction of calcitonin with its receptor in vivo. Thus, the present invention encompasses methods for therapeutic treatment of bone-related disorders. Such
35 bone-related disorders include, but are not limited to, osteoporosis, Paget's Disease, hyperparathyroidism, osteomalacia, periodontal defects (bone loss),

hypercalcemia of malignancy, idiopathic hypercalcemia of infancy, and other related conditions. Calcitonin mimetics are also contemplated to be advantageous as analgesics, in particular for relief of bone pain. 5 Calcitonin mimetics are further contemplated to be advantageous in inhibiting bone resorption. The calcitonin mimetics of the present invention can also be used to inhibit gastric secretion in the treatment of acute pancreatitis and gastrointestinal disorders. The 10 methods of the present invention may be used to treat these conditions in their acute or chronic stages.

Pharmaceutically or therapeutically effective amounts of calcitonin mimetics of the present invention can be formulated with pharmaceutically or therapeutically 15 acceptable carriers for parenteral, oral, nasal, rectal, topical, transdermal administration or the like, according to conventional methods. Formulations may further include one or more diluents, fillers, emulsifiers, preservatives, buffers, excipients, and the like, and maybe provided in 20 such forms as liquids, powders, emulsions, suppositories, liposomes, transdermal patches and tablets, for example. Slow or extended-release delivery systems, including any of a number of biopolymers (biological-based systems), systems employing liposomes, and polymeric delivery 25 systems, can also be utilized with the compositions described herein to provide a continuous or long-term source of the calcitonin mimetic. Such slow release systems are applicable to formulations, for example, for oral, topical and parenteral use. The term 30 "pharmaceutically or therapeutically acceptable carrier" refers to a carrier medium which does not interfere with the effectiveness of the biological activity of the active ingredients and which is not toxic to the host or patient. One skilled in the art may formulate the compounds of the 35 present invention in an appropriate manner, and in accordance with accepted practices, such as those disclosed in Remington: The Science and Practice of

Pharmacy, Gennaro, ed., Mack Publishing Co., Easton, PA, 19th ed., 1995. Preferably such compounds would be administered orally or parenterally.

As used herein, a "pharmaceutically or
5 therapeutically effective amount" of such a calcitonin
mimetic is an amount sufficient to induce a desired
biological result. The result can be alleviation of the
signs, symptoms, or causes of a disease, or any other
desired alteration of a biological system. For example,
10 an effective amount of a calcitonin mimetic is that which
provides either subject relief of symptoms or an
objectively identifiable improvement as noted by the
clinician or other qualified observer. In particular,
such an effective amount of a calcitonin mimetic results
15 in reduction in serum calcium, inhibition of bone
resorption, inhibition of gastric secretion or other
beneficial effect. Effective amounts of the calcitonin
mimetics can vary widely depending on the disease or
symptom to be treated. The amount of the mimetic to be
20 administered, and its concentration in the formulations,
depends upon the vehicle selected, route of
administration, the potency of the particular mimetic, the
clinical condition of the patient, the side effects and
the stability of the compound in the formulation. Thus,
25 the clinician will employ the appropriate preparation
containing the appropriate concentration in the
formulation, as well as the amount of formulation
administered, depending upon clinical experience with the
patient in question or with similar patients. Such
30 amounts will depend, in part, on the particular condition
to be treated, age, weight, and general health of the
patient, and other factors evident to those skilled in the
art. Estimation of appropriate dosages effective for the
individual patient is well within the skill of the
35 ordinary prescribing physician or other appropriate health
care practitioner. As a guide, the clinician can use
conventionally available advice from a source such as the

Physician's Desk Reference, 48th Edition, Medical Economics Data Production Co., Montvale, New Jersey 07645-1742 (1994). Typically a dose will be in the range of 0.1-100 mg/kg of subject. Preferably 0.5-50 mg/kg. Doses for specific compounds may be determined from *in vitro* or *ex vivo* studies on experimental animals. Concentrations of compounds found to be effective *in vitro* or *ex vivo* provide guidance for animal studies, wherein doses are calculated to provide similar concentrations at the site of action.

Well established animal models are available to test *in vivo* efficacy of calcitonin mimetics. For example, the hypocalcemic rat model can be used to determine the effect of synthetic calcitonin mimetics on serum calcium, and the ovariectomized rat or mouse can be used as a model system for osteoporosis. Bone changes seen in these models and in humans during the early stages of estrogen deficiency are qualitatively similar. Calcitonin has been shown to be an effective agent for the prevention of bone loss in ovariectomized humans and also in rats (Mazzuoli, et al., Calcif. Tissue Int. 47:209-14, 1990; Wronski, et al., Endocrinology 129:2246-50, 1991).

Only those compounds which retain calcitonin-like activity, as assayed by a CRE-luciferase assay, for example, are within the scope of this invention. The calcitonin receptor is a member of the G-protein receptor family and transduces signal via activation of adenylate cyclase, leading to elevation of cellular cAMP levels (Lin, et al., Science 254:1022-4, 1991). This assay system exploits the receptor's ability to detect other molecules, not calcitonin, that are able to stimulate the calcitonin receptor and initiate signal transduction.

Receptor activation can be detected by: (1) measurement of adenylate cyclase activity (Salomon, et al., Anal. Biochem. 58:541-8, 1974; Alvarez and Daniels, Anal. Biochem. 187:98-103, 1990); (2) measurement of change in intracellular cAMP levels using conventional

radioimmunoassay methods (Steiner, et al., J. Biol. Chem. 247:1106-13, 1972; Harper and Brooker, J. Cyc. Nucl. Res. 1:207-18, 1975); or (3) use of a cAMP scintillation proximity assay (SPA) method (Amersham Corp., Arlington Heights, IL). While these methods provide sensitivity and accuracy, they involve considerable sample processing prior to assay, are time consuming, may involve the use of radioisotopes, and would be cumbersome for large scale screening assays.

10 An alternative assay system (described in WO96/31536) involves selection of substances that are able to induce expression of a cyclic AMP response element (CRE)-luciferase reporter gene, as a consequence of elevated cAMP levels or other signaling pathways, such as
15 stimulation of Ca^{++}/Ip_3 pathway leading to CRE induction, in cells expressing a calcitonin receptor, but not in cells lacking calcitonin receptor expression. Such cells could include, for example, Boris/KS10-3 (expressing hamster calcitonin receptor and a CRE-luciferase reporter
20 gene in baby hamster kidney cells (BHK 570 cells)) or Hollex 1 or Hollex 2 (expressing human calcitonin receptor and a CRE-luciferase reporter gene in BHK cells, as described in WO96/31536) or KZ10-20-48/pLJ6-4-25, which expresses the human glucagon receptor and a CRE-luciferase
25 reporter gene in BHK cells. The human glucagon receptor is another member of the G-protein-coupled receptor that transduces signal through adenylate cyclase-mediated elevation of cAMP. PTH can be used as a control as well.

This CRE-luciferase assay measures the end
30 result of a multi-step signal transduction pathway triggered when a calcitonin mimetic stimulates the G-coupled calcitonin receptor. The complexity of this pathway provides multiple mechanisms for induction of luciferase transcription at points that are downstream of
35 the calcitonin receptor, and therefore may not be calcitonin receptor-specific (e.g., forskolin's direct activation of adenylate cyclase). Any response triggered

by non-specific inducers is eliminated by counter screening using the calcitonin receptor-negative cell lines described above.

The foregoing description and the following 5 examples are offered primarily for illustration and not as limitations. It will be readily apparent to those of ordinary skill in the art that the operating conditions, materials, procedural steps and other parameters of the system described herein may be further modified or 10 substituted in various ways without departing from the spirit and scope of the invention. The invention is further illustrated by the following non-limiting examples.

15

EXAMPLES

Example 1Preparation of Calcitonin Mimetics:
Urea of Aniline and L-Leucine Methylamide

20

Preparation of Trityl-leucine amide resin

In the preparation of the urea of aniline and leucine methyl amide, 100 mg of p-methylbenzhydrylamine (MBHA) resin (0.81 meq/g, 100-200 mesh) was contained 25 within a sealed polypropylene mesh packet as used in simultaneous multiple synthesis as described in Houghten, (Proc. Natl. Acad. Sci. USA 82:5131, 1985). Following neutralization (1 min) with 5% diisopropylethylamine (DIEA) in dichloromethane (DCM) (3 x 5 ml), the resin was 30 washed with DCM (3 x 5 ml). The resin packet was added to a solution of tert-butyloxycarbonyl-L-leucine (Boc-Leu) (111 mg, 0.48 meq) and 1-hydroxybenzotriazole (65 mg, 0.48 meq) in dimethylformamide (DMF) (2.4 ml) in a 10 ml polypropylene bottle. Following addition of 2.4 ml 0.2 M 35 diisopropylcarbodiimide (DICI) in DMF, the resin was shaken on a reciprocation shaker for 1.5 h. The resin was then washed with DMF (3 x 5 ml) and DCM (3 x 5 ml). The Boc protecting group was then removed by treatment with

55% trifluoroacetic acid in DCM for 30 min. The resin was then washed with DCM (2 x 5 ml), isopropanol (IPA, 3x5ml), DCM (3 x 5 ml), neutralized with 5%DIEA in DCM (3 x 5 ml), and washed with DCM (2 x 5 ml). The resin packet was then
5 shaken overnight (16h) in 5 ml of 0.1 M trityl chloride in DCM/DMF (9:1) in the presence of DIEA. Completeness of the trityl coupling was verified using the bromophenol blue color test as described in Krchnak et al., (Coll. Czech. Chem. Commun. 53:2542, 1988), and repeated as
10 necessary.

N-Methylation of trityl-leucine amide resin

N-methylation was then performed by treatment of the resin packet with a solution of 3.2 ml 0.5 M lithium
15 t-butoxide (LiOtBu) in THF for 15 min, as described by D'rner, et al., (Bioorg. Med. Chem. 4:709, 1996). Excess base was then removed by decantation, followed by addition of a solution of 0.3 ml methyl iodide in 3.2 ml dimethylsulfoxide (DMSO). The solution was shaken for 2
20 hours at room temperature. The solution was then removed, washed with THF (1 x 5ml) and the LiOtBu/methyl iodide treatment repeated. Following removal of the solution, the resin was washed with DMF (3 x 5 ml), IPA (2 x 5 ml), DCM (3 x 5 ml). The trityl group was removed by two
25 treatments (10 min) with 2% TFA in DCM (5ml). The resin was then washed with DCM (2 x 5 ml), IPA (3 x 5 ml) and DCM (3 x 5 ml).

30 Preparation of the urea of aniline and leucine methylamide resin

The resin packet was neutralized (1 min) with 5% DIEA in DCM (3 x 5 ml), and washed with DCM (2 x 5 ml). The isocyanate of aniline was then performed by slowly adding a solution of aniline (0.176 ml) in DCM (6.5 ml)
35 and DIEA (0.678 ml) dropwise with stirring to a solution of triphosgene (193 mg) in DCM (6.5 ml). The resin packet was added to the isocyanate solution and shaken for 1 hour at room temperature. Following decantation, the resin was

WO 99/37604

PCT/US99/01151

19

washed with DCM (1 x 5 ml), 0.05% NH₃ in DMF (2 x 5 ml), IPA (1 x 5 ml), DCM (1 x 5 ml), and methanol (1 x 5 ml). The resin was then dried under high vacuum overnight.

5 Cleavage of the urea from the resin

The product was cleaved from the resin using 5 ml of anhydrous HF for 1.5 h at 0°C by the procedures of Houghten et al., (Int. J. Pep. Prot. Res. 27:673, 1986). The product was extracted with 50% acetonitrile (ACN)/H₂O (2 x 5 ml) and lyophilized, followed by lyophilization from 50% ACN/H₂O (5 ml). 13.5 mg crude product (85% purity by RP-HPLC) having the expected molecular weight of 263 daltons was obtained.

15 Example 2

This example provides *in vitro*, *ex vivo*, and *in vivo* assays which can be used to evaluate compounds described herein for their use in therapeutic applications.

Assays for Calcitonin Mimetic Activity

CRE-Luciferase Assay Method for Calcitonin Mimetics

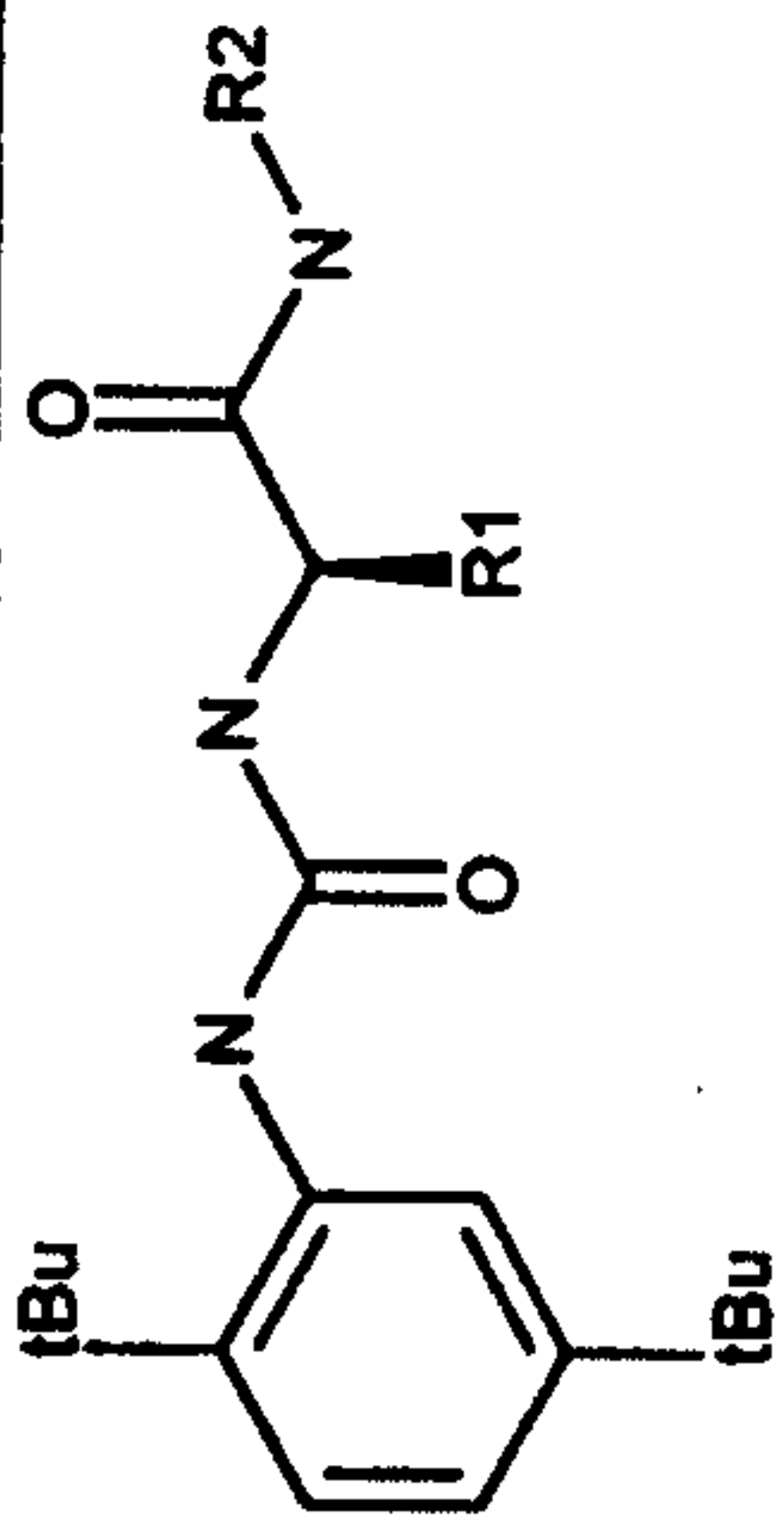
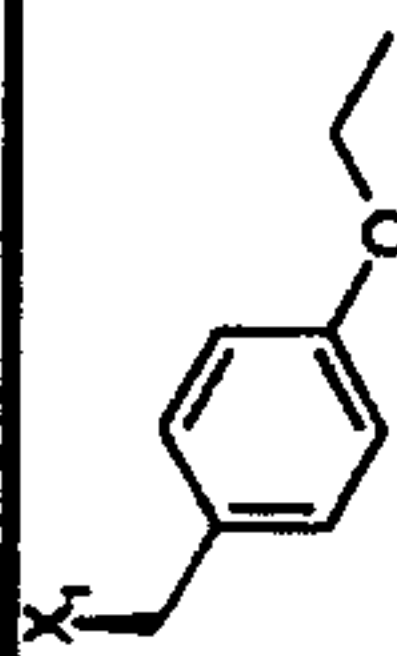
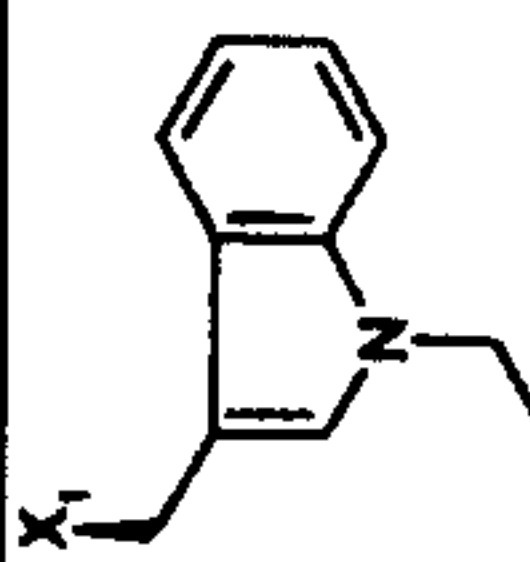
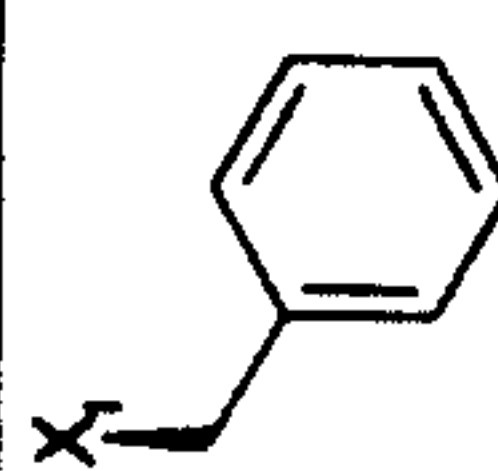
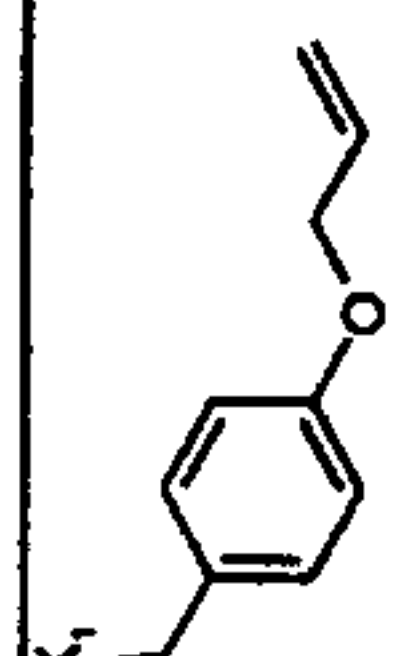
25 Human calcitonin receptor-positive and receptor-negative BHK-570 (Baby Hamster Kidney) cell lines were maintained by serial passage in growth medium (DMEM supplemented with 10% heat-inactivated fetal calf serum (HI-FCS), 2 mM L-glutamine, 1 mM sodium pyruvate, 250 nM MTX, and 1 mg/mL G418). On the day prior to assay, cells were trypsinized, adjusted to 2.5×10^5 cells/ml in growth medium, plated in opaque white Dynatech Microtiter microtiter tissue culture plates at 50 μ L/well, and grown overnight to confluence (37°C, 5% CO₂ atmosphere).

35 Test substances were prepared in DMSO or 10% DMF at 100 times the final desired assay concentration. At the time of assay, test substances were diluted into assay medium to 100, 50, 25, and 12.5 μ g/ml in DMEM supplemented

with 10% HI-FCS, 2 mM L-glutamine, 1 mM sodium pyruvate and 20 mM Hepes, pH 7.25, then 50 μ l/well was added to assay plates for final assay concentrations of 50, 25, 12.5 and 6.25 μ g/ml in 1% DMSO (or 0.1% DMF). Controls
5 were included on each plate: untreated wells (basal), 25 mM forskolin, and 100 nM human calcitonin. DMSO or DMF was included in control wells at a concentration equal to that in test samples (not to exceed a final assay concentration of 2% DMSO or 0.5% DMF, with a preferred maximum of 1%
10 DMSO or 0.1% DMF).

Plates were incubated for 3 to 8 hours (4 hours preferred) at 37°C in an atmosphere of 5% CO₂. Following induction, luciferase activity was measured using a Promega luciferase assay kit (E1500) according to the
15 assay kit protocol (Promega Corp., Madison, WI). Briefly, assay medium was removed and cells were washed once with phosphate buffered saline (PBS). After the wash, 25 μ l of lysis buffer was added to each well, and the plates were incubated for 15 minutes at room temperature. Fifty
20 microliters of Luciferase Assay Substrate (Promega, Corp.) was added to each well and the plates were transferred to a Labsystems Lumiscan microtiter luminometer (Labsystems Inc., Morton Grove, IL). The amount of luminescence (relative light units, RLU) was determined following a 0.1
25 second/well integration of signal. Basal (uninduced) luciferase signal was subtracted from all measurements, and the luciferase signal induced by test samples was expressed as a percentage of the signal in the calcitonin and forskolin controls. Specificity of the luciferase
30 induction for calcitonin receptor-positive cell lines was determined by comparing the percent control values in the calcitonin receptor-positive line (Hollelex-1) to those observed in the calcitonin receptor-negative cell line (KZ10-20-48/Zem 228) and the PTH receptor-positive cell
35 line (KZ10-20-48/PTH-20) described below. Samples inducing a signal over the basal level were selected for further characterization, see Table 1 for examples.

Table 1 Luciferase induction (% of maximum luciferase induction produced by CT, 100 nM)

		Crude µg/ml					
TPI #	R1	R2	50	25	12.5	6.25	3.125
628-007			31.73	55.34	31.97	10.61	0.76
628-008			50.39	50.93	20.07	2.91	-1.31
628-013			64.26	69.62	51.62	17.98	3.51
628-015			71.49	72.17	43.2	14.69	1.62

WO 99/37604

PCT/US99/01151

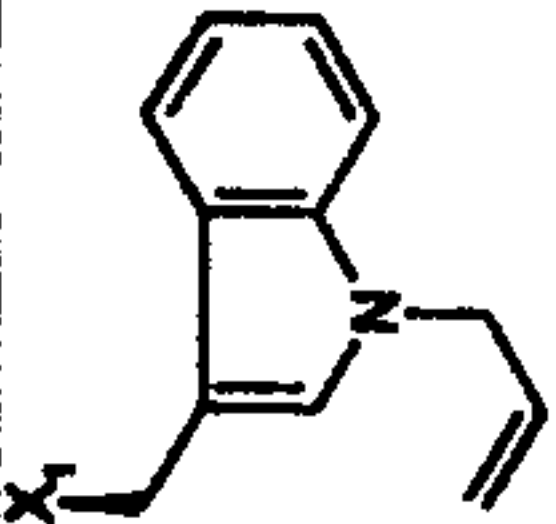
628-016			75.76	80.63	76.44	43.89	10.72
---------	---	---	-------	-------	-------	-------	-------

Table 1 cont.

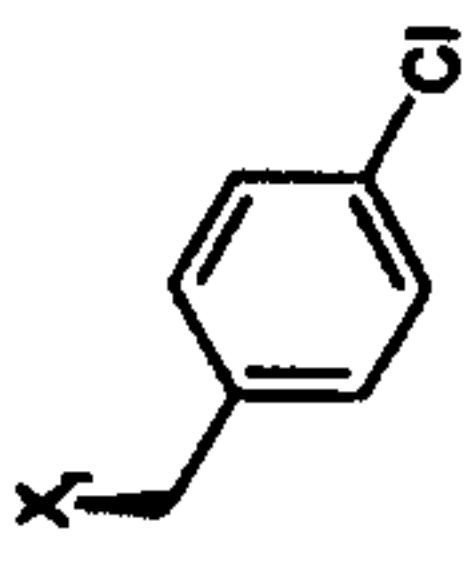
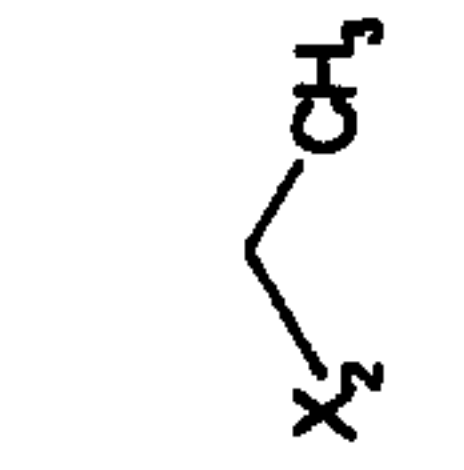
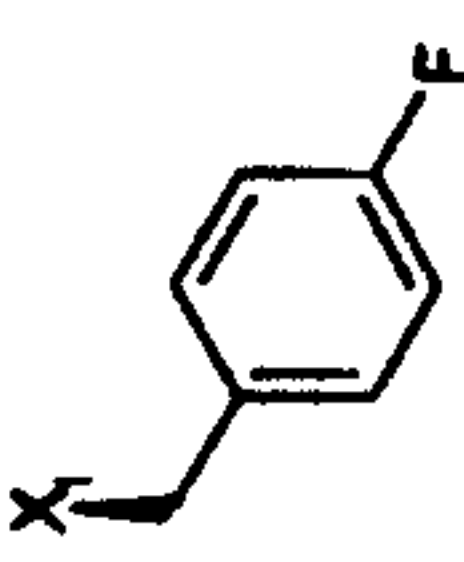
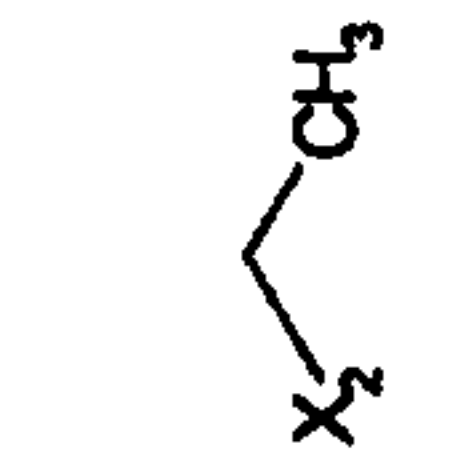
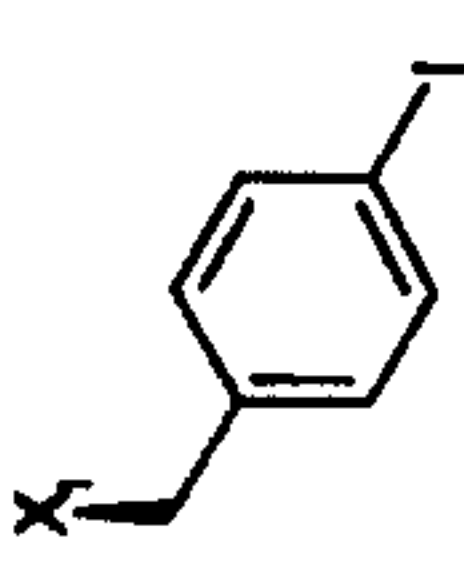
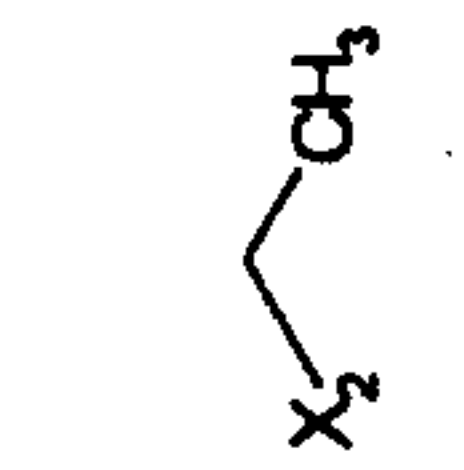
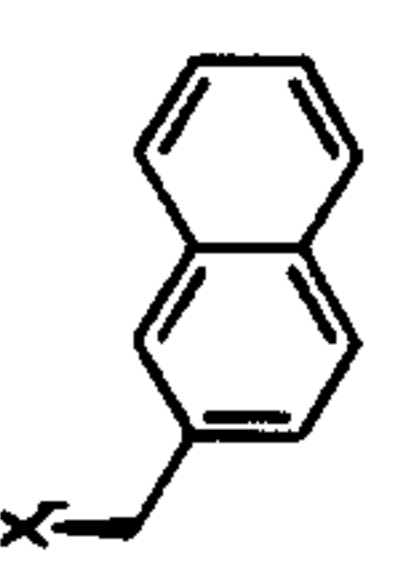
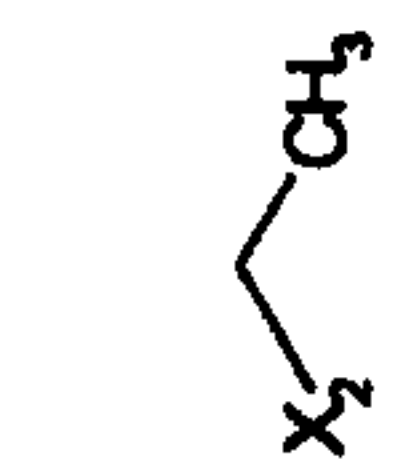
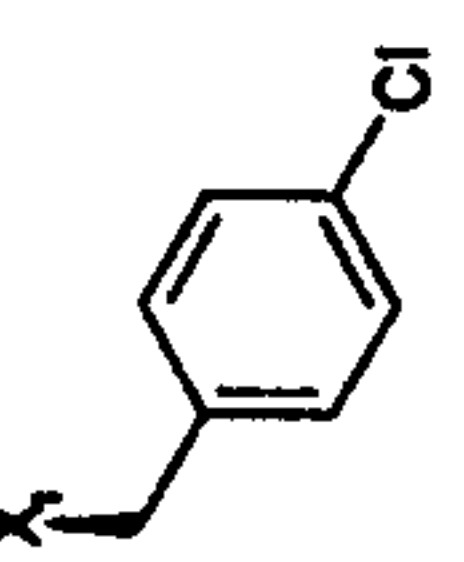
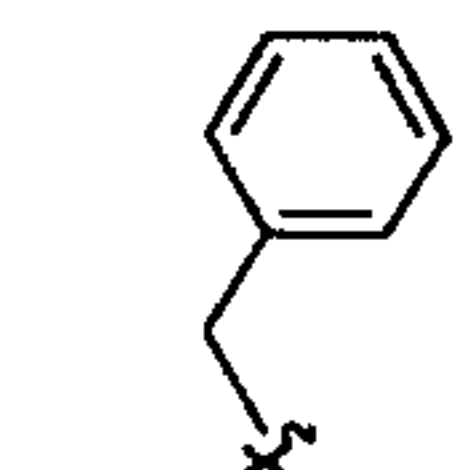
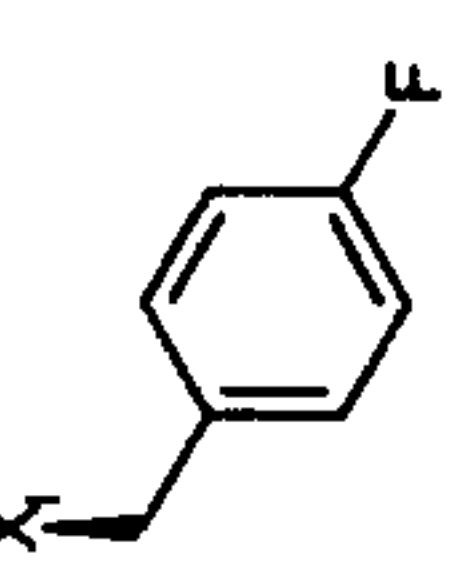
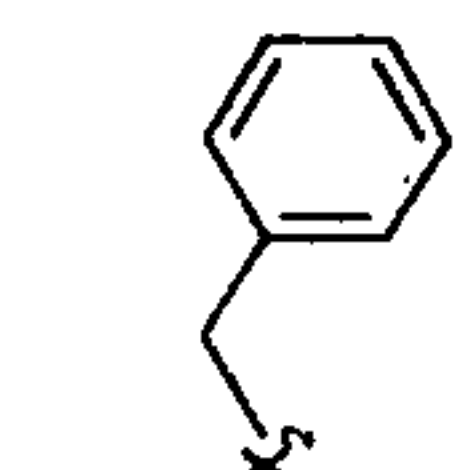
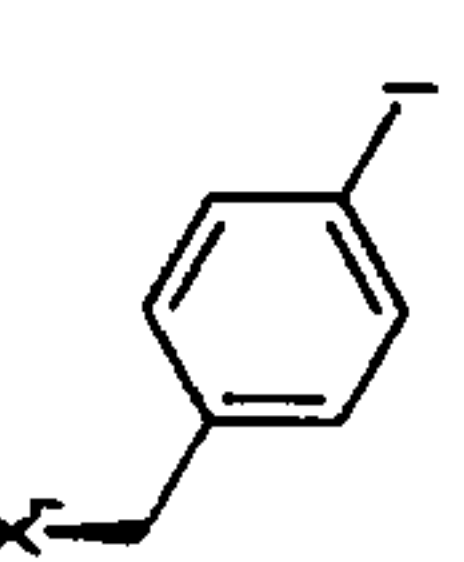
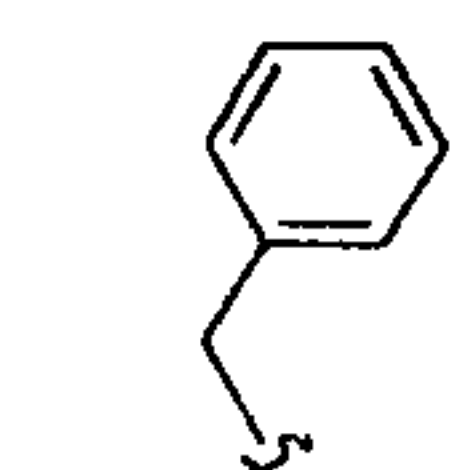
628-022			46.98	41.52	17.85	3.26	2.08
628-023			41.79	46.84	32.04	7.84	-0.46
628-024			30.25	22.64	11.8	1.39	-1.24
628-025			22.61	7.96	2.33	0.65	0.42
628-042			60.41	68.69	59.74	49.17	19.16
628-043			47.95	46.24	42.06	34.53	6.48
628-044			30.14	26.23	29.35	24.08	10.65

Table 1 cont.

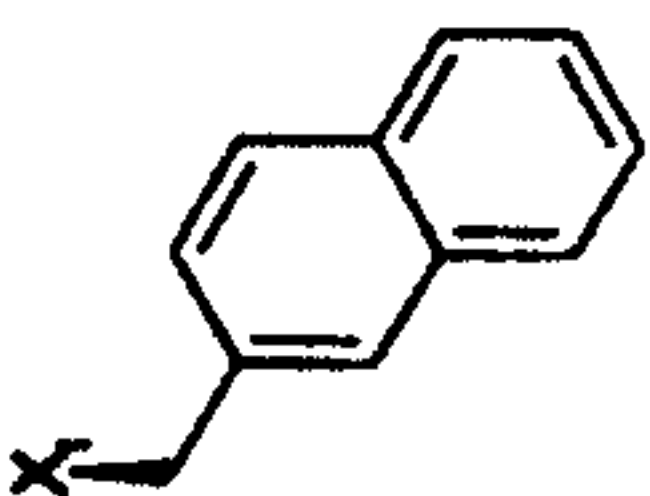
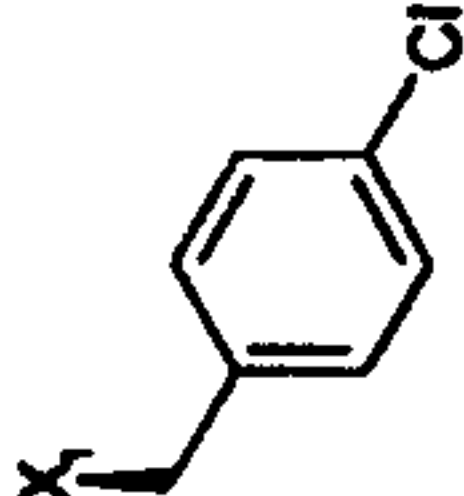
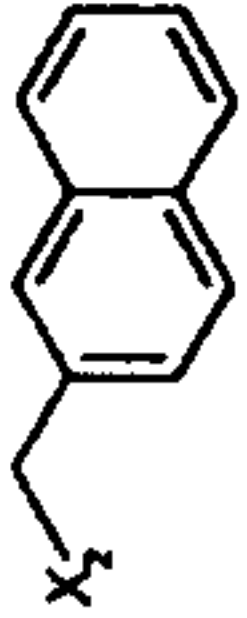
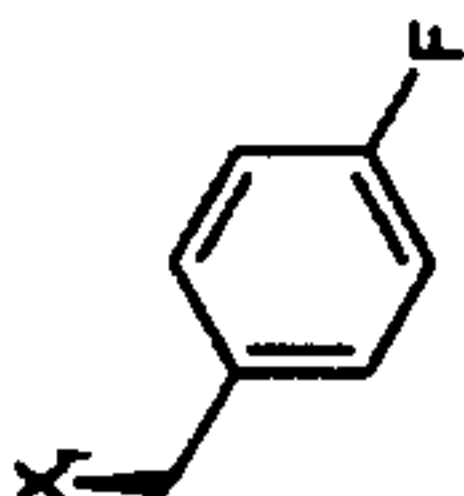
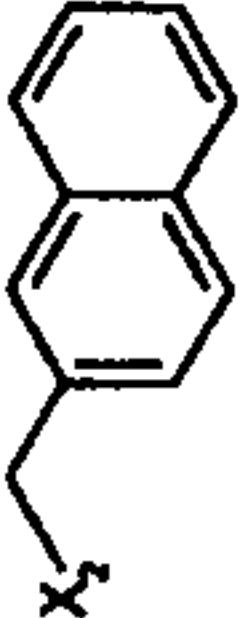
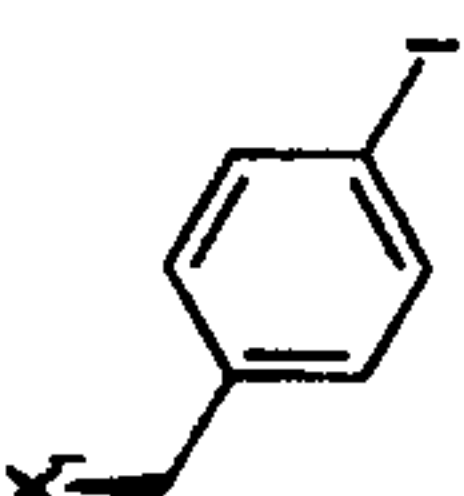
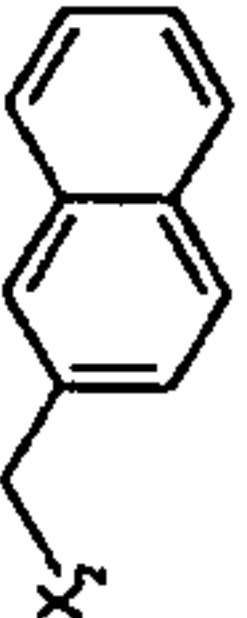
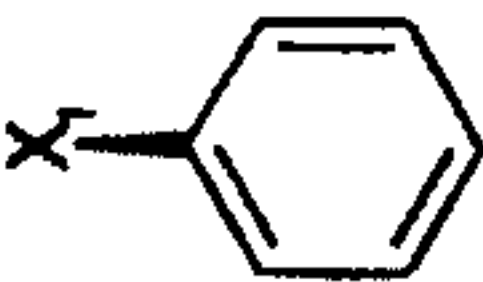
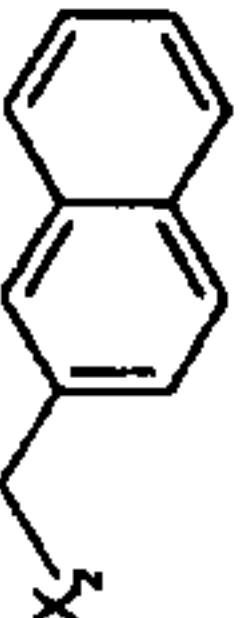
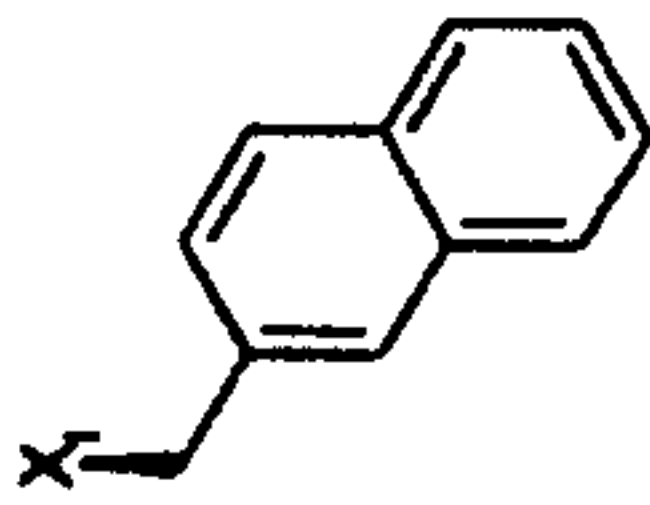
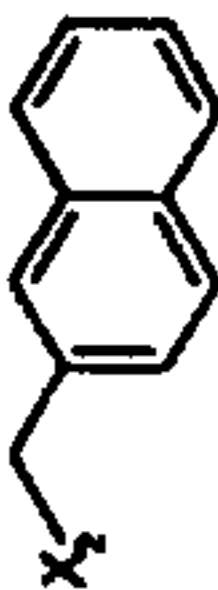
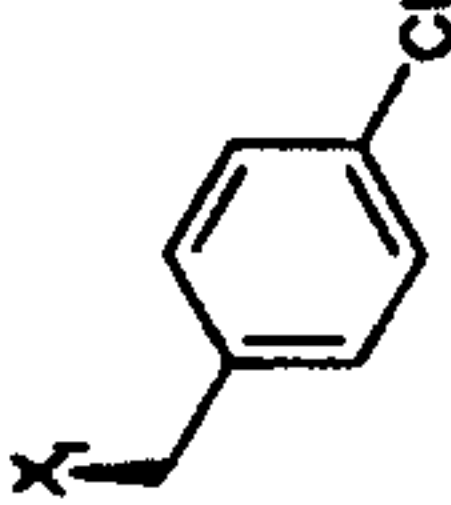
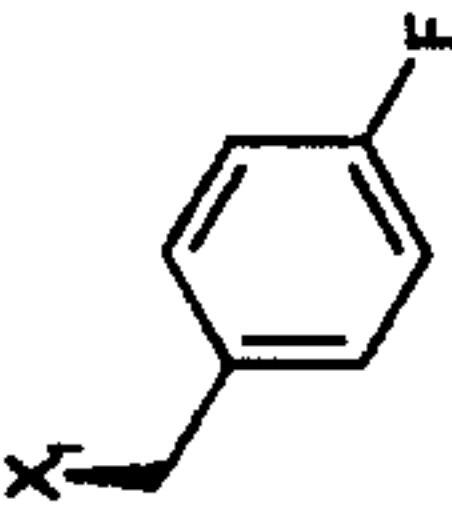
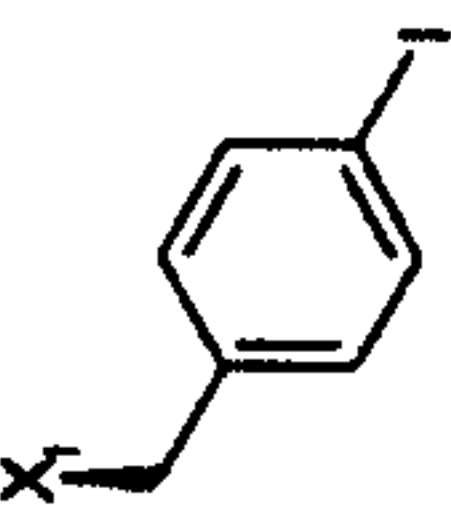
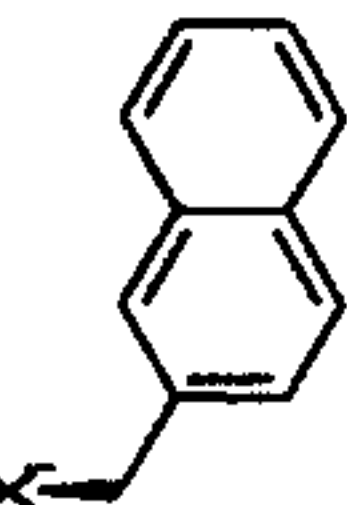
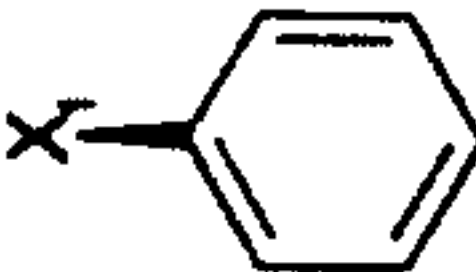
628-045			40.62	44.51	42.49	38.73	20.19
628-052			38.27	40.21	36.63	23.59	9.57
628-053			40.14	41.8	32.31	11.89	3.29
628-054			54.86	47.47	42.54	27.05	10.73
628-056			37.1	35.6	28.6	14.7	4.2

Table 1 cont.

TPI #	R1	R2	Purified µg/ml			
628-055			48.69	43.3	35.48	24.81
628-032			33.94	31.34	27.28	25.42
628-033			33.62	31.63	27.68	14.71
628-034			38.68	33.86	25.02	6.89
628-035			52.27	46.43	43.25	34.84
628-036			10.38	8.0	6.43	4.12

Test substances that appear to specifically elevate luciferase expression in CT-R positive cells but not CT-R negative cells were subjected to an additional specificity check, i.e. their inability to activate other members of the G-protein coupled receptor family. The parathyroid hormone (PTH) receptor is another member of the G-protein coupled receptor family that transduces signal through adenylate cyclase mediated elevation of cAMP. The receptor negative CRE-luciferase/DHFR expressing BHK570 clone (KZ10-20-48) was transfected with the plasmid phupthr.2, encoding the cloned human PTH receptor in plasmid pHZ-1 which also contains the G418 selectable marker. Stable transfectants were selected in 250 nM MTX + 1 mg/ml G418 and were screened for CRE-luciferase induction in response to 25 mM forskolin or 100 nM human PTH (Sigma) (as described in WO96/31536). Clone KZ10-20-48/PTH-20 was selected for use in specificity confirmation. This clone exhibits a 25 fold induction of luciferase in response to human PTH ($EC_{50} = 0.02$ nM) or forskolin ($EC_{50} = 2.0$ μ M).

20

Calvarial Assay

Calvaria from 4-day old neonatal CD-1 mice (pregnant mice received from Charles River Laboratories, Wilmington, MA) were trimmed with fine-tipped scissors to leave the parietal regions, including the sagittal suture. These trimmed bones were placed singly per well into 6-well cell culture cluster plates (Costar, Pleasanton, CA) with 1 ml/well of Dulbecco's Minimum Essential Medium, 4.5 μ g/ml glucose (DMEM, BioWhittaker, Walkersville, MD) or Basal Eagle's Medium with Earle's salts (EMEM, Gibco/BRL, Grand Island, NY) and 0.29 mg/ml L-glutamine, 1 mM sodium pyruvate, 15% heat-inactivated horse serum, and antibiotics (penicillin-G 50 μ g/ml, streptomycin 50 μ g/ml, and neomycin 100 μ g/ml). Calvaria were rocked gently (RedRocker™, model PR50-115V, Hoefer, San Francisco, CA or Labline Rocking Shaker, model 4635, Labline Instruments, Melrose Park, IL)

at 37°C in a 5% CO₂ humidified incubator for 24 hours preincubation.

Following preincubation, medium was removed and replaced with 1.5 ml/well of growth medium containing 1 nM parathyroid hormone (PTH) 1-34 (Sigma) to stimulate bone resorption. For evaluation of the ability of calcitonin mimetics to inhibit PTH induced bone resorption, mimetic compounds in DMSO were added to the growth medium at concentrations ranging from 1-400 µg/ml (final assay concentration of DMSO less than or equal to 1%). In each experiment human calcitonin (0.02-20nM, 0.2-2nM preferred) was added to PTH treated bones as a positive control. Control wells that did not receive PTH, human calcitonin or calcitonin mimetic were included for determination of calcium release from untreated bones. All control wells contained a final assay concentration of DMSO equal to that present in calcitonin mimetic treated wells.

Five bones were included in each sample group. Bones were incubated for 72 hours following PTH addition to allow resorption of bone to occur. Observations were made of the general appearance, healthiness and number of cells that migrate from the calvaria during the incubation as a possible indication of cell toxicity. Calvaria to be examined histologically were transferred to glass scintillation vials containing 10 ml of 10% neutral buffered formalin.

The medium was removed from the wells, and total calcium measurements were made using a Nova 7/7+7 Electrolyte Analyzer or Nova CRT 10 analyzer (Nova Biomedical, Waltham, MA) according to the manufacturer's specifications. Induction of bone resorption by PTH is seen as an increase in the concentration of calcium in the growth medium due to degradation of the bone matrix. Human calcitonin and biologically active calcitonin mimetics inhibit this bone resorptive process as demonstrated by a lowering of the calcium in growth medium as compared to bones treated with PTH alone.

Calvaria Histology

To confirm the findings in the calvarial bone resorption assay employing calcium release from culture mouse calvariae, selected bones were fixed in 10% neutral buffered formalin and demineralized in 5% formic acid with 5% formalin. The bones were dehydrated through an ascending series of ethanol concentrations, infiltrated in glycol methacrylate, and embedded using a JB-4 embedding kit (PolySciences, Warrington, PA) (Liu, et al., J. Bone Mineral Res. 5:973-82, 1990). When necessary, an alternative embedding method (paraffin embedding) was used to speed up the embedding process. Cross sections of calvariae cut at 5 μ m were obtained and stained for tartrate-resistant acid phosphatase (TRAP) activity and counterstained with methyl green and thionin for cell morphology (Liu, et al., ibid.). Osteoclasts were identified by TRAP stain, multinucleation, large cell size, and irregular cell shape. The number of osteoclasts were counted from endocranial and ectocranial bone surfaces and expressed as number/mm perimeter. The size of all the osteoclasts counted was also measured using a Bone Morphometry program (Liu, et al., ibid.; Bain, et al., J. Bone Miner. Res. 8:435-42, 1993). This histomorphometric method demonstrated increases in the number and size of osteoclasts due to human parathyroid hormone (PTH 1-34) treatment. This PTH-induced increase was suppressed by treatment with human calcitonin.

Calcitonin mimetic compounds were evaluated in a similar fashion for their ability to suppress PTH-induced increases in osteoclast number and size (Table 2). Cell toxicity (or death) was also evaluated by the appearance of pyknotic nuclei in a small number of bone cells. With an increased level of toxicity, a further increase in the number of these pyknotic nuclei, detachment of cells from bone surfaces, and losses of cytoplasmic stain and cell

WO 99/37604

PCT/US99/01151

29

boundaries were observed. The osteocytic space also appeared empty.

TABLE 2: Effect of Calcitonin Mimetics on PTH-Induced Bone Resorption in Mouse Calvariae Release of PTH Induced Ca⁺⁺

	<u>Calcitonin Mimetic</u>	<u>IC50</u> (µg/ml)	<u>Histology</u>
10	628-033	30	Decreases in bone destruction by PTH, Oc size and #
	628-035	23	Decreases in bone destruction by PTH, Oc size and #
15	628-055	14	Decreases in bone destruction by PTH, Oc size and #

20 Oc = Osteoclast

For comparative purposes, the IC50 for human calcitonin is about 0.2 to 0.5 nM.

25 There was no apparent toxicity or tissue necrosis detected based on histological observation of calvaria treated with up to 50 ug/ml of compound.

Induction of hypocalcemia in rats

30 This assay is based on the *in vivo* acute effect of calcitonin on osteoclasts, which causes rapid retraction of osteoclasts from bone surface (typically within 30 minutes) and which results in decreased bone resorption. See Mills, et al., in *Endocrinology* 1971 - Proceedings of the Third International Symposium, Taylor (ed), Heinemann Medical, London, pp. 79-88 (1972) and Singer, et al., Clin. Endocrinol. 5(Supp):333s-40s, 1976. The assay method was modified from the method described by Sturtridge and Kumar, Lancet 545:725-6, 1968. For the assay of hypocalcemic activity, weanling male Holtzman Sprague-Dawley rats (22 days old) are infused with vehicle (PBS with 1 mM HCl and 0.1% BSA), calcitonin or calcitonin mimetics through the

tail vein. One hour later, blood samples are collected by orbital sinus puncture to determine serum levels of calcium. A decrease in serum calcium indicates a hypocalcemic response. The hypocalcemic response is dose-dependent as determined using salmon calcitonin (0.5, 2.5, 5, 50 and 100 ng/rat) in this model.

Inhibition of PTH-induced hypercalcemia in TPTX rats

Continuous PTH infusion is associated with extensive destruction and severe hypercalcemia in thyroparathyroidectomized (TPTX) rats. See Thompson, et al., Proc. Natl. Acad. Sci. USA 85:5673-7, 1988. An animal model has been successfully established. See Liu, et al., J. Bone Mineral Res. 11 (Suppl. 1):S206, 1996. For *in vivo* assay, male Sprague-Dawley rats (weighing about 150 g) are thyroparathyroidectomized and the success of surgery is determined by measuring the levels of serum calcium. Animals which are successfully operated on (serum calcium levels less than 8 mg/dl) are maintained on a low calcium diet (0.02% Ca and 0.6% P, ICN special diet) and infused s.c. with vehicle (PBS with 1 mM HCl and 0.1% BSA), PTH (75 ug human PTH 1-34/kg body weight/day), PTH + calcitonin (salmon calcitonin 50 U/kg body weight/day), or PTH + calcitonin mimetic via Alzet osmotic minipumps (Model 1003D, Alza Corp., Palo Alto, CA). Two days after infusion, animals are sacrificed and blood samples are collected to determine if the hypercalcemic response induced by PTH is inhibited by co-administration of calcitonin or calcitonin mimetic. Additionally, tibial and kidney samples are collected to determine osteoclastic bone resorption and nephrocalcinosis, respectively, and to confirm the findings in serum chemistry. Severe hypercalcemia induced by PTH has been shown to be accompanied by increases in the number and size of osteoclasts, extensive bone destruction, and calcification in kidneys (nephrocalcinosis) following only two days of

treatment (see, Liu, et al., ibid.). The serum, bone and kidney changes were attenuated by co-administration of CT.

5 Bone loss induced by combined ovariectomy and immobilization in rats

Estrogen deficiency and immobilization both induce bone loss in humans and in experimental animals. The combined effects cause severe osteopenia. See, Strachan, et al., J. Bone Mineral Res. 11(Suppl. 1):S456, 10 1996. A few studies have also shown that calcitonin is effective at reducing bone loss associated with combined ovariectomy and immobilization. See, Hayashi, et al., Bone 10:25-8, 1989 and McSheehy, et al., Bone 16:435-44, 1995. Slightly modified procedures were recently used to 15 reproduce those results and demonstrate that calcitonin is very effective at reducing bone loss associated with the combined surgery, when evaluated by pQCT or histomorphometry in rats (see, Strachan, et al., ibid.).

For induction of bone loss, 2-month old Sprague- 20 Dawley rats (weighing about 200 g) are ovariectomized and immobilized by neurotomy of the sciatic nerve in the left hind limb. The immobilized animals are treated with vehicle (PBS with 1 mM HCl and 0.1% BSA), calcitonin (15 U/kg body weight/day), or calcitonin mimetics for 6 weeks. 25 Calcein injections (15 mg/kg body weight/day) are given i.p. at 9 and 2 days prior to sacrifice. Bone histomorphometry is performed as previously described (see, Liu, et al., J. Bone Mineral Res. 5:973-82, 1990) to determine the effects of calcitonin and calcitonin 30 mimetics.

Calvarial Assay to Determine Calcitonin Escape

Calvaria from 4-day old neonatal CD-1 mice (pregnant mice received from Charles River Laboratories) 35 are trimmed with fine-tipped scissors to leave the parietal regions, including the sagittal suture. These trimmed bones are placed singly per well into 6-well culture

cluster plates (Costar) with 1 ml/well of growth medium, (Eagle's with Earle's salts (GIBCO BRL) containing 4.5 g/l glucose, 0.29 mg/ml L-glutamine, 1mM sodium pyruvate, 15% heat-inactivated horse serum, antibiotics (penicillin-G 50 µg/ml, streptomycin 50 µg/ml, and neomycin 100 µg/ml) and 5 nM parathyroid hormone (PTH) 1-34 (Sigma)), and rocked gently (RedRocker™) at 37°C in a 5% CO₂ humidified incubator for 17.5 hours preincubation. The concentration of PTH is chosen to insure maximum resorption.

Following preincubation, medium is removed and replaced with 1 ml/well of growth medium, as above, containing 20 or 30 µg/ml of the calcitonin mimetic in DMSO (final assay concentration of DMSO less than or equal to 1%). Positive controls which can be used include, growth medium containing 0.5, 1.0, 5.0 or 10 nM human calcitonin (hCT) and/or 0.01, 0.02, 0.05 or 0.2 nM salmon calcitonin (sCT). Control wells that do not receive PTH, human or salmon calcitonin or the calcitonin mimetic are included for determination of calcium release from untreated bones. All control wells contain a final assay concentration of DMSO equal to that present in the calcitonin mimetic treated wells.

Five bones are included in each sample group. Bones are incubated for 4, 8, 11, 24, 50.5, 72.5 and 98 hours. At each time point the media is removed and fresh dilutions of compound in media are added to the calvaria. After the media is removed, total calcium measurements are made using a Nova 7/7+7 Electrolyte Analyzed (Nova Biomedical) according to the manufacturer's specifications. Induction of bone resorption by PTH is seen as an increase in the concentration of calcium in the growth medium due to degradation of the bone matrix.

Human and salmon calcitonin and biologically active calcitonin mimetics inhibit the bone resorptive process as demonstrated by a lowering of the calcium in growth medium as compared to bones treated with PTH alone. The inhibitory effect of hCT and sCT is lost after a period

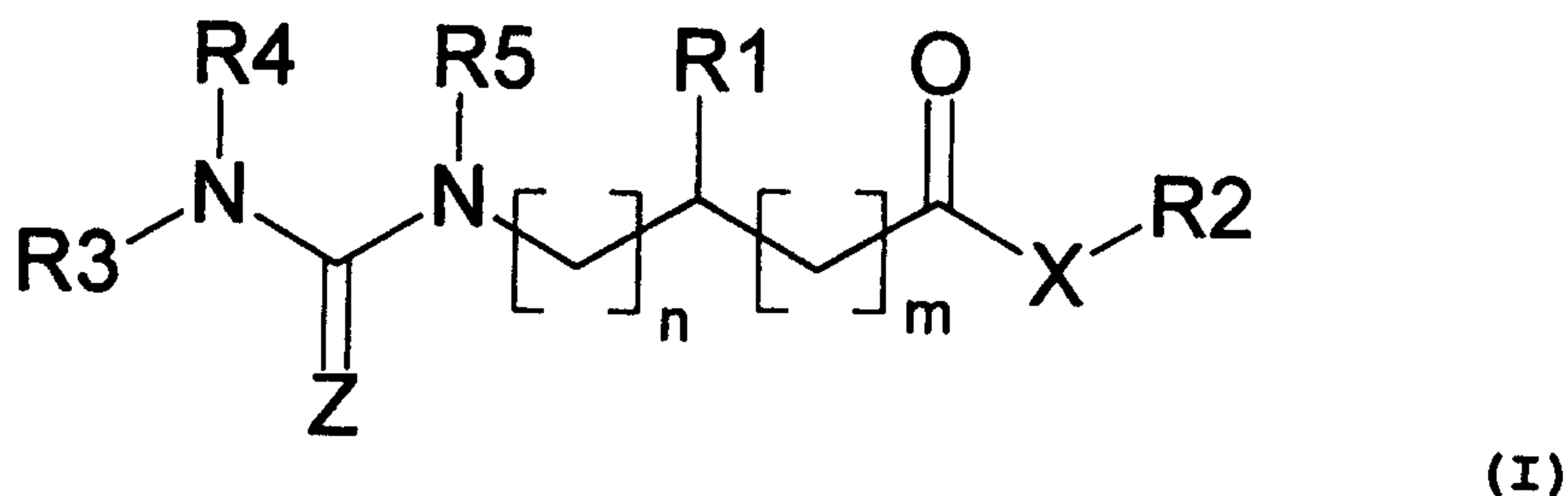
of time, generally 24 hours, and the rate of resorption follows the same slope as that of PTH alone. Those mimetic compounds which do not have this escape will be able to continue inhibition of resorption for a longer period of
5 time. Calvaria can also be observed, as described above, at each time point for signs of inhibition and signs of toxicity.

From the foregoing, it will be appreciated that, although specific embodiments of the invention have been
10 described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

What is claimed is:

1. A compound of formula I:



wherein

R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R3 is a 2,5 disubstituted aryl;

R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6 carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings;

Z and X are each independently selected from the group NH, O, S, or NR, wherein R is a lower alkyl group of from 1 to 6 carbon atoms; and

n and m are each independently an integer from 0 to 6.

2. A compound according to claim 1 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl,

wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are hydrogen;

Z is O; and

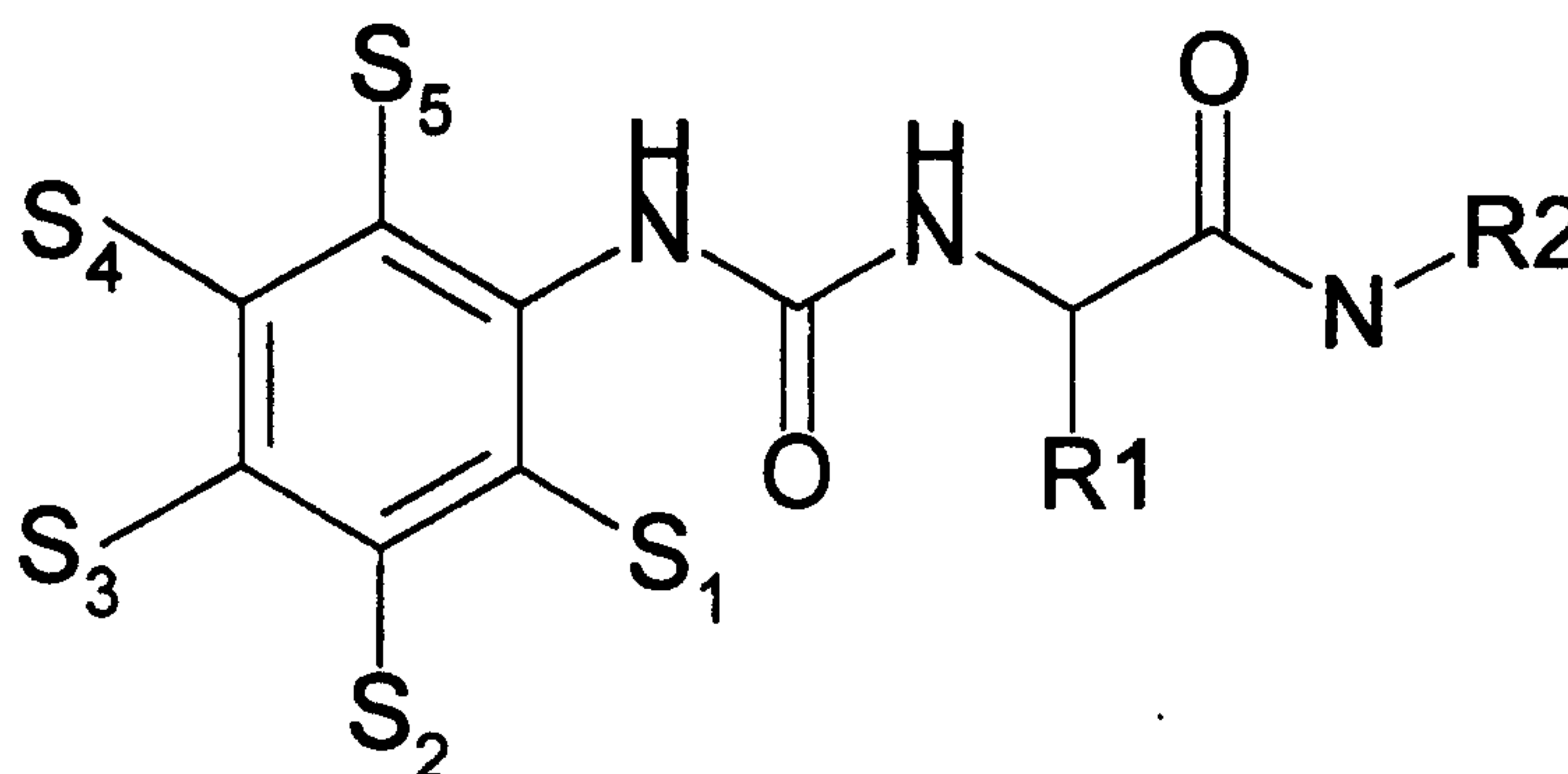
X is NH.

3. A compound according to claim 2 wherein

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl.

4. A compound according to claim 1 having the formula:



wherein,

R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon

atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

S1, S3 and S4 are each independently selected from the group consisting of hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S2 and S5 are each independently alkyl or aryl.

5. A compound according to claim 4 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S2 and S5 are t-butyl,.

6. A compound according to claim 5 wherein,

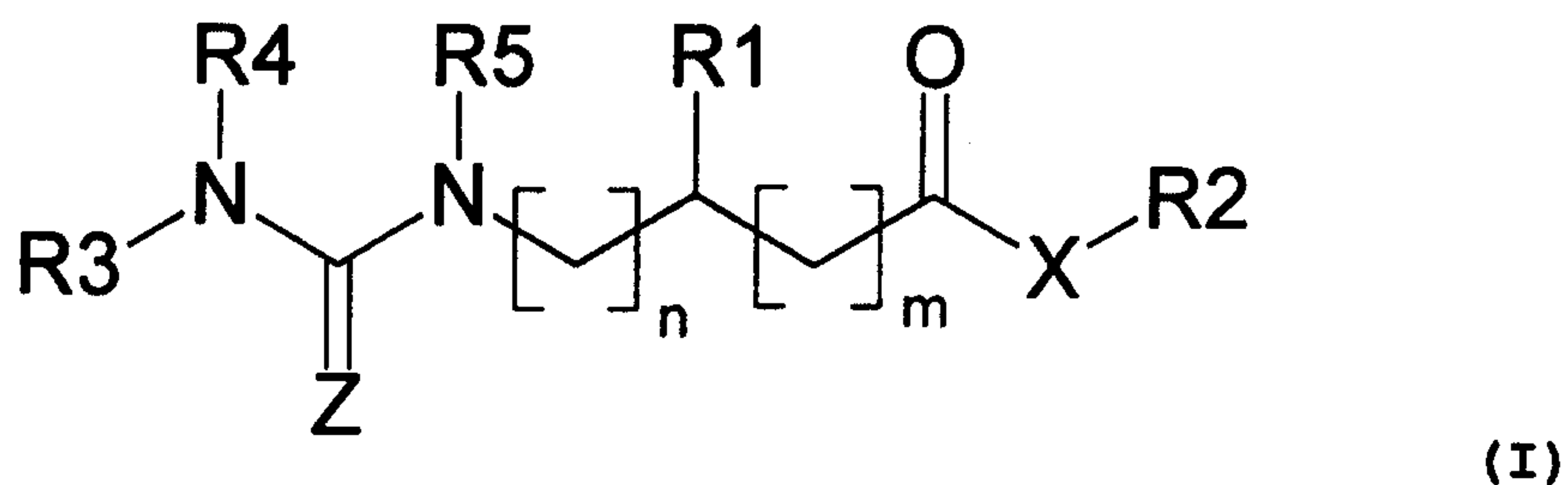
R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl;

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl;

and

S2 and S5 are t-butyl.

7. A pharmaceutical composition comprising an effective amount of a compound having the formula:



wherein

R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R3 is selected from the group consisting of hydrogen, aryl, substituted aryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6 carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member

rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings;

Z and X are each independently selected from the group NH, O,

S, or NR, wherein R is a lower alkyl group of from 1 to 6 carbon atoms; and

n and m are each independently an integer from 0 to 6, in a pharmaceutically acceptable carrier.

8. A pharmaceutical composition according to claim 7, wherein

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are hydrogen;

Z is O; and

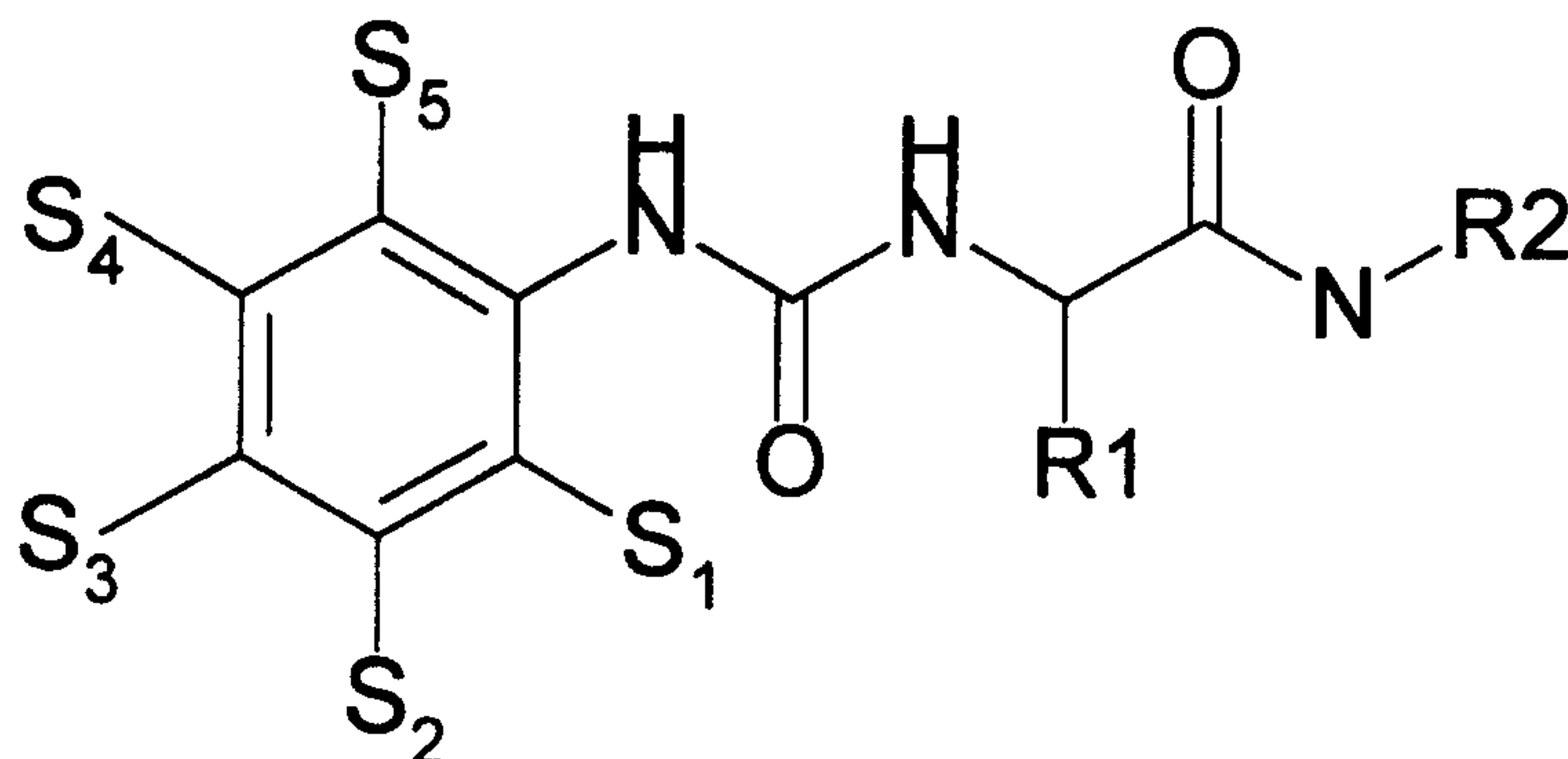
X is NH.

9. A pharmaceutical composition according to claim 8 wherein,

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl.

10. A pharmaceutical composition according to claim 7 wherein said compound has the formula:



wherein,

R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S1, S2, S3, S4 and S5 are each independently selected from the group consisting of hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl.

11. A pharmaceutical composition according to claim 10, wherein

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S2 and S5 are t-butyl.

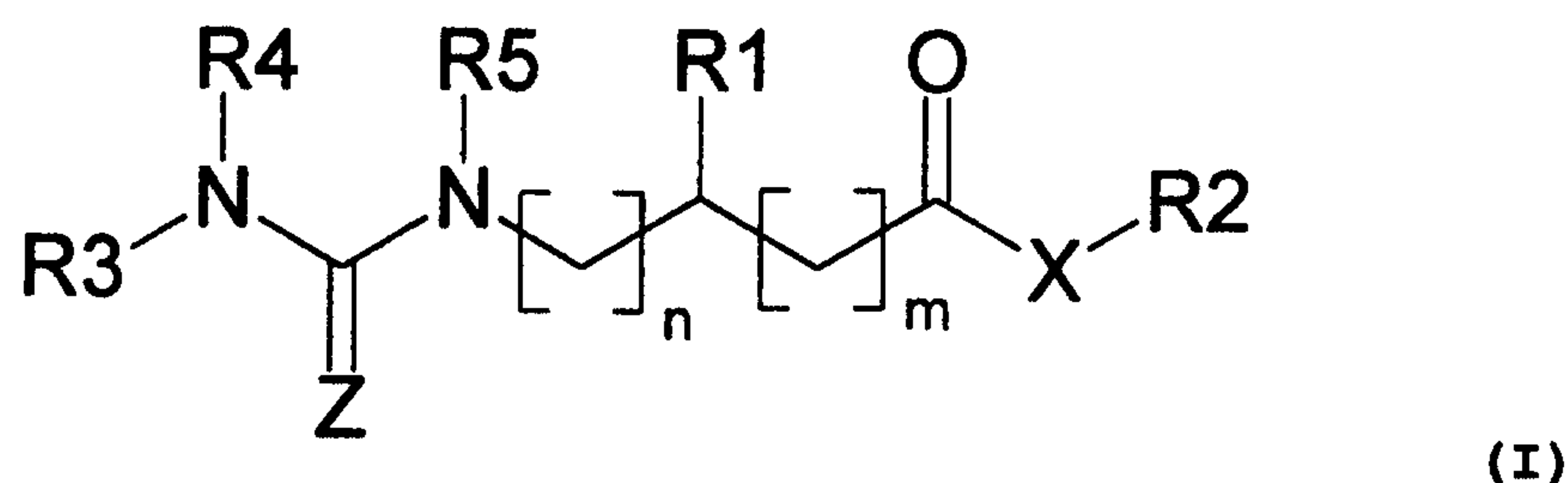
12. A pharmaceutical composition according to claim 10, wherein

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl;

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl; and

S2 and S5 are t-butyl.

13. A method for treating a bone-related disorder, comprising administering to a subject suffering from such disorder an effective amount of a calcitonin mimetic of formula I:



wherein

R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy,

haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R3 is selected from the group consisting of hydrogen, aryl, substituted aryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6 carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings;

Z and X are each independently selected from the group NH, O, S, or NR, wherein R is a lower alkyl group of from 1 to 6 carbon atoms; and

n and m are each independently an integer from 0 to 6.

14. A method according to claim 13 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are hydrogen;

Z is O; and

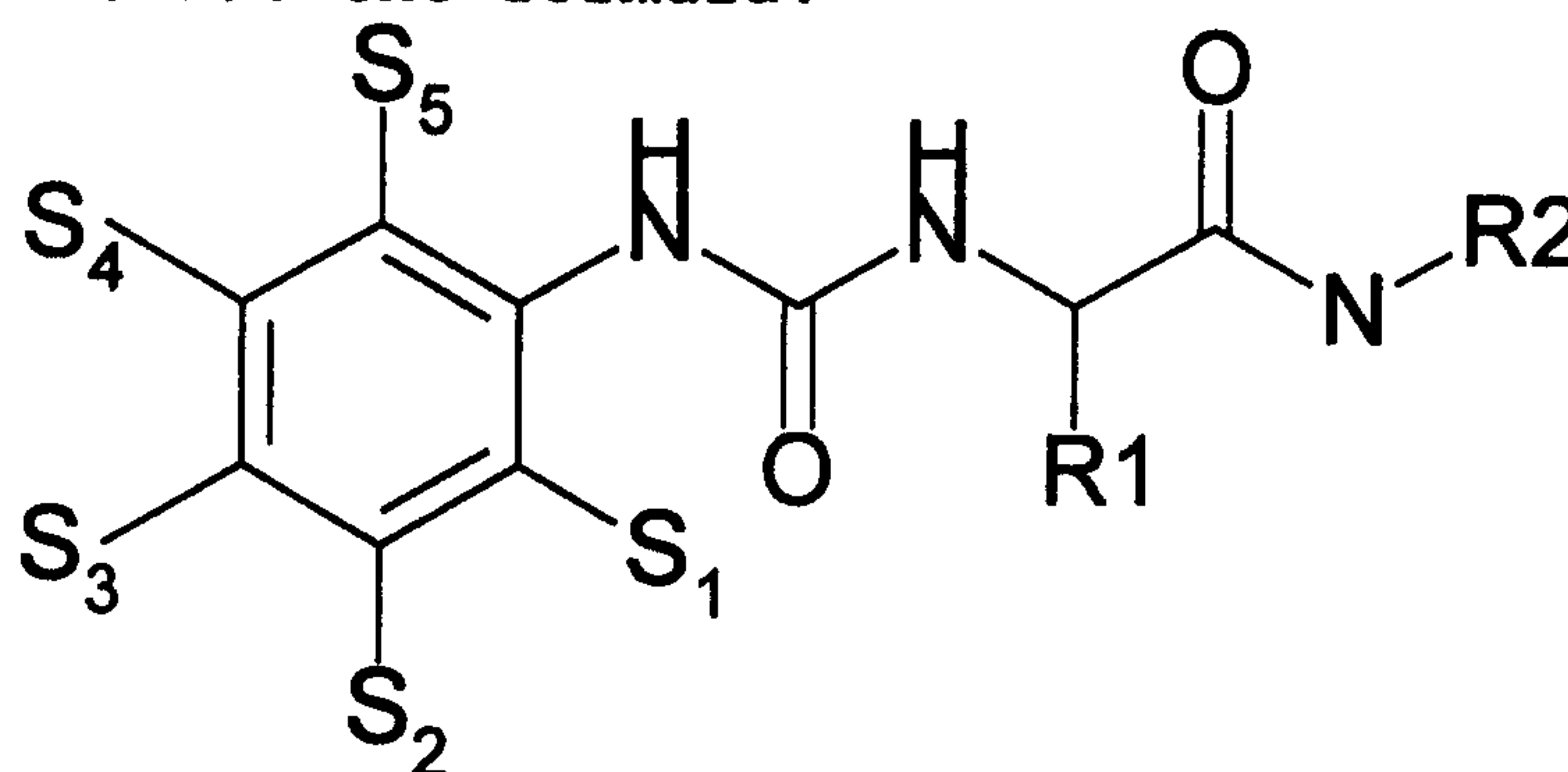
X is NH.

15. A method according to claim 14 wherein

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl.

16. A method according to claim 13, wherein said calcitonin mimetic has the formula:



wherein,

R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S1, S2, S3, S4 and S5 are each independently selected from the group consisting of hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl.

17. A method according to claim 13 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S2 and S5 are t-butyl.

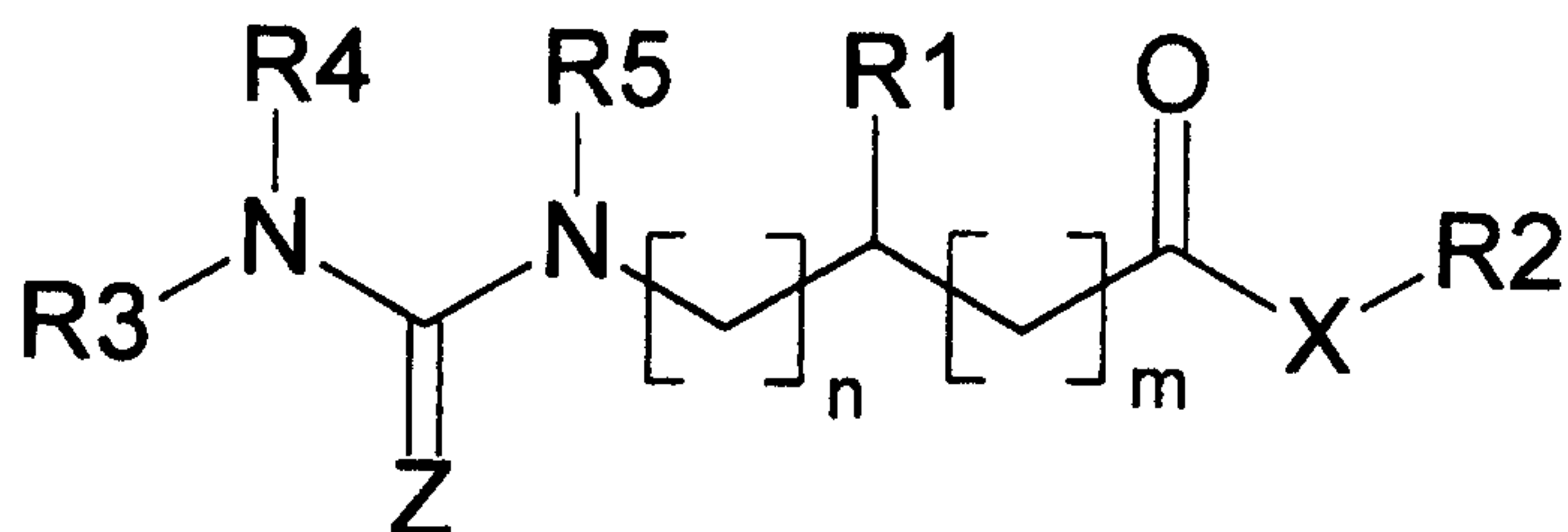
18. A method according to claim 17 wherein,

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl;

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl; and
S2 and S5 are t-butyl.

19. A method according to claim 13, wherein the bone-related disorder is selected from the group consisting of osteoporosis, Paget's disease, hyperparathyroidism, osteomalacia, periodontal applications (bone loss), hypercalcemia of malignancy and hypercalcemia of infancy.

20. A method of inhibiting bone resorption comprising administering to a subject in need of such inhibition an effective amount of a calcitonin mimetic of formula I:



(I)

wherein

R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R3 is selected from the group consisting of hydrogen, aryl, substituted aryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6 carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings;

Z and X are each independently selected from the group NH, O, S, or NR, wherein R is a lower alkyl group of from 1 to 6 carbon atoms; and

n and m are each independently an integer from 0 to 6.

21. A method according to claim 20 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are hydrogen;

Z is O; and

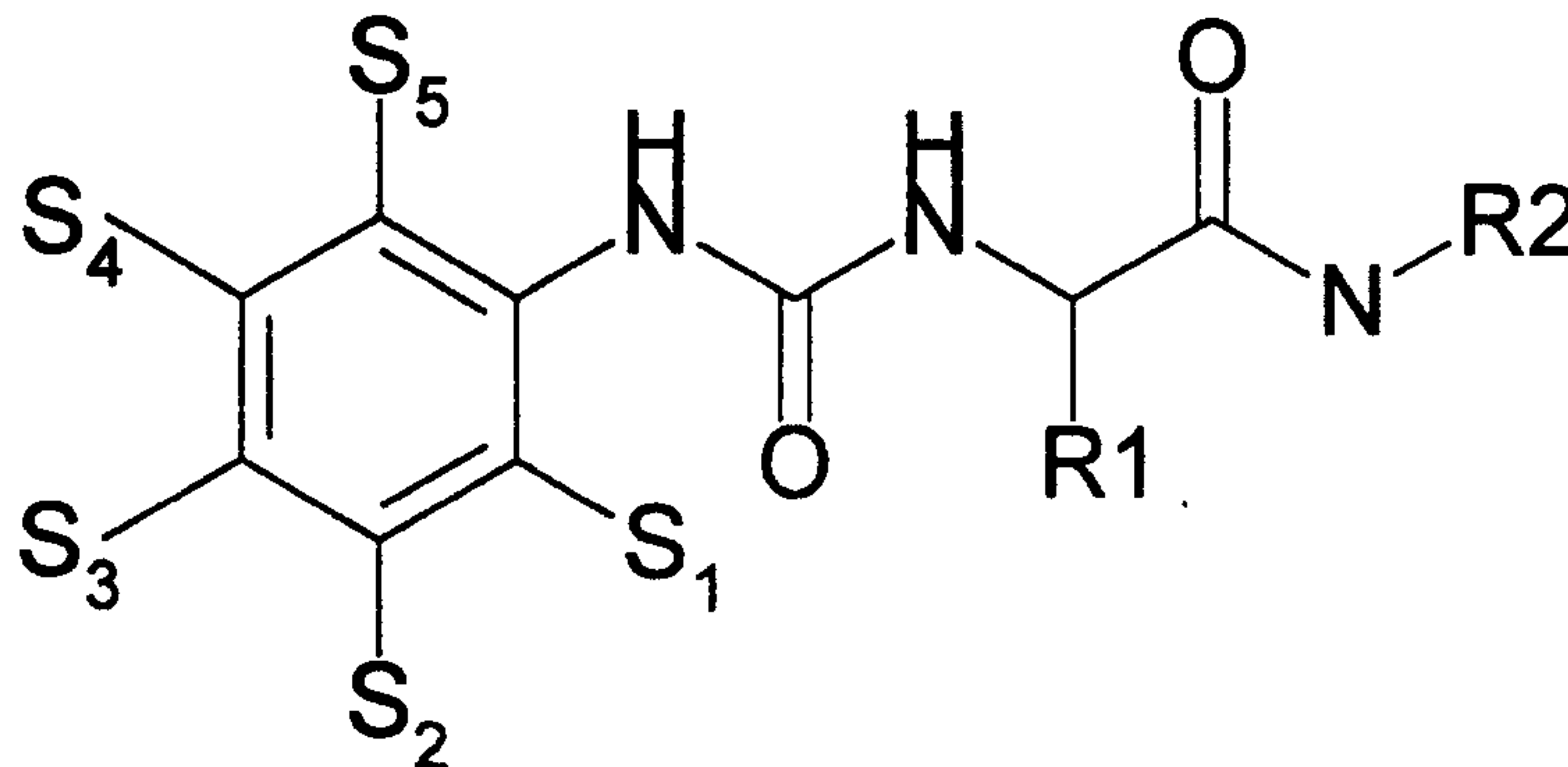
X is NH.

22. A method according to claim 20 wherein

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl.

23. A method according to claim 20, wherein said calcitonin mimetic has the formula:



wherein,

R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S1, S2, S3, S4 and S5 are each independently selected from the group consisting of hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl.

24. A method according to claim 23 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls having from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

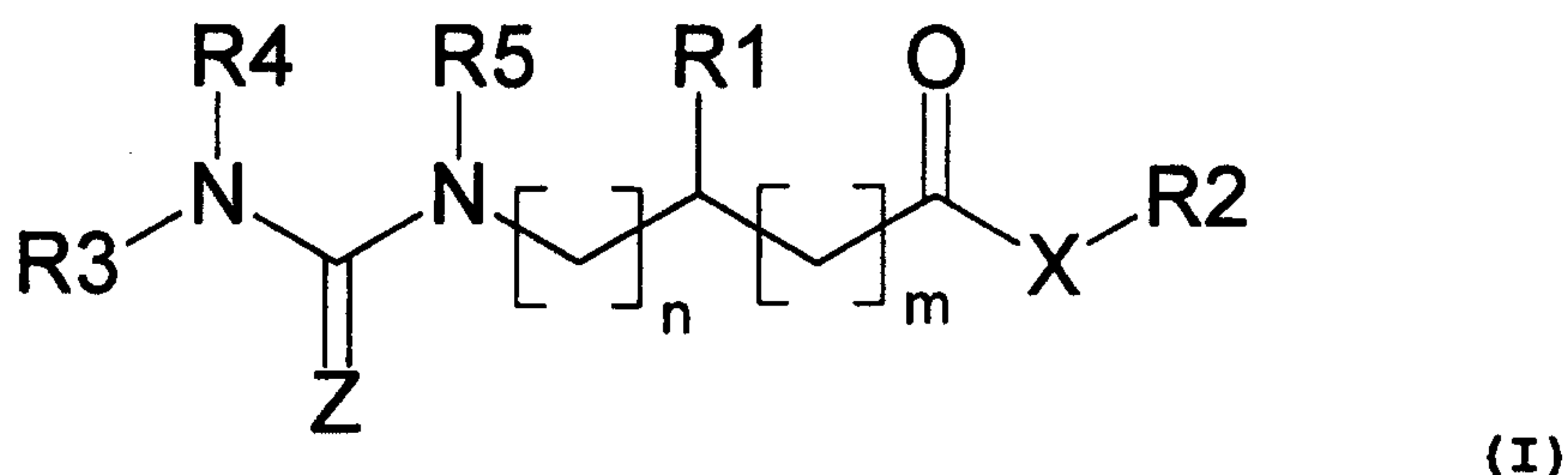
S2 and S5 are t-butyl.

25. A method according to claim 24 wherein,

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl;

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl; and S2 and S5 are t-butyl.

26. A method for providing an analgesic effect comprising administering to a subject in need of such an effect an effective amount of a calcitonin mimetic of formula I:



wherein

R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R3 is selected from the group consisting of hydrogen, aryl, substituted aryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6

carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings;

Z and X are each independently selected from the group NH, O, S, or NR, wherein R is a lower alkyl group of from 1 to 6 carbon atoms; and

n and m are each independently an integer from 0 to 6.

27. A method according to claim 26 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are hydrogen;

Z is O; and

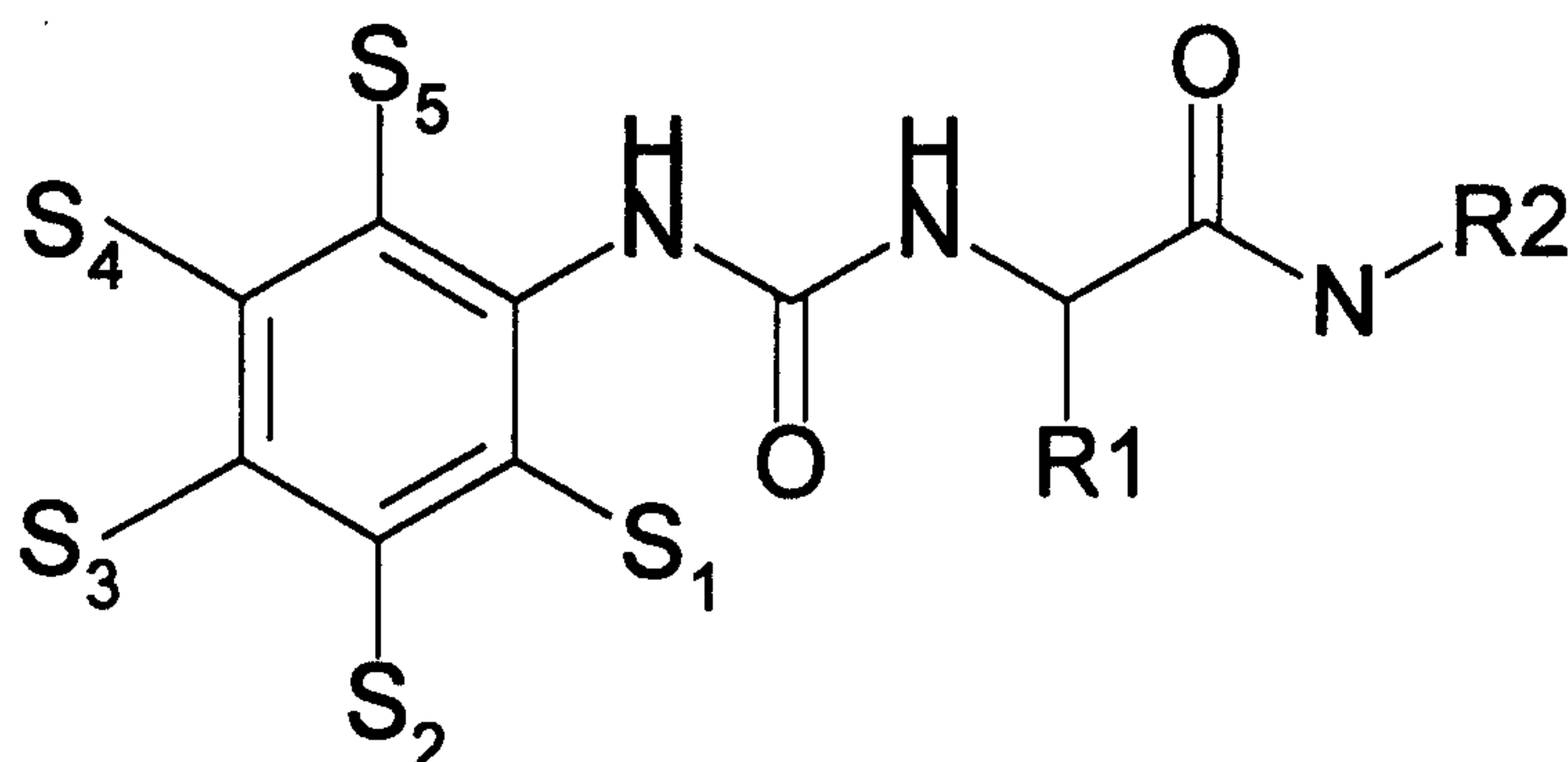
X is NH.

28. A method according to claim 27 wherein

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl.

29. A method according to claim 26, wherein said calcitonin mimetic has the formula:



wherein,

R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S1, S2, S3, S4 and S5 are each independently selected from the group consisting of hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl.

30. A method according to claim 29 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy,

alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S2 and S5 are t-butyl.

31. A method according to claim 30 wherein,

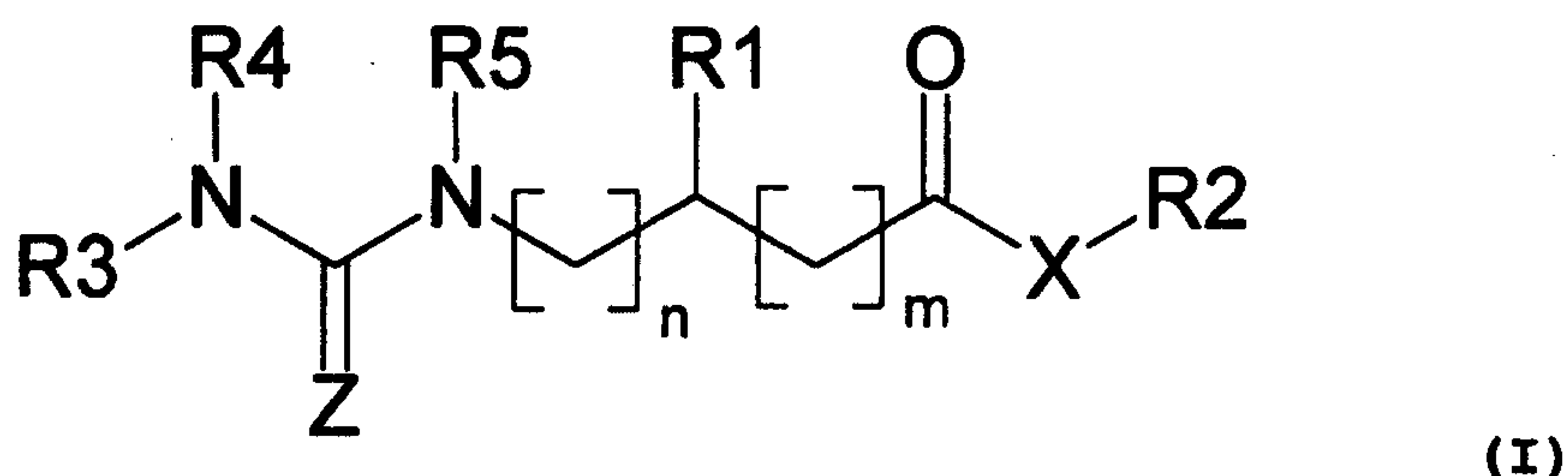
R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl;

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl; and

S2 and S5 are t-butyl.

32. A method according to claim 26, wherein the analgesic effect provides relief from bone pain.

33. A method for treating conditions associated with inhibiting gastric secretion comprising administering to a subject in need of such inhibition an effective amount of a calcitonin mimetic of formula I



wherein

R1 and R2 are each members independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy,

haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R3 is selected from the group consisting of hydrogen, aryl, substituted aryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are each independently selected from the group consisting of hydrogen and alkyls having from 1 to 6 carbon atoms, or taken together from a ring selected from the group consisting of saturated or unsaturated five-member rings, saturated or unsaturated six-member rings and saturated or unsaturated seven-member rings;

Z and X are each independently selected from the group NH, O, S, or NR, wherein R is a lower alkyl group of from 1 to 6 carbon atoms; and

n and m are each independently an integer from 0 to 6.

34. A method according to claim 33 wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl;

R4 and R5 are hydrogen;

Z is O; and

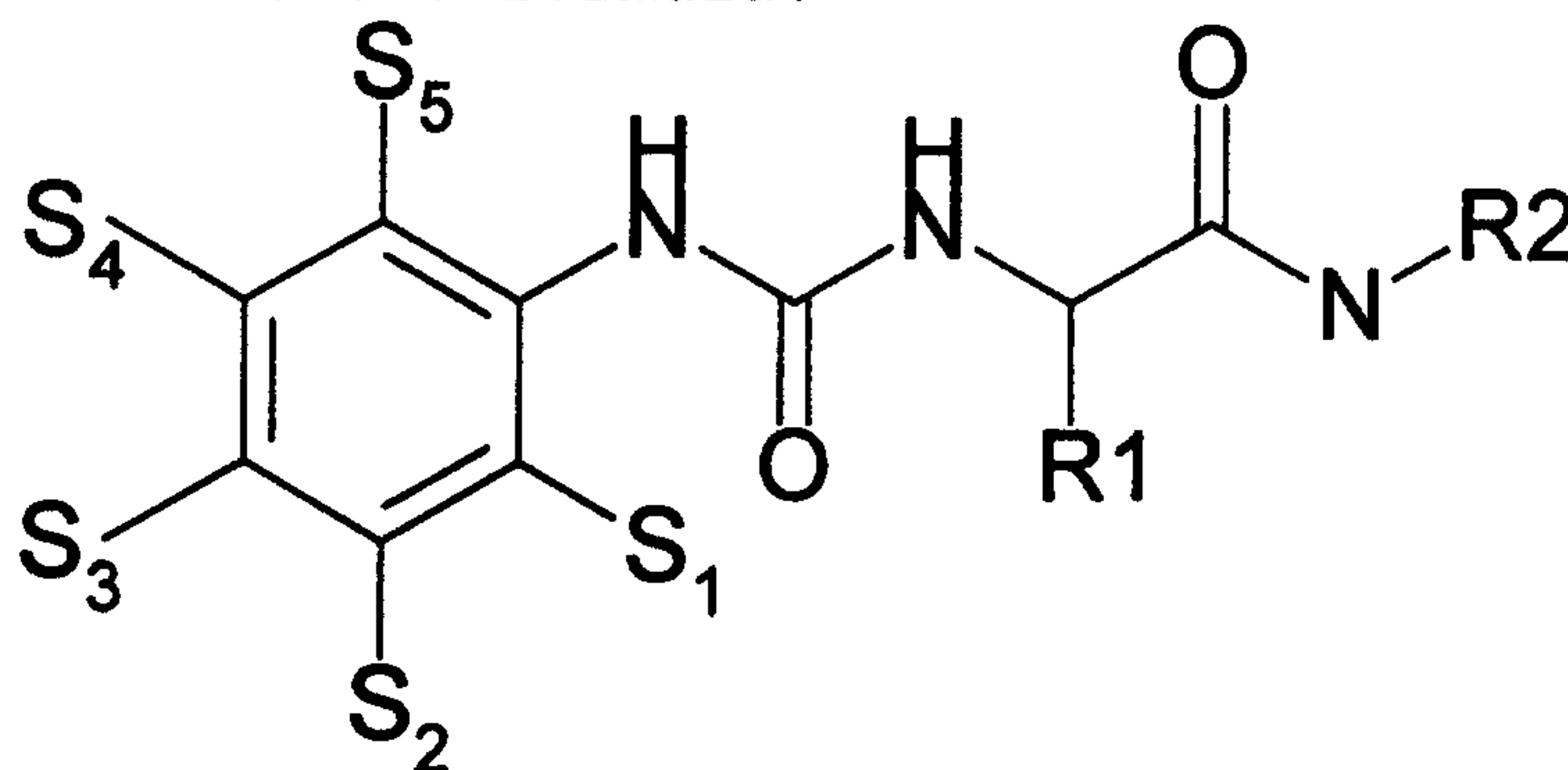
X is NH.

35. A method according to claim 34 wherein

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl; and

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl.

36. A method according to claim 33, wherein said calcitonin mimetic has the formula:



wherein,

R1 and R2 are each independently selected from the group consisting of hydrogen, alkyls having from 1 to 6 carbon atoms, alkenyls having from 1 to 6 carbon atoms, aryl, substituted aryl, alkylaryl, substituted alkylaryl, carbocyclic ring, substituted carbocyclic ring, heterocyclic ring, substituted heterocyclic ring, and combinations thereof, the combinations are fused or covalently linked and the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S1, S2, S3, S4 and S5 are each independently selected from the group consisting of hydrogen, halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl.

37. A method according to claim 36, wherein,

R1 is selected from the group consisting of phenyl, substituted phenyl, benzyl, substituted benzyl, naphthylmethyl, substituted naphthylmethyl, indolymethyl, and substituted indolymethyl;

R2 is selected from the group consisting of alkyls of from 1 to 6 carbon atoms, alkenyls of from 1 to 6 carbon atoms, benzyl, substituted benzyl, naphthylmethyl, and substituted naphthylmethyl;

wherein the substituents are selected from the group consisting of halogen, haloalkyl, hydroxy, aryloxy, benzyloxy, alkoxy, haloalkoxy, amino, monoalkylamino, dialkylamino, acyloxy, acyl, alkyl and aryl; and

S2 and S5 are t-butyl.

38. A method according to claim 37 wherein,

R1 is 4-ethoxybenzyl, 1-ethyl-indolylmethyl, benzyl, 4-allyloxybenzyl, 1-allyl-indolylmethyl, 4-chlorobenzyl, 4-fluorobenzyl, 4-iodobenzyl, 2-naphthylmethyl or phenyl;

R2 is ethyl, allyl, benzyl or 2-naphthylmethyl;

and

S2 and S5 are t-butyl.

39. A method according to claim 33, wherein the condition is a gastrointestinal disorder.