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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 June 2011 (16.06.2011)

PCT

(10) International Publication Number
WO 2011/070415 A1

(51) International Patent Classification:
A61K 31/343 (2006.01) *A61P 19/02* (2006.01)
A61P 29/00 (2006.01) *A61P 17/02* (2006.01)
A61P 37/02 (2006.01) *A61P 11/00* (2006.01)
A61P 37/06 (2006.01)

(21) International Application Number:
PCT/IB2010/003050

(22) International Filing Date:
8 November 2010 (08.11.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/263,517 23 November 2009 (23.11.2009) US

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

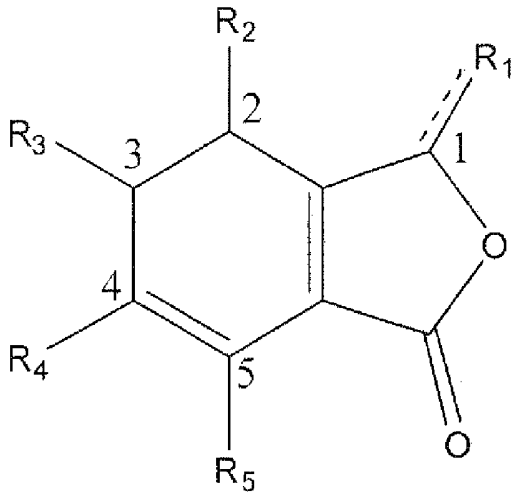
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU,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

Published:

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

— *with sequence listing part of description (Rule 5.2(a))*

(54) **Title**: NOVEL THERAPEUTIC METHODS FOR TREATING INFLAMMATION AND IMMUNE SYSTEM DISORDERS



(I)

(57) **Abstract**: A method for treating inflammatory and immune conditions by modulating TNF-α and nitric oxide production is provided. Said [method comprises administering a compound having the following formula (I):

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DESCRIPTION

NOVEL THERAPEUTIC METHODS FOR TREATING INFLAMMATION AND IMMUNE SYSTEM DISORDERS

CROSS-REFERENCE TO A RELATED APPLICATION

This application claims the benefit of U.S. provisional application Serial No. 61/263,517 filed November 23, 2009, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

In response to injury, cancer, microbial invasion, and the like, humans and other animals mount inflammatory responses to control the pathological condition and to initiate a repair process. During inflammation, various immune cells including T-lymphocytes, neutrophils and macrophages are recruited to the site where they produce cytokines to facilitate the immune response. Among these cytokines, tumor necrosis factor-α (TNF-α) is one of the major proinflammatory proteins that mediates the immune response. Although the effects of proinflammatory cytokines are protective, their overproduction may have adverse effects to the host. In fact, uncontrolled induction of proinflammatory cytokines can lead to complications such as hypotension, organ failure and even death[1,2].

During an acute phase of infection such as in the case of sepsis, uncontrolled production of TNF-α is well known to cause deleterious effects to the host. Sepsis is the second most common cause of death in non-coronary intensive care units and the tenth leading cause of death overall in high-income countries[3]. The clinical outcome of infection leading to sepsis is primarily associated with the excessive stimulation of the host immune cells, particularly monocytes or macrophages, by bacterial endotoxins (e.g., lipopolysaccharide [LPS])[4,5,6]. Macrophages overstimulated by LPS also produce high levels of mediators such as interleukin-1 (IL-1), IL-6, and TNF-α[7]. These mediators are implicated in the pathogenesis of sepsis and found to be contributing factors to the demise of the host.

In addition to its role in acute phase response, TNF-α has been shown to be involved in the progression of various chronic diseases including tumorigenesis and rheumatoid arthritis (RA). The dysregulation of TNF-α production has been demonstrated to be involved

in different stages of tumorigenesis including initiation of tumor growth[8], cell proliferation[9] and invasion[10]. For tumor cell proliferation, TNF-α upregulates specific growth factors to mediate the malignant growth. The cytokine promotes angiogenesis that supports tumor migration, and thus plays a key role in tumor metastasis. For example, glioblastoma migration and induction of matrix metalloproteinases (MMP) are significantly enhanced in response to TNF-α effects[11]. This induction of MMP in glioblastoma T98G cells can be reversed by treatment of the cells with interferon-g[12].

The uncontrolled production of TNF-α is associated with many acute and chronic neurodegenerative conditions, including stroke, brain trauma, spinal cord injury, amyotrophic lateral sclerosis (ALS), Huntington's disease, Alzheimer's disease, and Parkinson's disease. Studies show that TNF-α rapidly upregulates in the brain after injury, and it plays a pivotal role in inflammatory processes. For instance, studies show that cerebrovascular diseases including ischemic stroke are associated with inflammation mediated responses in the neural cells. Also, the enhanced expression of TNF-α has been found in association with glial cells in the substantia nigra of patients with Parkinson's disease.

The toxic effects of TNF-α and its role as a mediator of focal ischemia may involve many other mechanisms in addition to inflammation. For example, increased TNF-α in the brain and blood in response to lipopolysaccharide (LPS) appears to contribute to increased brain stem thrombosis and hemorrhage, and increased stroke sensitivity/risk. Additionally, TNF-α increases blood-brain barrier permeability and produces pial artery constriction, which can contribute to focal ischemic brain injury. Further, there appears to be a direct toxic effect of TNF-α on capillaries. Specifically, TNF-α increases capillary permeability and opens the blood-brain barrier, apparently by increasing matrix-damaging metalloproteinase (gelatinase B) production, which is also expressed early after focal stroke. TNF-α also causes damage to myelin and oligodendrocytes and increases astrocytic proliferation, thus potentially contributing to demyelination and reactive gliosis during brain injury.

Further examples of acute and chronic disease pathogenesis mediated by TNF-α include rheumatoid arthritis and inflammatory bowel diseases. Patients with rheumatoid arthritis have a low grade insidious inflammation in the synovial tissues. It is known that overproduction of TNF-α at the inflamed joint leads to slow destruction of the joint cartilage and surrounding bone.

Additionally, inflammatory responses including TNF-α production may play an important role in the pathogenesis of cerebrovascular diseases including ischemic stroke and cardiovascular diseases (CVD). It has been suggested that TNF- α may destabilize atherogenesis and atherosclerotic plaques leading to their rupture, resulting in myocardial infarction or stroke in CVD patients.

Furthermore, studies have shown that disease pathogenesis mediated by TNF-α can be associated with microbial, bacterial and viral infections. Cytokines such as TNF-α play a role in defending against the invading pathogens such as, for example, mycobacteria, influenza viruses, SARS-coronavirus and retroviruses including HIV. However, many microbes and viruses have also developed various immunosuppressive mechanisms that cause dysfunction of protein signaling kinases and transcription factors as well as other components involved in the TNF-α signaling pathway[13, 14, 15, 16, 17, 18].

In addition to uncontrolled production of TNF- α, immune cells in a diseased condition are activated by cytokines, microbial compounds or both to generate nitric oxide (NO). Generation of nitric oxide is a feature of genuine immune-system cells such as dendritic cells, NK cells, mast cells and phagocytic cells including monocytes, macrophages, microglia, Kupffer cells, eosinophils, and neutrophils as well as other cells involved in immune reactions. Many targets of NO are themselves regulatory molecules, for example transcription factors and components of various signaling cascade.

Additional keys mediators involved in immune response further include interferons such as Interferon-gamma (IFN-γ); the interleukin family such as Interleukin-1 (IL-1), Interleukin-2 (IL-2), Interleukin-3 (IL-3), Interleukin-4 (IL-4), Interleukin-5 (IL-5), Interleukin-6 (IL-6), Interleukin-7 (IL-7), Interleukin-8 (IL-8), Interleukin-9 (IL-9), Interleukin-10 (IL-10), Interleukin-11 (IL-11), Interleukin-12 (IL-12), Interleukin-13 (IL-13), Interleukin-14 (IL-14), Interleukin-15 (IL-15), Interleukin-16 (IL-16), Interleukin-17 (IL-17), Interleukin-18 (IL-18), Interleukin-19 (IL-19), Interleukin-20 (IL-20), Interleukin-21 (IL-21), Interleukin-22 (IL-22), Interleukin-23 (IL-23), Interleukin-24 (IL-24), Interleukin-25 (IL-25), Interleukin-26 (IL-26), Interleukin-27 (IL-27), Interleukin-28 (IL-28), Interleukin-29 (IL-29), Interleukin-30 (IL-30), Interleukin-31 (IL-31), Interleukin-32 (IL-32), Interleukin-33 (IL-33), Interleukin-34 (IL-34), Interleukin-35 (IL-35); the interleukin receptor family; the macrophage inflammatory protein family such as macrophage inflammatory protein 2

(MIP-2) and macrophage inflammatory protein 1α (MIP-1 α); macrophage colony-stimulating factor (M-CSF); and monocyte chemotactic protein-1 (MCP-1).

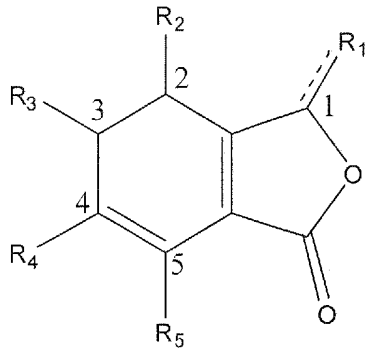
Targeting the uncontrolled production of inflammatory mediators such as TNF-α and nitric oxide has played an increasing role in treating inflammatory and immune conditions. Use of exogenous anti-inflammatory therapeutics would be particularly desirable to control the adverse effects of immune over-activation. In recent years, immunotherapeutics have been developed that aim at the neutralization of TNF-α and suppression of its undesirable proinflammatory effects. For example, as TNF-α exacerbates focal ischemic injury in neurodegenerative diseases, agents for blocking endogenous TNF-α have been shown to be neuroprotective. These agents include soluble TNF-α receptor (Enbrel) and anti-TNF-α antibody (Infliximab). Despite their novelty and efficacy in the arrest of disease progression, they are very expensive therapeutic regimens.

In addition, non-steroid anti-inflammatory drugs (NSAIDs) including aspirin, ibuprofen, and indomethacin are well-known in ameliorating acute and chronic pain associated with inflammatory diseases such as rheumatoid arthritis and inflammatory bowel disease. However, they are not effective in the treatment of advanced stages of rheumatoid arthritis and related autoimmune diseases. For those conditions, steroids and cytotoxic drugs such as methotrexate and cyclophosphamide are used. These drugs are associated with severe adverse effects including gastrointestinal irritation, severe bleeding, and bone marrow suppression.

The development of novel therapies directed towards the inhibition of pathological production of TNF-α and NO is needed to aid in the treatment of these acute and chronic diseases.

BRIEF SUMMARY OF THE INVENTION

The present invention provides novel and advantageous therapeutic methods for treating inflammation and/or modulating immune responses. Specifically exemplified herein is the therapeutic use of senkyunolide A (Sen A) and Z-ligustilide (Z-Lig), compounds isolated from traditional Chinese medicinal material *Ligusticum chuanxiong* (LCX). The therapeutic methods of the subject invention can be used to modulate TNF-α production by administering, to a subject in need of such treatment, an effective amount of an isolated compound having the following formula:



wherein

------ represents a carbon-carbon single bond or a carbon-carbon double bond;

R_1 is alkyl or CR_6, wherein R_6 is alkyl, acyl, haloalkyl, alkylamino or hydroxylalkyl;

R_2, R_3 and R_4 are, independently, –H, acyl, halo, haloalkyl, amino, alkylamino, hydroxyl, alkyl, hydroxylalkyl, or –COOH; and

R_5 is –H, acyl, halo, haloalkyl, amino, alkylamino, alkyl, hydroxylalkyl, or –COOH.

The subject invention further provides pharmaceutical compositions containing these compounds.

Advantageously, the methods of the present invention can be used to control over-production of TNF-α and nitric oxide in cells associated with inflammation and immune conditions. In addition, the methods of the present invention inhibit cell death induced by cell injury associated with inflammation and immune conditions.

The methods of the present invention are useful for treating conditions selected from, for example, ischemic stroke, autoimmune conditions, rheumatoid arthritis, psoriasis, cardiovascular disease, cerebrovascular disease, neurodegenerative disease, post-infection associated neurological neuralgia or neurasthenia conditions including shingles and chronic fatigue syndrome, inflammatory bowel disorder, septic shock, infections, environmental toxins, intestinal inflammation, allergy, graft rejection, pathological immune cell proliferation or activity, and respiratory inflammation.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows an extraction scheme of bioactive compounds, including senkyunolide A and Z-ligustilide, from *Ligusticum chuanxiong*.

Figure 2 shows high performance liquid chromatography (HPLC) chromatograms of subfractions separated from the extract LCX-1-Et-EA-S1.

Figure 3 shows the effect of subfractions separated from LCX-1-Et-EA-S1 on nitrite production in BV cells. ($p<0.05$, compared with DMSO + LPS only).

Figure 4 shows the dose-dependent effect of senkyunolide A on nitrite production in BV cells. ($p<0.05$, compared with DMSO + LPS only).

Figure 5 shows the dose-dependent effect of Z-ligustilide on nitrite production in BV cells. ($p<0.05$, compared with DMSO + LPS only).

Figure 6 shows the effect of senkyunolide A on TNF-α production in human blood macrophages. ($p<0.001$, compared with DMSO + LPS only).

Figure 7 shows the dose-dependent effect of senkyunolide A on TNF-α protein production in BV cells. ($p<0.05$, compared with DMSO + LPS only).

Figure 8 shows the dose-dependent effect of Z-ligustilide on TNF-α protein production in BV cells. ($p<0.05$, compared with DMSO + LPS only).

Figure 9 shows the effect of senkyunolide A on TNF-α mRNA expression and iNOS expression in BV cells.

Figure 10 shows the effect of senkyunolide A on TNF-α mRNA stability in BV cells. ($p<0.05$, compared with DMSO + LPS only).

Figure 11 shows the effect of Z-ligustilide on hydrogen peroxide-induced death of PC-12 cells. PC-12 cells were pretreated with either DMSO (0.05%) or Z-ligustilide for 24 h, followed by treatment with 0.8mM H_2O_2 for another 6 h. Cell viability was measured using MTT assays. A set of representative results is shown.

BRIEF DESCRIPTION OF THE SEQUENCES

SEQ ID NO:1 is a primer useful according to the subject invention.

SEQ ID NO:2 is a primer useful according to the subject invention.

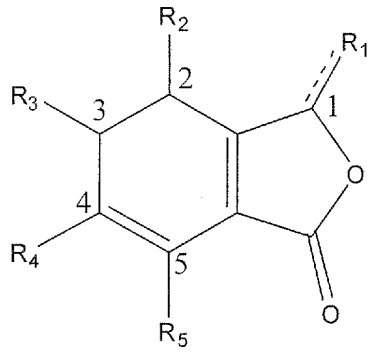
SEQ ID NO:3 is a primer useful according to the subject invention.

SEQ ID NO:4 is a primer useful according to the subject invention.

DETAILED DESCRIPTION OF THE INVENTION

The subject invention provides novel and advantageous therapeutic methods for treating inflammatory and immune conditions in a subject. The treatment method, which is

capable of modulating TNF-α production, comprises administering, to a subject in need of such treatment, an effective amount of an isolated compound having the following formula:



wherein

------ represents a carbon-carbon single bond or a carbon-carbon double bond;

R_1 is alkyl or CR_6, wherein R_6 is alkyl, acyl, haloalkyl, alkylamino or hydroxylalkyl;

R_2, R_3 and R_4 are, independently, –H, acyl, halo, haloalkyl, amino, alkylamino, hydroxyl, alkyl, hydroxylalkyl, or –COOH; and

R_5 is –H, acyl, halo, haloalkyl, amino, alkylamino, alkyl, hydroxylalkyl, or –COOH.

"Alkyl" means linear saturated monovalent radicals of one to eight carbon atoms or a branched saturated monovalent of three to eight carbon atoms. It may include hydrocarbon radicals of one to four or one to three carbon atoms, which may be linear. Examples include methyl, ethyl, propyl, 2-propyl, n-butyl, iso-butyl, tert-butyl, pentyl, and the like.

"Acyl" means a radical –C(O)R where R is hydrogen, alkyl or cycloalkyl, or heterocycloalkyl. Examples include formyl, acetyl, ethylcarbonyl, and the like.

"Halo" means fluoro, chloro, bromo, or iodo, such as bromo and chloro.

"Haloalkyl" means alkyl substituted with one or more, same or different, halo atoms, e.g., $-CH_2Cl$, $-CH_2Br$, $-CF_3$, $-CH_2CH_2Cl$, $-CH_2CCl_3$, and the like.

"Amino" means the radical $-NH_2$.

"Alkylamino" means a radical -NHR or $–NR_2$ where each R is, independently, an alkyl group. Examples include methylamino, (1-methylethyl)amino, dimethylamino, methylethylamino, di(1-methylethyl)amino, and the like.

"Hydroxy" means the radical -OH.

Hydroxyalkyl" means an alkyl radical as defined herein, substituted with one or more, preferably one, two or three, hydroxy groups. Representative examples include, but are not limited to, hydroxymethyl, 2-hydroxyethyl, 2-hydroxypropyl, 3-hydroxypropyl, 1-(hydroxymethyl)-2-methylpropyl, 2-hydroxybutyl, 3-hydroxybutyl, 4-hydroxybutyl, 2,3-dihydroxypropyl, 2-hydroxy-1-hydroxymethylethyl, 2,3-dihydroxybutyl, 3,4-dihydroxybutyl and 2- (hydroxymethyl)-3-hydroxy-propyl, preferably 2-hydroxyethyl, 2,3- dihydroxypropyl and 1- (hydroxymethyl) 2-hydroxyethyl.

An "alkoxy" is intended to mean the radical $-OR_a$, where R_a is an alkyl group. Exemplary alkoxy groups include methoxy, ethoxy, propoxy, and the like.

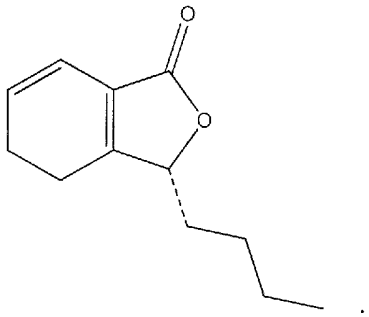
The subject invention further provides methods for treating inflammatory and immune conditions by administering isolated enantiomeric compounds. The isolated enantiomeric forms of the compounds of the invention are substantially free from one another (i.e., in enantiomeric excess). In other words, the "R" forms of the compounds are substantially free from the "S" forms of the compounds and are, thus, in enantiomeric excess of the "S" forms. Conversely, "S" forms of the compounds are substantially free of "R" forms of the compounds and are, thus, in enantiomeric excess of the "R" forms. In one embodiment of the invention, the isolated enantiomeric compounds are at least about in 80% enantiomeric excess. In a preferred embodiment, the compounds are in at least about 90% enantiomeric excess. In a more preferred embodiment, the compounds are in at least about 95% enantiomeric excess. In an even more preferred embodiment, the compounds are in at least about 97.5% enantiomeric excess. In a most preferred embodiment, the compounds are in at least about 99% enantiomeric excess.

The term "subject," as used herein, describes an organism, including mammals such as primates, to which treatment with the compositions according to the present invention can be provided. Mammalian species that can benefit from the disclosed methods of treatment include, but are not limited to, apes, chimpanzees, orangutans, humans, monkeys; and domesticated animals such as dogs, cats, horses, cattle, pigs, sheep, goats, chickens, mice, rats, guinea pigs, and hamsters.

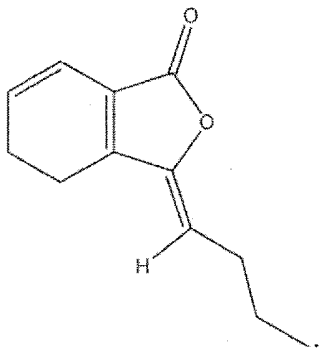
The term "effective amount," as used herein, refers to an amount that is capable of preventing, ameliorating, or treating inflammation or an immune disease or condition. For instance, an effective amount enables at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%,

45%, 50%, 60%, 70%, 80%, 90%, or 100% reduction in TNF-α and/or NO in a test sample of a subject in need of such treatment.

In a specific embodiment, the subject method comprises administering, to a subject, an effective amount of isolated senkyunolide A (Sen A). The chemical structure of senkyunolide A is:



In another specific embodiment, the subject method comprises administering, to a subject, an effective amount of isolated Z-ligustilide (Z-Lig). The chemical structure of Z-ligustilide is:



Senkyunolide A and Z-ligustilide can be isolated from *Ligusticum chuanxiong* (Chuanxiong) and its Chinese counterparts using isolation and bioassay-guided procedures as described herein.

In one embodiment, the subject invention provides therapeutic methods for treating inflammatory and immune conditions by administering an effective amount of senkyunolide A and/or Z-ligustilide to control over-production of TNF-α and nitric oxide. Advantageously, incubation of BV-2 cells with Sen A and Z-Lig at a concentration above 5 μg/ml and 10 μg/ml, respectively, significantly inhibits production of TNF-α under LPS induction. In addition, the subject treatment method is capable of decreasing NO production

and TNF-α mRNA stability. Further, the compounds of the subject invention have cytoprotective effects. As shown in Example 7, the application of Z-ligustilide protects cells from apoptotic death during hydrogen peroxide-induced cell injury.

The methods of the subject invention can also be used to treat inflammation associated with infection, including, but not limited to, infections by viruses, bacteria, fungi, yeast, and other microbes. Additionally, the compounds of the subject invention can be used to treat inflammation mediated by a variety of factors including, but not limited to, interferons, interleukins, and environmental toxins.

In one embodiment, the compounds of the subject invention can be used to treat inflammation caused by concurrent infection or immunological over-reaction to pathogen invasion, including but not limited to inflammation caused by viruses including Varicella zoster (also known as chickenpox or herpes zoster), herpes simplex, cytomegalovirus and herpes simplex virus-8 (also known as AIDS-associated Kaposi sarcoma virus).

In a specific embodiment, the subject invention is used to treat neuralgia or neurasthenia associated with herpes zoster reactivation, commonly known as shingles. In another specific embodiment, the subject invention is used to treat chronic fatigue syndrome caused by viral infections.

In another embodiment, the subject invention is used to treat ischemic stroke, rheumatoid arthritis, psoriasis, cardiovascular disease, cerebrovascular disease, inflammatory bowel disorder, septic shock, and/or graft vs. host rejection.

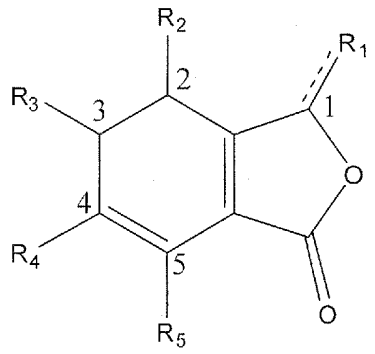
In one embodiment of the subject invention, a patient who has been diagnosed with a pathological condition is administered a compound or composition of the subject invention. The diagnosis may be made through an appropriate assay, including for example, the detection of a fever. Other assays such as the culturing of tissue or other biological samples to identify pathogens can be used.

In a specific embodiment, the subject method reduces TNF-α and/or nitric oxide production levels and/or destabilizes TNF-α mRNA in cells associated with inflammatory and immune conditions.

In one embodiment, the subject method for treating inflammatory and immune conditions comprises:

(a) determining the presence and/or level of one or more immune system markers in a subject;

(b) administering, to the subject in need of such treatment, an effective amount of an isolated compound having the following formula:



wherein

------ represents a carbon-carbon single bond or a carbon-carbon double bond;

R_1 is alkyl or CR_6, wherein R_6 is alkyl, acyl, haloalkyl, alkylamino or hydroxylalkyl;

R_2, R_3 and R_4 are, independently, –H, acyl, halo, haloalkyl, amino, alkylamino, hydroxyl, alkyl, hydroxylalkyl, or –COOH; and

R_5 is –H, acyl, halo, haloalkyl, amino, alkylamino, alkyl, hydroxylalkyl, or –COOH; and

(c) determining the presence and/or level of one or more immune system markers in the subject; wherein the determination is optionally made at multiple times to monitor the change over time.

In a specific embodiment, the immune system marker(s) is selected from cytokines including TNF-α; NO; interferons such as Interferon-gamma (IFN-γ); the interleukin family such as Interleukin-1 (IL-1), Interleukin-2 (IL-2), Interleukin-3 (IL-3), Interleukin-4 (IL-4), Interleukin-5 (IL-5), Interleukin-6 (IL-6), Interleukin-7 (IL-7), Interleukin-8 (IL-8), Interleukin-9 (IL-9), Interleukin-10 (IL-10), Interleukin-11 (IL-11), Interleukin-12 (IL-12), Interleukin-13 (IL-13), Interleukin-14 (IL-14), Interleukin-15 (IL-15), Interleukin-16 (IL-16), Interleukin-17 (IL-17), Interleukin-18 (IL-18), Interleukin-19 (IL-19), Interleukin-20 (IL-20), Interleukin-21 (IL-21), Interleukin-22 (IL-22), Interleukin-23 (IL-23), Interleukin-24 (IL-24), Interleukin-25 (IL-25), Interleukin-26 (IL-26), Interleukin-27 (IL-27), Interleukin-28 (IL-28),

Interleukin-29 (IL-29), Interleukin-30 (IL-30), Interleukin-31 (IL-31), Interleukin-32 (IL-32), Interleukin-33 (IL-33), Interleukin-34 (IL-34), Interleukin-35 (IL-35); the interleukin receptor family; the macrophage inflammatory protein family such as macrophage inflammatory protein 2 (MIP-2) and macrophage inflammatory protein 1α (MIP-1 α); macrophage colony-stimulating factor (M-CSF); monocyte chemotactic protein-1 (MCP-1); and immunoglobulins such as IgA, IgG, IgM, IgD, and IgE.

Immunoglobulins include IgG, IgM, IgD, IgE, IgA and subtypes such as for example IgG1, IgG2, IgG3, IgG4, IgA1, and IgA2. They further include molecules in monomeric or multimeric form, whether digested from whole antibody or produced by other means.

In a further specific embodiment, the immune system marker is selected from the group consisting of TNF-α, NO, IFN-γ, IL-1, IL-2, IL -3, IL-5, IL-4, IL-6, IL-8, IL-10, IL-12, IL-13, IL-14, IL-17, IL-18, IL-23, IL-24, IL-25, IL27, IL-32, G-CSF, M-CSF, MCP-1, MIP-2, MIP-1α, IgA, IgG, IgM, IgD and IgE.

The presence and/or level of the immune system markers can be determined from a sample of biological fluid obtained for the purpose of diagnosis, prognosis, or evaluation of a subject of interest, such as a patient. In certain embodiments, the immune system marker is measured for the purpose of determining the outcome of an ongoing condition or the effect of a treatment regimen on a condition. The immune system marker can be measured in a sample such as, blood, tissue, serum, plasma, urine, saliva, and tears. In one embodiment, the sample is a tissue sample. In one embodiment, the sample is a blood sample. In addition, one of skill in the art would realize that some samples would be more readily analyzed following a fractionation or purification procedure, for example, separation of whole blood into serum or plasma components.

In a further embodiment, the immune system marker can be determined by quantitative immunological detection methods, such as for example, enzyme-linked immunosorbant assay (ELISA), western blot, immunological assays, microarray, and radioimmunoassay.

Further, a plurality of markers can be measured. In addition, analysis of a plurality of markers may be carried out separately or simultaneously. Several markers may be combined into one test for efficient processing of multiple samples from a subject.

In addition, the presence and/or level of one or more markers can be determined multiple times over time to monitor the change of a subject's conditions. Such testing of

multiple samples allows for the identification of changes in the marker over time. Increases or decreases in the marker, as well as the absence of change in levels, would provide useful information about the disease status that includes, but is not limited to, identifying the approximate time from onset of the event, the appropriateness of the subject therapy, the effectiveness of the subject therapy, identification of the severity of the event, identification of the disease severity, and identification of a future outcome.

In addition, the method of the present invention can be used in the treatment, or amelioration, of inflammatory symptoms in any disease, condition or disorder where immune and/or inflammation suppression is beneficial. Inflammatory diseases, conditions or disorders in which the compounds and compositions of the present invention can be used to inhibit include, but are not limited to, unwanted immune reactions and inflammation including, but not limited to, arthritis (e.g., rheumatoid arthritis), ischemic stroke, and other diseases, conditions or disorders of the joints or musculoskeletal system in which immune and/or inflammation suppression is beneficial.

Moreover, the subject method is also useful to treat or ameliorate inflammation associated with atherosclerosis; arteriosclerosis; atherosclerotic heart disease; reperfusion injury; cardiac arrest; myocardial infarction; vascular inflammatory disorders including cerebro-vascular disease (stroke); respiratory distress syndrome and other cardiopulmonary diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial.

In addition, the subject method is also useful to treat or ameliorate inflammation associated with peptic ulcer; ulcerative colitis, Crohn's Disease, irritable bowel syndrome, other inflammatory bowel conditions, and other diseases, conditions or disorders of the gastrointestinal tract where immune inflammation suppression would be beneficial; hepatic fibrosis; liver cirrhosis and other hepatic diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial; thyroiditis and other glandular diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial; glomerulonephritis and other renal and urologic diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial.

In addition, the subject method is useful to treat or ameliorate inflammation associated with post-traumatic inflammation; septic shock; infectious diseases where immune and/or inflammation suppression would be beneficial; inflammatory complications and side

effects of surgery where immune and/or inflammation suppression would be beneficial; bone marrow transplantation and other transplantation complications and/or side effects where immune and/or inflammation suppression would be beneficial; inflammatory and/or immune complications and side effects of gene therapy, e.g., due to infection with a viral carrier; and inflammation associated with acquired immune deficiency syndrome (AIDS).

Further, the subject method is also useful to inhibit macrophage or T cell associated aspects of an immune response that are not associated with inflammation. The compounds and compositions are able to inhibit macrophage or T cell activities including, but not limited to, macrophage antigen-presenting activity, macrophage cytokine production, T cell cytokine production, T cell adhesion activity, T cell proliferation, etc. Thus, the compounds and compositions are useful to suppress or inhibit a humoral and/or cellular immune response.

The subject method is also useful to treat or ameliorate monocyte and leukocyte proliferative diseases, e.g., leukemia, by reducing the amount of monocytes and lymphocytes.

The subject method is further useful for the prevention and/or treatment of graft rejection in cases of transplantation of natural or artificial cells, tissue and organs, such as cornea, bone marrow, organs, lenses, pacemakers, natural and artificial skin tissue, and the like.

The subject method is also useful to treat or ameliorate inflammation associated with hypersensitivity; allergic reactions; asthma; systemic lupus erythematosus; collagen diseases and other autoimmune diseases such as multiple sclerosis, conditions or disorders in which immune and/or inflammation suppression is beneficial.

The subject method is also useful to treat or ameliorate inflammation associated with otitis and other otorhinolaryngological diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial; dermatitis and other dermal diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial; periodontal diseases and other dental diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial.

In addition, the subject method also is useful to treat or ameliorate inflammation associated with herpes zoster (shingles); posterior uveitis; intermediate uveitis; anterior uveitis; conjunctivitis; chorioretinitis; uveoretinitis; optic neuritis; intraocular inflammation, such as retinitis and cystoid macular edema; sympathetic ophthalmia; scleritis; retinitis pigmentosa; immune and inflammatory components of degenerative fondus disease;

inflammatory components of ocular trauma; ocular inflammation caused by infection; proliferative vitreoretinopathies; acute ischemic optic neuropathy; excessive scarring, for example, following glaucoma filtration operation; immune and/or inflammation reaction against ocular implants and other immune and inflammatory-related ophthalmic diseases, conditions or disorders where immune and/or inflammation suppression would be beneficial.

Moreover, the subject method is also useful to treat or ameliorate inflammation associated with autoimmune diseases and conditions or disorders where, both in the central nervous system (CNS) and in any other organ, immune and/or inflammation suppression would be beneficial; Parkinson's disease; complications and/or side effects from treatment of Parkinson's disease; AIDS-related dementia complex (HIV-related encephalopathy); Devic's disease; Sydenham chorea; Alzheimer's disease and other degenerative diseases, conditions or disorders of the central nervous system where immune and/or inflammation suppression would be beneficial; inflammatory components of strokes; post-polio syndrome; immune and inflammatory components of psychiatric disorders; myelitis; encephalitis; subacute sclerosing panencephalitis; encephalomyelitis; acute neuropathy; subacute neuropathy; chronic neuropathy; Guillaim-Barre syndrome; myasthenia gravis; pseudotumor cerebri; Down's Syndrome; Huntington's disease; amyotrophic lateral sclerosis; inflammatory components of central nervous system (CNS) compression or CNS trauma or cerebrovascular accidents (stroke) or infections or hypoxia-ischemia of the CNS; inflammatory components of muscular atrophies and dystrophies; and immune and inflammatory related diseases, conditions or disorders of the central and peripheral nervous systems where immune and/or inflammation suppression would be beneficial.

In yet another embodiment, the subject method is useful to restore immune privilege at an immune privileged site which has lost its immune privilege such as brain, eye and testis.

In one embodiment, the subject invention provides a therapeutic method by administering isolated compounds. As used herein, "isolated" refers to compounds that have been removed from any environment in which they may exist in nature. For example, isolated Sen A or isolated Z-Lig would not refer to the Sen A compound or the Z-Lig compound as it exists in *Ligusticum chuanxiong*. In preferred embodiments, the compounds of the subject invention are at least 75% pure, preferably at least 90% pure, more preferably are more than 95% pure, and most preferably are more than 99% pure (substantially pure).

The present invention also provides for a therapeutic method by administering therapeutic or pharmaceutical compositions in a form that can be combined with a pharmaceutically acceptable carrier. In this context, the compound may be, for example, isolated or substantially pure. The term "carrier" refers to a diluent, adjuvant, excipient, or vehicle with which the compound is administered. Such pharmaceutical carriers can be sterile liquids, such as water and oils, including those of petroleum oil such as mineral oil, vegetable oil such as peanut oil, soybean oil, and sesame oil, animal oil, or oil of synthetic origin. Saline solutions and aqueous dextrose and glycerol solutions can also be employed as liquid carriers, particularly for injectable solutions. Particularly preferred pharmaceutical carriers for treatment of or amelioration of inflammation in the central nervous system are carriers that can penetrate the blood/brain barrier. As used herein carriers do not include the natural plants as they exist in nature.

Suitable pharmaceutical excipients include starch, glucose, lactose, sucrose, gelatin, malt, rice, flour, chalk, silica gel, sodium stearate, glycerol monostearate, talc, sodium chloride, dried skim milk, glycerol, propylene, glycol, water, ethanol and the like. The therapeutic composition, if desired, can also contain minor amounts of wetting or emulsifying agents, or pH buffering agents. These compositions can take the form of solutions, suspensions, emulsion, tablets, capsules, powders, sustained-release formulations and the like. The composition can be formulated with traditional binders and carriers such as triglycerides. Examples of suitable pharmaceutical carriers are described in "Remington's Pharmaceutical Sciences" by E. W. Martin. Such compositions contain a therapeutically effective amount of the therapeutic composition, together with a suitable amount of carrier so as to provide the form for proper administration to the patient. The formulation should suit the mode of administration.

In one embodiment, the composition is formulated in accordance with routine procedures as a pharmaceutical composition adapted for local injection administration to human beings. Typically, compositions for local injection administration are solutions in sterile isotonic aqueous buffer. Where necessary, the composition may also include a solubilizing agent and a local anesthetic such as lidocaine to ease pain at the site of the injection. Generally, the ingredients are supplied either separately or mixed together in unit dosage form, for example, as a dry lyophilized powder or water free concentrate in a hermetically sealed container such as an ampoule or sachette indicating the quantity of active

agent. Where the composition is administered by injection, an ampoule of sterile water for injection or saline can be provided so that the ingredients may be mixed prior to administration.

The therapeutic or pharmaceutical compositions of the invention can be formulated as neutral or salt forms. Pharmaceutically acceptable salts include those derived from hydrochloric, phosphoric, acetic, oxalic, tartaric acids, sodium, potassium, ammonium, calcium, ferric hydroxides, isopropylamine, triethylamine, 2-ethylamino ethanol, histidine, procaine, etc.

The present invention also provides for the modification of the compound such that it is more stable once administered to a subject, i.e., once administered it has a longer time period of effectiveness as compared to the unmodified compound. Such modifications are well known to those of skill in the art, e.g., microencapsulation, etc.

The amount of the therapeutic or pharmaceutical composition of the invention which is effective in the treatment of a particular disease, condition or disorder will depend on the nature of the disease, condition or disorder and can be determined by standard clinical techniques. In general, the dosage ranges from about 0.001 mg/kg to about 2 mg/kg.

For instance, suitable unit dosages may be between about 0.01 to about 5 mg, about 0.01 to about 4 mg, about 0.01 to about 3 mg, about 0.01 to about 2 mg, about 0.01 to about 1 mg, about 0.01 to about 500 μg, about 0.01 to about 400 μg, about 0.01 to about 300 μg, about 0.01 to about 200 μg, about 0.01 to about 100 μg, or about 0.01 to about 50 μg. Such a unit dose may be administered more than once a day, e.g. two or three times a day.

In addition, *in vitro* assays may optionally be employed to help identify optimal dosage ranges. The precise dose to be employed in the formulation will also depend on the route of administration, and the seriousness of the disease, condition or disorder, and should be decided according to the judgment of the practitioner and each patient's circumstances. Effective doses may be extrapolated from dose-response curves derived from in vitro or animal model test systems. For example, in order to obtain an effective mg/kg dose for humans based on data generated from rat studies, the effective mg/kg dosage in rats is divided by six.

The invention also provides a pharmaceutical pack or kit comprising one or more containers filled with one or more of the ingredients, e.g., compound, carrier suitable for administration.

The method of administration can also be practiced consistent with traditional Chinese medicine practices. The composition and dosage of the formulation that are effective in the treatment of a particular disease, condition or disorder will depend on the nature of the disease, condition or disorder by standard clinical techniques.

The traditional Chinese medicine in prescription amounts can be readily made into any form of drug, suitable for administering to humans or animals. Suitable forms include, for example, tinctures, decoctions, and dry extracts. These can be taken orally, applied through venous injection or mucous membranes. The active ingredient can also be formulated into capsules, powder, pallets, pastille, suppositories, oral solutions, pasteurized gastroenteric suspension injections, small or large amounts of injection, frozen powder injections, pasteurized powder injections and the like. All of the above-mentioned methods are known to people skilled in the art, described in books and commonly used by practitioners of herbal medicine.

A tincture is prepared by suspending herbs in a solution of alcohol, such as, for example, wine or liquor. After a period of suspension, the liquid (the alcohol solution) may be administered for example, two or three times a day, one teaspoon each time.

A decoction is a common form of herbal preparation. It is traditionally prepared in a clay pot, but can also be prepared in glass, enamel or stainless steel containers. The formulation can be soaked for a period of time in water and then brought to a boil and simmered until the amount of water is reduced by, for example, half.

An extract is a concentrated preparation of the essential constituents of a medicinal herb. Typically, the essential constituents are extracted from the herbs by suspending the herbs in an appropriate choice of solvent, typically, water, ethanol/water mixture, methanol, butanol, iso-butanol, acetone, hexane, petroleum ether or other organic solvents. The extracting process may be further facilitated by means of maceration, percolation, repercolation, counter-current extraction, turbo-extraction, or by carbon-dioxide hypercritical (temperature/pressure) extraction. After filtration to rid of herb debris, the extracting solution may be further evaporated and thus concentrated to yield a soft extract (extractum spissum) and/or eventually a dried extract (extractum siccum), by means of spray drying, vacuum oven drying, fluid-bed drying or freeze-drying. The soft extract or dried extract may be further dissolved in a suitable liquid to a desired concentration for administering or processed into a form such as pills, capsules, injections, etc.

Materials and methods

Chemicals

Endotoxin (lipopolysacharride, LPS) from *E. coli* was purchased from Sigma and used as an inducer of TNF-α expression.

Cell culture and primary blood macrophage isolation

Murine microglia cell line BV-2 is maintained in Dulbecco's modified Eagle's minimum essential medium (DMEM) supplemented with 10% FBS and 1% penicillin and streptomycin (Invitrogen Life Technologies) at 37°C in a humidified atmosphere with 5% CO_2 in warm air.

PC-12 cells derived from a transplantable rat pheochromocytoma were obtained from American Type Culture Collection (ATCC Accession No. CRL-1721.1). The cells were maintained in F-12K Medium supplemented with 15% horse serum, 2.5% FBS, 1% penicillin, and streptomycin (Invitrogen Life Technologies, Carlsbad, CA) at 37°C in a humidified atmosphere of 5% CO_2.

Human peripheral blood monocytic cells (PBMC) were isolated from the buffy coat of healthy donor blood supplied by Hong Kong Red Cross by Ficoll-Paque (GE Healthcare) density gradient centrifugation as described in our previous reports [14,15,34]. In brief, the buffy coat was spun at 3000 rotations per minute (rpm) for 15 minutes to separate the blood cells from the plasma. The heat inactivated serum was filtered for future use.

The cell layer was diluted with phosphate buffered saline (PBS) in a ratio of 1:1. The diluted cells were overlaid on Ficoll-Paque slowly and centrifuged at 2300 rpm for 20 minutes for separation of mononuclear cells from erythrocytes. The mononuclear cell layer was removed and washed with RPMI 1640 medium until the supernatant was clear.

The cells were finally resuspended in RPMI 1640 medium supplemented with 5% autologous serum and cultured for 1 hour. The non-adherent cells were removed afterwards and the remaining adherent cells were further incubated for another 24 hours at 37°C in 5% carbon dioxide (CO_2).

The adherent monocytic cells were detached and seeded onto tissue culture plates and incubated for another 7-14 days in order to differentiate the primary blood monocytic cells to primary blood macrophages (PBMac).

Polymerase chain reaction (PCR) and Real-time RT-PCR

Semi-quantitative PCR assays of targeted genes were performed in a 25µl reaction mixture containing 1.5mM $MgCl_2$, 0.2mM of each deoxynucleoside triphosphate, 0.25µM of each primer, 2 units of *Taq* polymerase (GE Healthcare), and 1µl of cDNA. PCR primer sets for TNF-α and glyceraldehyde-3-phosphate dehydrogenase (GAPDH) were as follows. TNF-α (upstream: 5′-GGCTCCAGGCGGTGCT TGTCC-3′ (SEQ ID NO:1); downstream: 5′-AGACGGCGATGCGGCTGATG-3′ (SEQ ID NO:2)), and GAPDH (upstream: 5′-ACCACAGTCCATGCCATCAC-3′ (SEQ ID NO:3); downstream: 5′-TCCACCACCCTGTTGCTGTA-3′ (SEQ ID NO:4). The thermal cycling condition for PCR was 94°C for 30 s, 60°C for 30 s, and 72°C for 1 min. The cycling reactions were repeated for 24 more cycles.

The levels of TNF-α mRNA were determined by real-time RT-PCR (Roche 480II). 18S ribosomal RNA (18S) was used as an internal control. All of the real-time RT-PCR probes were obtained from the Universal Probe Library (Roche). All of the samples were performed in duplicate. The number of C_T of the targeted gene was normalized to that of the 18S in each sample (ΔC_T). The mRNA expression levels of the samples were relative to the mock-treated samples ($\Delta\Delta C_T$). The relative mRNA expression of the targeted genes was calculated by $2^{-\Delta\Delta CT}$ and expressed as fold induction.

Nitrite measurement

Nitrite levels in the culture media were determined using Griess reagent under manufacturer's instructions (Sigma Aldrich). Fresh culture media were used as blanks and the nitrite levels were determined by using a standard sodium nitrite curve.

Enzyme-Linked Immunosorbent Assay (ELISA)

To measure the TNF-α level in cell culture supernatants, cells were seeded at 1 x 10^6 cells/ml in the volume of 0.5ml in 24 well plates. After incubation, the supernatants were collected and TNF-α levels were determined by ELISA according to the manufacturer's instructions (R&D Systems).

MTT Assay for Cell Viability

Cell viability was assessed using MTT assay. PC-12 cells (2.5×10^4) were seeded in 24-well culture plates. Cells were treated with Z-ligustilide, followed by treatment with hydrogen peroxide for the indicated time periods. The treated cells were incubated with 0.5 mg/ml MTT solution (Sigma Aldrich, St. Louis, MO) for 1 h at 37°C. The medium was discarded and 200 µl isopropyl alcohol (IPP) was then added. After 15 min of incubation, the absorbance was measured at 570 nm.

EXAMPLES

Following are examples that illustrate procedures for practicing the invention. These examples should not be construed as limiting.

EXAMPLE 1 – EXTRACTION AND ISOLATION OF BIOACTIVE COMPOUNDS FROM LIGUSTICUM CHUANXIONG

Ligusticum chuanxiong (LCX) obtained from Purapharm International (H.K.) Ltd. is ground into powder. Methods for extracting bioactive compounds are shown in Figure 1 and illustrated as follows.

In the first method, LCX powders are soaked in absolute ethanol at room temperature with continuous sonication for 30 minutes. After the extract is concentrated using a Rotavapor (Büchi), it is suspended in water and then partitioned sequentially with hexane, ethyl acetate and then butanol. Three fractions, namely LCX-1-Et-H, LCX-1-Et-EA and LCX-1-Et-Bu, are obtained.

In the second method, LCX powders are heated in 70% ethanol under continuous reflux for 30 minutes. After the extract is concentrated using a Rotavapor (Büchi), it is suspended in water, and partitioned with dichloromethane (DCM). Two fractions, namely LCX-2-Et-D (the DCM fraction) and LCX-2-Et-W (the water faction), are obtained.

In the third method, LCX powders are boiled in water for 30 minutes. After the extract is concentrated using a Rotavapor (Büchi), it is partitioned sequentially with hexane, ethyl acetate and then butanol. Three fractions, namely LCX-3-W-H, LCX-3-W-EA and LCX-3-W-Bu, are obtained.

In the fourth method, LCX powders are soaked in water at room temperature with continuous sonication for 30 minutes. After the extract is concentrated using a Rotavapor

(Büchi), it is partitioned sequentially with hexane, ethyl acetate and then butanol. Three fractions, namely LCX-4-W-H, LCX-4-W-EA and LCX-4-W-Bu, are obtained.

EXAMPLE 2 – EFFECT OF BIOACTIVE EXTRACTS ON NITRIC OXIDE PRODUCTION

The effect of each extract on nitric oxide production is evaluated according to the procedures illustrated as follows. Briefly, murine microglia cell line BV-2 is maintained in Dulbecco's modified Eagle's minimum essential medium (DMEM) supplemented with 10% FBS and 1% penicillin and streptomycin (Invitrogen Life Technologies) at 37°C in a humidified atmosphere with 5% CO_2 in warm air.

0.1 M cells/ml BV-2 cells are seeded in 24-well plates (0.5 ml in each well). Cells are treated with 0.05% DMSO; 0.05% DMSO and 100 ng/ml LPS; or 100 ng/ml LPS and 50 µg/ml of an LCX extract for 18 hours, respectively. The culture supernatant is collected. The nitric oxide level is measured using the Griess reagent according to standard manufacturer's instructions (Sigma Aldrich), and assessed using the standard sodium nitrite curve.

The results reveal that LCX-1-Et-EA extract inhibits nitrite production in BV-2 cells. The LCX-1-Et-EA extract is subjected to additional column chromatography. The extract is further purified by reversed-phase high-performance liquid chromatography (HPLC) using a reversed-phase column Econosphere C18 10u (250 x 22mm ID), with a detection wavelength at 210 nm and a gradient elution at a flow of 6 ml min^{-1} consisting of solvents (A) water and (B) acetonitrile of the following concentration: 0 – 15 min, 50% - 90% B; 16 - 20 min, 90% B; and 21 - 35 min, 50% B.

Using the chromatographic conditions described as above, LCX-1-Et-EA-S1 is separated into 9 fractions as shown in Figures 2a) and 2b). Nine fractions are obtained, including LCX-1-Et-EA-S1-1 (S1-1), LCX-1-Et-EA-S1-2 (S1-2), LCX-1-Et-EA-S1-3 (S1-3), LCX-1-Et-EA-S1-4 (S1-4), LCX-1-Et-EA-S1-5 (S1-5), LCX-1-Et-EA-S1-6 (S1-6), LCX-1-Et-EA-S1-7 (S1-7), LCX-1-Et-EA-S1-8 (S1-8), and LCX-1-Et-EA-S1-9 (S1-9).

The effect of S1-1 – S1-9 on nitrite production in BV-2 cells is further evaluated using the same procedure as illustrated above. The results, as shown in Figure 3, reveal that S1-5, S1-7, and S1-8 significantly inhibit nitrite production. Specifically, S1-7 and S1-8 successfully inhibit nitrite production by 6-fold and 4-fold, respectively.

The bioactive compounds of S1-7 and S1-8 are indentified by gas chromatography mass spectrometry (GC: Agilent, 7890A, MS: Agilent, 5975C) using a HP-5MS column (25 m x 350 μm). The oven temperature starts at 70°C for 1 min, and then increases to 180°C at a rate of 10°C/min. After holding for 2 min, the temperature increases from 180°C to 280°C at a rate of 10°C/min and it is held at 280°C for 3 min. The injection temperature is 275°C. Helium is used as the carrier gas at a flow of 1 ml/min. The structures of pure compounds S1-7 and S1-8 are elucidated based on their mass spectrometric fragmentation patterns. It reveals that the bioactive compound of S1-7 is senkyunolide A (Sen A) and the bioactive compound of S1-8 is Z-ligustilide (Z-Lig).

EXAMPLE 3 – EFFECT OF SENKYUNOLIDE A AND Z-LIGUSTILIDE ON NITRIC OXIDE PRODUCTION

The effect of senkyunolide A (Sen A) and Z-ligustilide (Z-Lig) at various concentrations on nitrite production is further evaluated in this Example. Briefly, 0.1 M cells/ml BV-2 cells are seeded in 24-well plates (0.5 ml in each well). Cells are treated with 0.05% DMSO; 0.05% DMSO and 100 ng/ml LPS; 50 μg/ml Sen A / Z-Lig; or 100 ng/ml LPS and Sen A / Z-Lig at a concentration of 1 μg/ml, 5 μg/ml, 10 μg/ml, 25 μg/ml, and 50 μg/ml for 18 hours, respectively. The culture supernatant is collected. The nitric oxide level is measured using the Griess reagent according to standard manufacturer's instructions (Sigma Aldrich), and evaluated using the standard sodium nitrite curve.

The results, as shown in Figures 4 and 5, reveal that the application of either Sen A or Z-Lig at a concentration above 5 μg/ml significantly inhibits nitrite production. Specifically, Sen A at a concentration of 10 μg/ml and 25 μg/ml produces an approximately 4-fold and 20-fold reduction in nitrite production, respectively. More significantly, Sen A at a concentration of 50 μg/ml almost completely inhibits nitrite production. Z-ligustilide also inhibits nitrite production in a dose-dependent manner (Figure 5).

EXAMPLE 4 - EFFECT OF SENKYUNOLIDE A ON TNF-α PRODUCTION

To study the effect of Sen A at various concentrations on TNF-α production, 1 x 10^6 cells/ml PBMac cells are seeded in 24-well plates (0.5 ml in each well). Cells are treated with 25 μg/ml or 50 μg/ml Sen A for 24 hours prior to the addition of 1ng/ml LPS, and

further incubated for another 24 hours. The culture supernatants are collected and the level of secreted TNF-α is measured by ELISA according to the manufacturer's instructions (R&D Systems). The results, as shown in Figure 6, reveal that the application of Sen A at a concentration 50 μg/ml significantly inhibits TNF-α production.

EXAMPLE 5 - EFFECT OF SENKYUNOLIDE A AND Z-LIGUSTILIDE ON TNF-α PRODUCTION

The role of senkyunolide A (Sen A) and Z-ligustilide (Z-Lig) in suppressing TNF-α production is further evaluated in this Example. Briefly, 5 x 10^4 cells/ml BV-2 cells are seeded in 24-well plates (0.5 ml in each well). Cells are treated with 0.05% DMSO; 0.05% DMSO and 100 ng/ml LPS; 50 μg/ml Sen A / Z-Lig; or 100 ng/ml LPS and Sen A / Z-Lig at a concentration of 1 μg/ml, 5 μg/ml, 10 μg/ml, 25 μg/ml, and 50 μg/ml for 18 hours, respectively. The culture supernatant is collected and the level of secreted TNF-α is measured by ELISA.

The results, as shown in Figures 7 and 8, reveal that the application of Sen A and Z-Lig at a concentration of 5 and 10 μg/ml, respectively, significantly inhibits TNF-α production. Specifically, senkyunolide A at a concentration of 10 μg/ml, 25 μg/ml, and 50 μg/ml produces an approximately 2-fold, 4-fold, and 10-fold reduction in TNF-α production, respectively. Z-ligustilide also inhibits TNF-α production in a dose-dependent manner (Figure 8).

EXAMPLE 6 - MOLECULAR MECHANISMS OF DOWNREGULATION OF TNF-α PRODUCTION

The molecular pathways involved in senkyunolide A inhibition of TNF-α production are elucidated. It is well documented that the activation of cytokine production in LPS-treated cells is initiated by the binding of LPS to its receptor[19]. After binding to the receptor, a cascade of signaling kinases is activated. Among the activated kinases, MAP kinases play a crucial role in LPS-induced cytokine production. Previous studies illustrated that the induction of TNF-α by LPS and other pathogens requires the phosphorylation and activation of ERK1/2 and p38 MAPK[20].

To study the role of senkyunolide A in suppressing TNF-α production, 10^5 cells/ml BV-2 cells are treated with senkyunolide A at various concentrations for 1 hour prior to the addition of LPS for another 6 hours. Total RNA of the treated samples is isolated and subjected to semi-quantitative RT-PCR assays using specific human TNF-α primers. The results, as shown in Figure 9, reveal that senkyunolide A inhibits TNF-α mRNA and iNOS expression.

In addition, the effect of senkyunolide A on TNF-α mRNA stability is evaluated. Specifically, 10^5 cells/ml BV-2 cells are treated with Sen A at various concentrations for 1 hour prior to the addition of LPS for another 2 hours, and further incubated with 1μg/ml actinomycin for various time periods. Total RNA of the treated samples is isolated and subjected to real-time RT-PCR. The results, as shown in Figure 10, reveal that senkyunolide A destabilizes TNF-α mRNA.

EXAMPLE 7 – CYTOPROTECTIVE EFFECT OF Z-LIGUSTILIDE

This Example shows that Z-ligustilide (Z-Lig) suppresses cell death caused by hydrogen peroxide-induced cell injury. Briefly, PC-12 cells (2.5×10^4) are seeded in 24-well culture plates. The cells are treated with Z-ligustilide, followed by treatment with hydrogen peroxide to induce cell injury. The treated cells are incubated with 0.5 mg/ml MTT solution (Sigma Aldrich, St. Louis, MO) for 1 h at 37°C. The medium is discarded and 200 μl isopropyl alcohol (IPP) is then added. After 15 min of incubation, the absorbance is measured at 570 nm.

The results, as shown in Figure 11, reveal that hydrogen peroxide causes a marked decrease in cell viability. Treatment with 25 μg/ml Z-Lig increases cell viability from 17% to 57%. Treatment with 50 μg/ml Z-Lig further increases cell viability to 70%. The results reveal that Z-Lig protects cells from hydrogen peroxide-induced cell death.

All references, including publications, patent applications and patents, cited herein are hereby incorporated by reference to the same extent as if each reference was individually and specifically indicated to be incorporated by reference and was set forth in its entirety herein.

The terms "a" and "an" and "the" and similar referents as used in the context of describing the invention are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context.

Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. Unless otherwise stated, all exact values provided herein are representative of corresponding approximate values (*e.g.*, all exact exemplary values provided with respect to a particular factor or measurement can be considered to also provide a corresponding approximate measurement, modified by "about," where appropriate).

The use of any and all examples, or exemplary language (*e.g.*, "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise indicated. No language in the specification should be construed as indicating any element is essential to the practice of the invention unless as much is explicitly stated.

The description herein of any aspect or embodiment of the invention using terms such as "comprising", "having", "including" or "containing" with reference to an element or elements is intended to provide support for a similar aspect or embodiment of the invention that "consists of", "consists essentially of", or "substantially comprises" that particular element or elements, unless otherwise stated or clearly contradicted by context (*e.g.*, a composition described herein as comprising a particular element should be understood as also describing a composition consisting of that element, unless otherwise stated or clearly contradicted by context).

It should be 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.

REFERENCES

1 Ohlsson K, Bjork P, Bergenfeldt M, Hageman R, Thompson RC. Interleukin-1 receptor antagonist reduces mortality from endotoxin shock. Nature. 1990;348:550-552.

2 Tracey KJ, Fong Y, Hesse DG, et al. Anti-cachectin/TNF monoclonal antibodies prevent septic shock during lethal bacteraemia. Nature. 1987;330:662-664.

3 Montesano R, Soulie P, Eble JA, Carrozzino F. Tumour necrosis factor alpha confers an invasive, transformed phenotype on mammary epithelial cells. J Cell Sci. 2005;118:3487-3500.

4 Raetz CR. Biochemistry of endotoxins. Annu Rev Biochem. 1990;59:129-170.

5 Bone RC. Gram-negative sepsis. Background, clinical features, and intervention. Chest. 1991;100:802-808.

6 Raetz CR, Ulevitch RJ, Wright SD, Sibley CH, Ding A, Nathan CF. Gram-negative endotoxin: an extraordinary lipid with profound effects on eukaryotic signal transduction. Faseb J. 1991;5:2652-2660.

7 Tracey KJ, Cerami A. Tumor necrosis factor: a pleiotropic cytokine and therapeutic target. Annu Rev Med. 1994;45:491-503.

8 Aggarwal BB, Shishodia S, Sandur SK, Pandey MK, Sethi G. Inflammation and cancer: how hot is the link? Biochem Pharmacol. 2006;72:1605-1621.

9 Woodworth CD, McMullin E, Iglesias M, Plowman GD. Interleukin 1 alpha and tumor necrosis factor alpha stimulate autocrine amphiregulin expression and proliferation of human papillomavirus-immortalized and carcinoma-derived cervical epithelial cells. Proc Natl Acad Sci U S A. 1995;92:2840-2844.

[10] Montesano R, Soulie P, Eble JA, Carrozzino F. Tumour necrosis factor alpha confers an invasive, transformed phenotype on mammary epithelial cells. J Cell Sci. 2005;118:3487-3500.

[11] Raetz CR. Biochemistry of endotoxins. Annu Rev Biochem. 1990;59:129-170.

[12] Cheng SM, Xing B, Li JC, Cheung BK, Lau AS, Interferon-gamma regulation of TNF alpha-induced matrix metalloproteinase 3 expression and migration of human glioma T98G cells. Int J Cancer. 2007 Sep 15;121(6):1190-6

[13] Law AH, Lee DC, Cheung BK, Yim HC, Lau AS., J Virol, Role for nonstructural protein 1 of severe acute respiratory syndrome coronavirus in chemokine dysregulation. 2007 Jan; 81(1):416-22. Epub 2006 Oct 11.

[14] Cheung BK, Lee DC, Li JC, Lau YL, Lau AS., A role for double-stranded RNA-activated protein kinase PKR in Mycobacterium-induced cytokine expression. J Immunol. 2005 Dec 1;175(11):7218-25.

[15] Lee DC, Cheung CY, Law AH, Mok CK, Peiris M, Lau AS., p38 mitogen-activated protein kinase-dependent hyperinduction of tumor necrosis factor alpha expression in response to avian influenza virus H5N1.

[16] Li JC, Lee DC, Cheung BK, Lau AS., Mechanisms for HIV Tat upregulation of IL-10 and other cytokine expression: kinase signaling and PKR-mediated immune response. FEBS Lett. 2005 Jun 6;579(14):3055-62.

[17] Yim HC, Li JC, Lau JS, Lau AS., HIV-1 Tat dysregulation of lipopolysaccharide-induced cytokine responses: microbial interactions in HIV infection. AIDS. 2009 Jul 31;23(12):1473-84.

[18] Cheng SM, Li JC, Lin SS, Lee DC, Liu L, Chen Z, Lau AS., HIV-1 transactivator protein induction of suppressor of cytokine signaling-2 contributes to dysregulation of IFN{gamma} signaling. Blood. 2009 May 21;113(21):5192-201. Epub 2009 Mar 11.

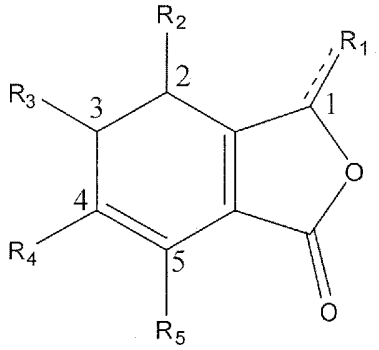
[19] Lu YC, Yeh WC, Ohashi PS. LPS/TLR4 signal transduction pathway. Cytokine. 2008;42:145-151.

[20] Kim SH, Kim J, Sharma RP. Inhibition of p38 and ERK MAP kinases blocks endotoxin-induced nitric oxide production and differentially modulates cytokine expression. Pharmacol Res. 2004;49:433-439.

CLAIMS

We claim:

1. A method for treating a subject to reduce inflammation and/or to modulate an immune response, wherein said method comprises administering, to a subject in need of such treatment, an effective amount of an isolated compound having the following formula:



wherein

====== represents a carbon-carbon single bond or a carbon-carbon double bond;

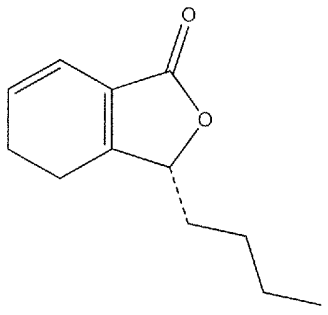
R_1 is alkyl or CR_6, wherein R_6 is alkyl, acyl, haloalkyl, alkylamino or hydroxylalkyl;

R_2, R_3 and R_4 are, independently, –H, acyl, halo, haloalkyl, amino, alkylamino, hydroxyl, alkyl, hydroxylalkyl, or –COOH; and

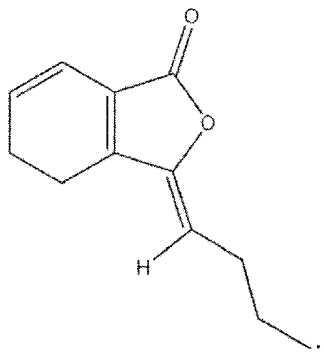
R_5 is –H, alkyl, halo, haloalkyl, amino, alkylamino, hydroxylalkyl, or –COOH.

2. The method, according to claim 1, wherein the subject is a human.

3. The method, according to claim 1, wherein the compound is selected from



and



4. The method, according to claim 1, used to reduce inflammation.

5. The method, according to claim 1, used to reduce TNF-α production.

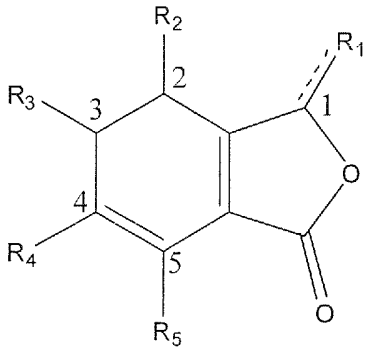
6. The method, according to claim 1, used to reduce nitric oxide production.

7. The method, according to claim 1, used to reduce TNF-α mRNA stability.

8. The method, according to claim 1, used to treat a condition selected from the group consisting of an infection, inflammation caused by an environmental toxin, an autoimmune condition, neurodegenerative disease, cardiovascular disease, cerebrovascular disease, intestinal inflammation, post-infection associated neurological neuralgia, shingles, chronic fatigue syndrome, inflammation caused by concurrent infection or immunological over-reaction to pathogen invasion, allergy, graft rejection, pathological immune cell proliferation or activity, and respiratory inflammation.

9. The method, according to claim 1, used to treat a condition selected from the group consisting of ischemic stroke, rheumatoid arthritis, psoriasis, cardiovascular disease, cerebrovascular disease, inflammatory bowel disorder, septic shock, graft vs. host rejection, varicella zoster infection, herpes simplex infection, cytomegalovirus infection, herpes simplex virus-8 infection, neuralgia, and neurasthenia associated with herpes zoster reactivation.

10. A method for treating a subject having a condition associated with TNF-α overproduction, wherein said method comprises administering, to the subject in need of such treatment, an effective amount of an isolated compound having the following formula:



wherein

------ represents a carbon-carbon single bond or a carbon-carbon double bond;

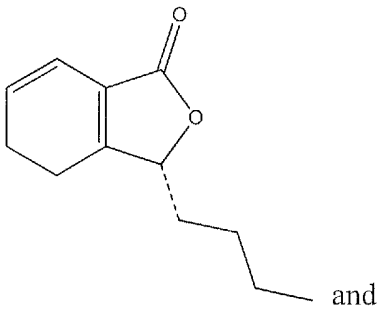
R_1 is alkyl or CR_6, wherein R_6 is alkyl, acyl, haloalkyl, alkylamino or hydroxylalkyl;

R_2, R_3 and R_4 are, independently, –H, acyl, halo, haloalkyl, amino, alkylamino, hydroxyl, alkyl, hydroxylalkyl, or –COOH; and

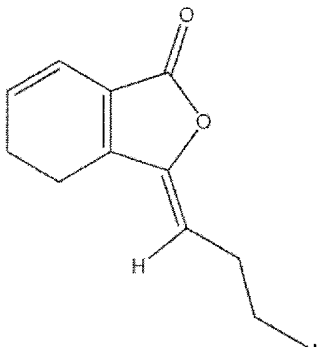
R_5 is –H, alkyl, halo, haloalkyl, amino, alkylamino, hydroxylalkyl, or –COOH.

11. The method, according to claim 10, wherein the subject is a human.

12. The method, according to claim 10, wherein the compound is selected from



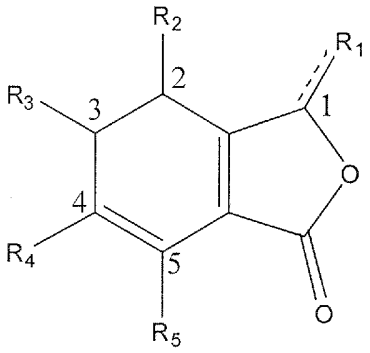
and



13. A method for treating a subject to reduce inflammation and/or to modulate an immune response, wherein said method comprises

(a) determining the presence and/or level of one or more immune system markers in the subject; and

(b) administering, to the subject in need of such treatment, an effective amount of an isolated compound having the following formula:



wherein

------ represents a carbon-carbon single bond or a carbon-carbon double bond;R_1 is alkyl or CR_6, wherein R_6 is alkyl, acyl, haloalkyl, alkylamino or hydroxylalkyl;

R_2, R_3 and R_4 are independently –H, acyl, halo, haloalkyl, amino, alkylamino, hydroxyl, alkyl, hydroxylalkyl, or –COOH; and

R_5 is –H, alkyl, halo, haloalkyl, amino, alkylamino, hydroxylalkyl, or –COOH;

wherein the immune system marker is selected from the group consisting of TNF-α, NO, IFN-γ, IL-1, IL-2, IL-3, IL-5, IL-4, IL-6, IL-8, IL-10, IL-12, IL-13, IL-14, IL-17, IL-18,

IL-23, IL-24, IL-25, IL27, IL-32, G-CSF, M-CSF, MCP-1, MIP-2, MIP-1α, IgA, IgG, IgM, IgD and IgE.

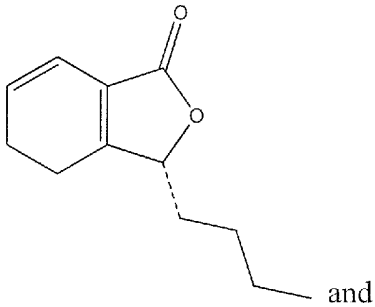
14. The method, according to claim 13, wherein the presence and/or level of the marker is determined in a bodily fluid sample of the subject.

15. The method, according to claim 14, further comprising step (c): determining the presence and/or level of one or more immune system markers in the subject after step (b).

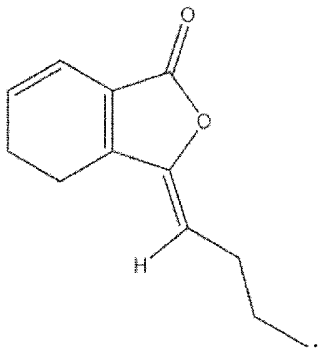
16. The method, according to claim 15, wherein step (c) is performed repeatedly over time.

17. The method, according to claim 14, wherein the subject is a human.

18. The method, according to claim 14, wherein the compound is selected from



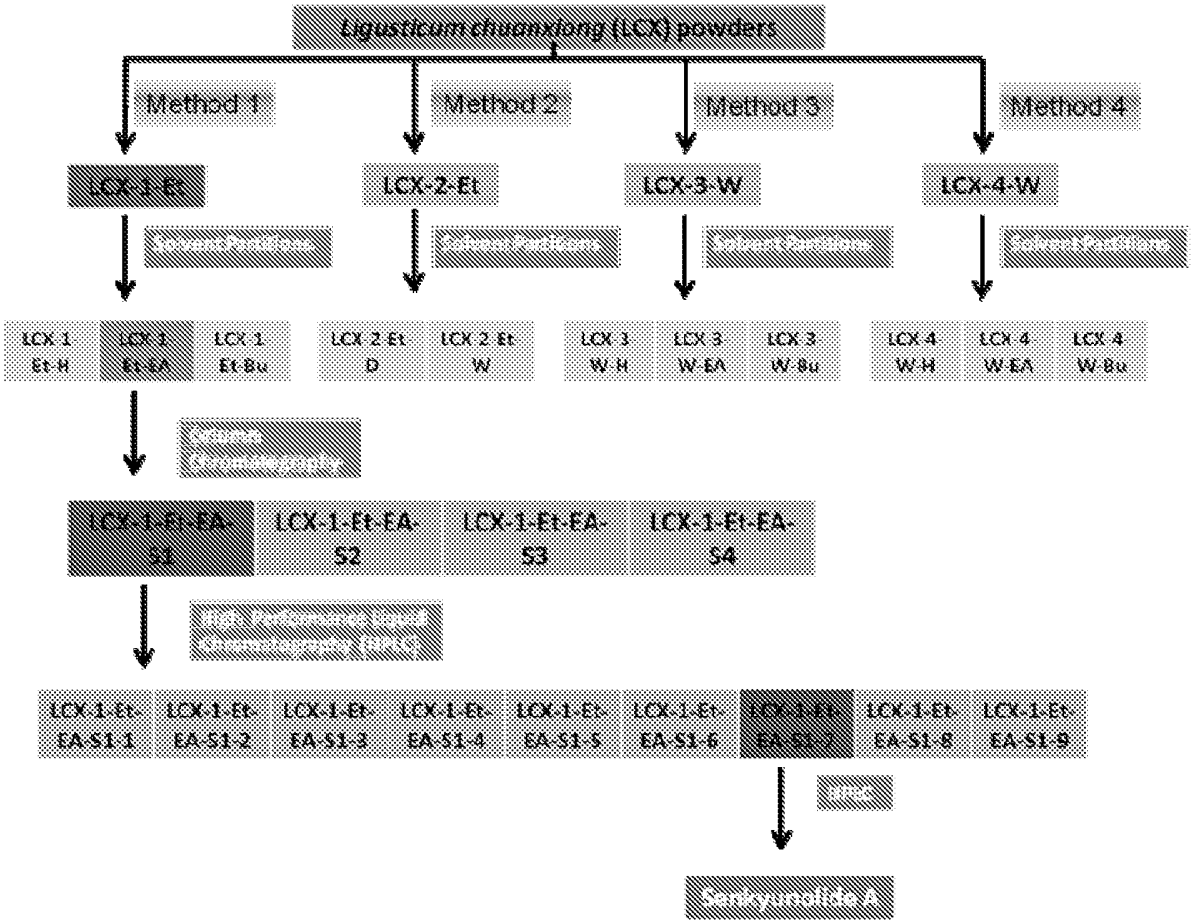
and



19. The method, according to claim 13, used to treat a condition selected from the group consisting of an infection, inflammation caused by an environmental toxin, an autoimmune condition, neurodegenerative disease, cardiovascular disease, cerebrovascular disease, intestinal inflammation, post-infection associated neurological neuralgia, shingles, chronic

fatigue syndrome, inflammation caused by concurrent infection or immunological over-reaction to pathogen invasion, allergy, graft rejection, pathological immune cell proliferation or activity, and respiratory inflammation.

20. The method, according to claim 13, used to treat a condition selected from the group consisting of ischemic stroke, rheumatoid arthritis, psoriasis, cardiovascular disease, cerebrovascular disease, inflammatory bowel disorder, septic shock, graft vs. host rejection, varicella zoster infection, herpes simplex infection, cytomegalovirus infection, herpes simplex virus-8 infection, neuralgia, and neurasthenia associated with herpes zoster reactivation.



Method 1: Macerate in absolute ethanol at room temperature with continous sonication for 30min

Method 2: Reflux in 70% ethancl for 30min

Method 3: Boil in water for 30min

Method 4: Macerate in water at room temperature with continuous sonication for 30min

Figure 1: The extraction scheme of senkyunolide A from *Ligusticum chuanxiong*.

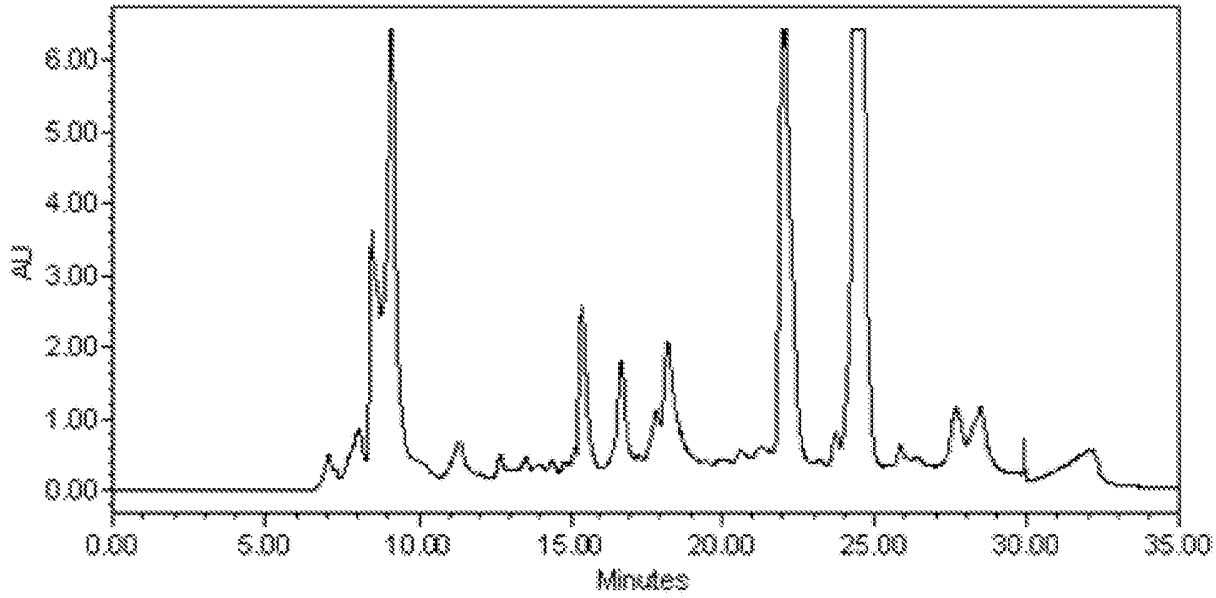


Figure 2a): High performance liquid chromatography (HPLC) chromatogram of LCX-1-Et-EA-S1.

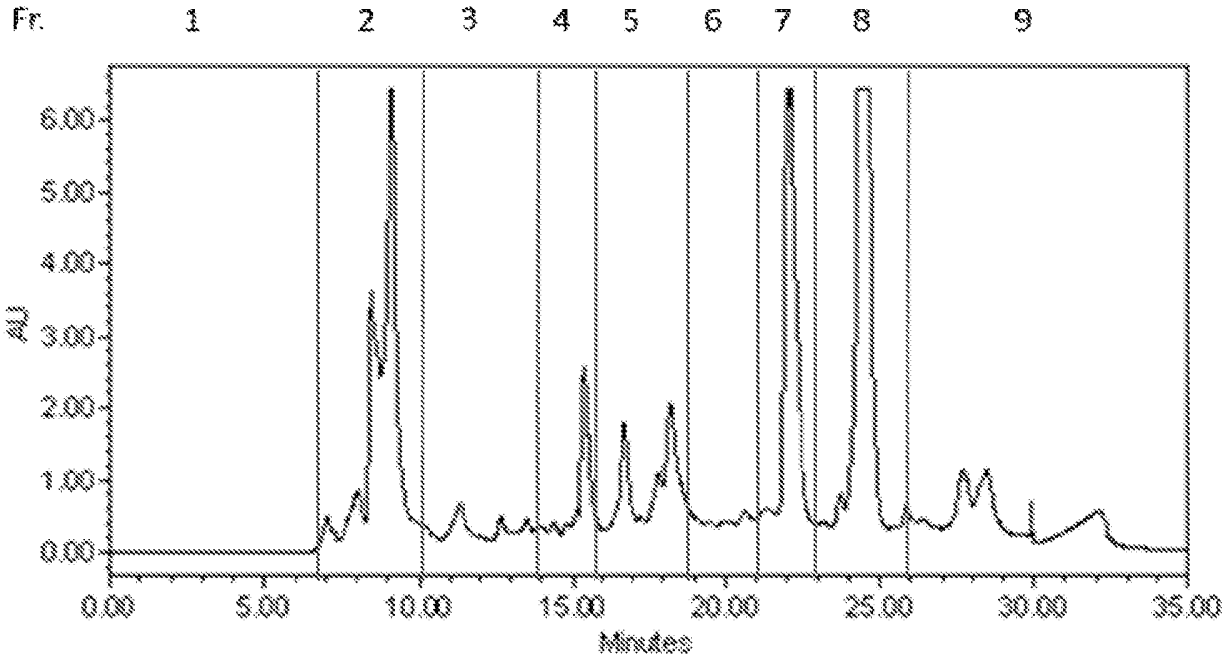


Figure 2b): Fractionation of LCX-1-Et-EA-S1 using HPLC.

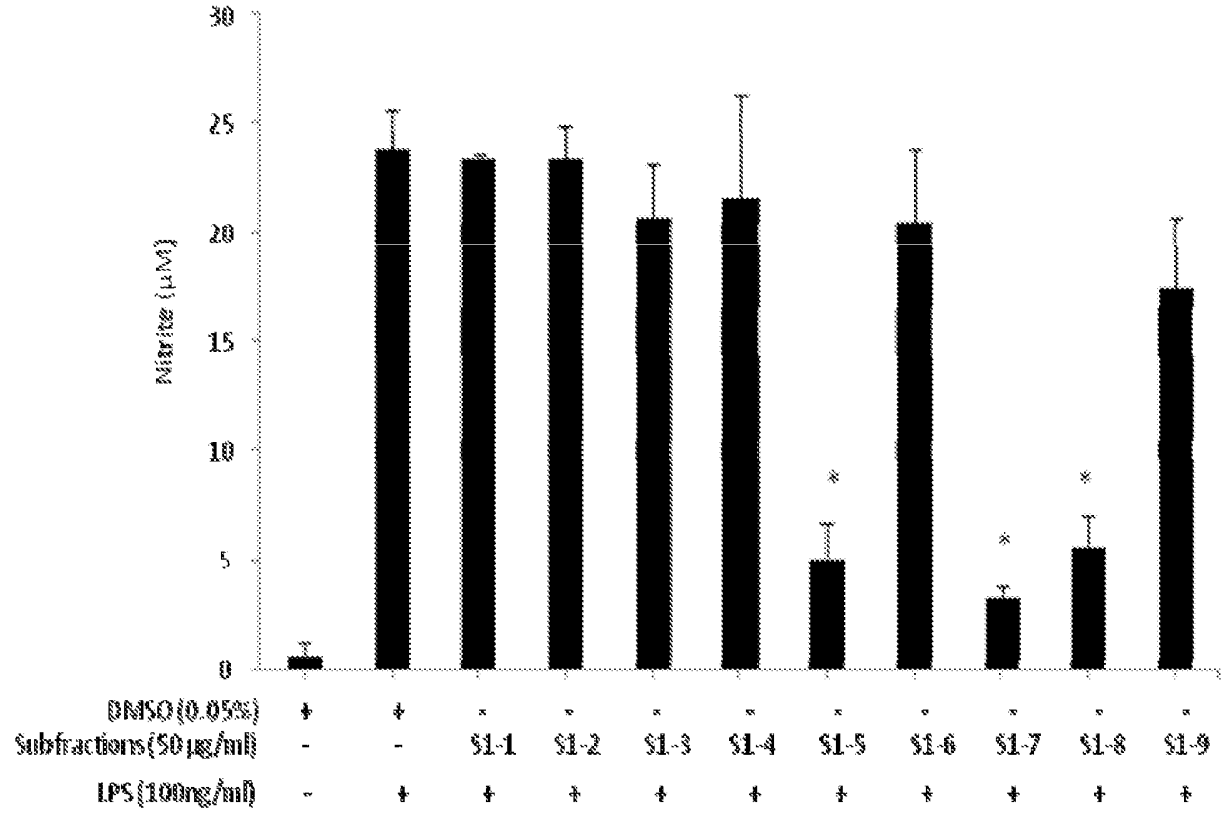


Figure 3: The effect of different subfractions separated from LCX-1-Et-EA-S1 on the production of nitrite in LPS-induced BV-2 cells.

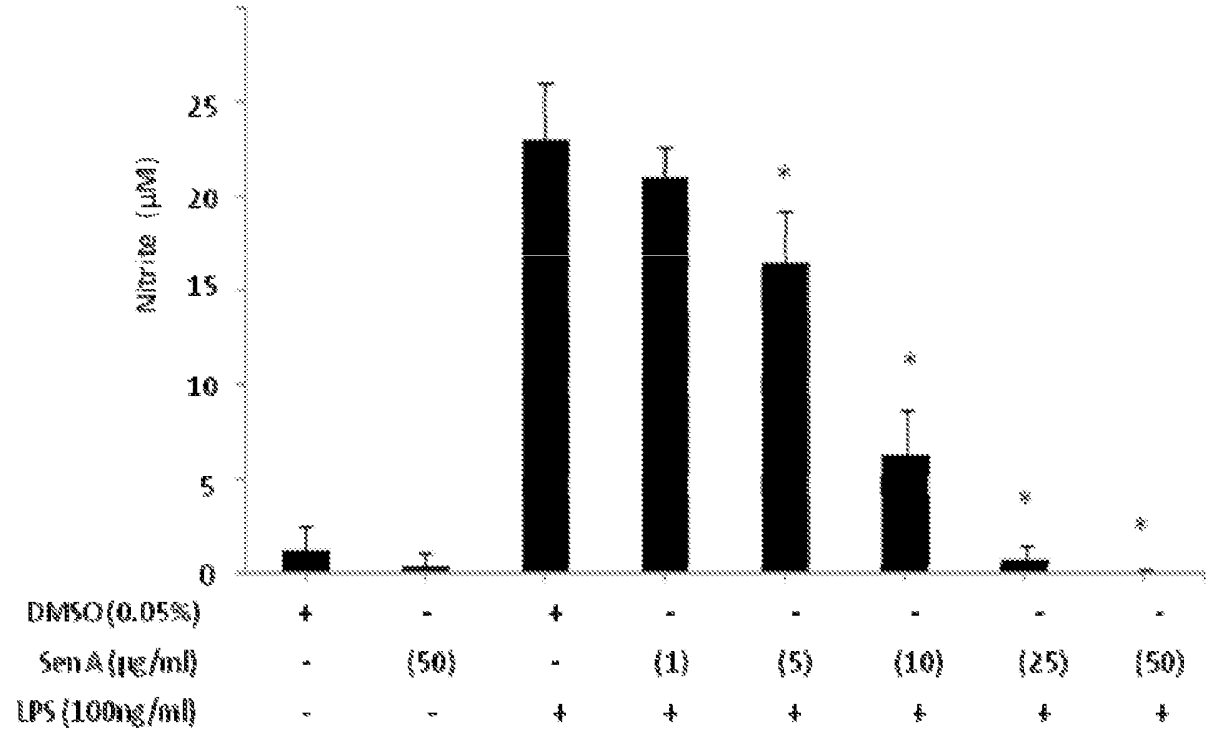


Figure 4: The dose-dependent effect of senkyunolide A (Sen A) on the production of nitrite in LPS-induced BV-2 cells.

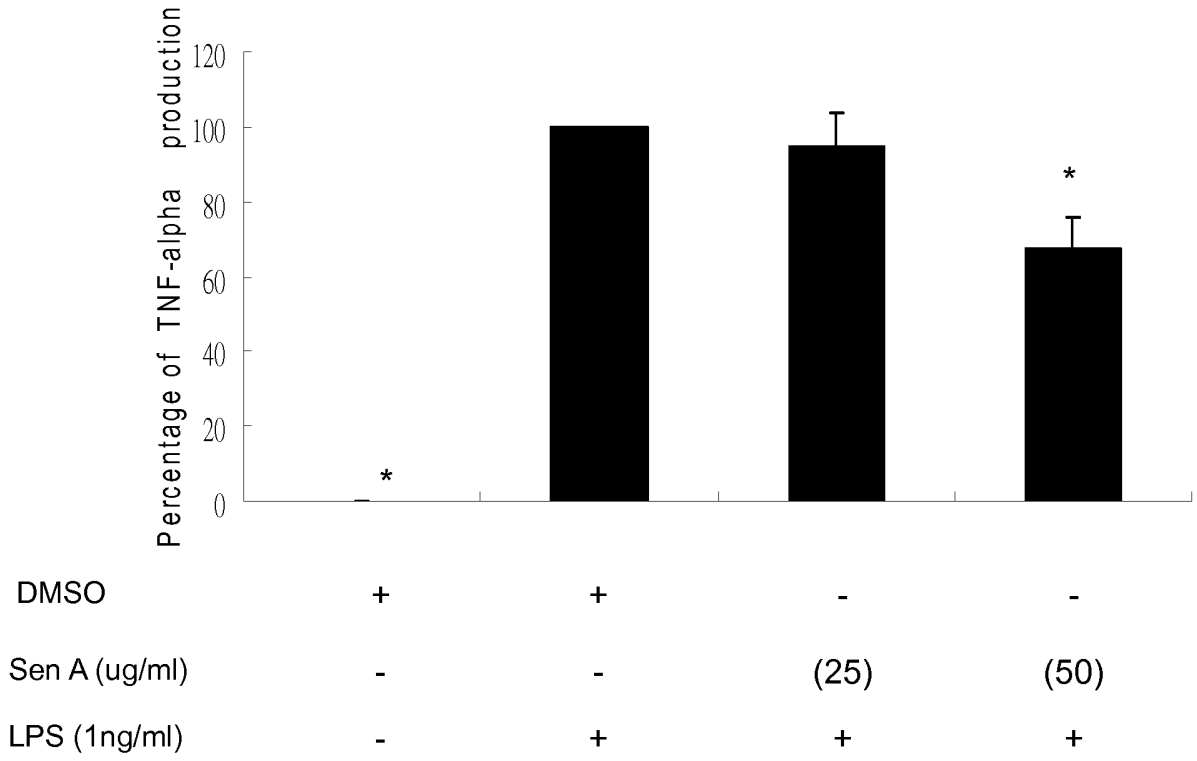


Figure 5: The effect of Senkyunolide A (Sen A) on the production of TNF-α in LPS-induced human blood macrophages.

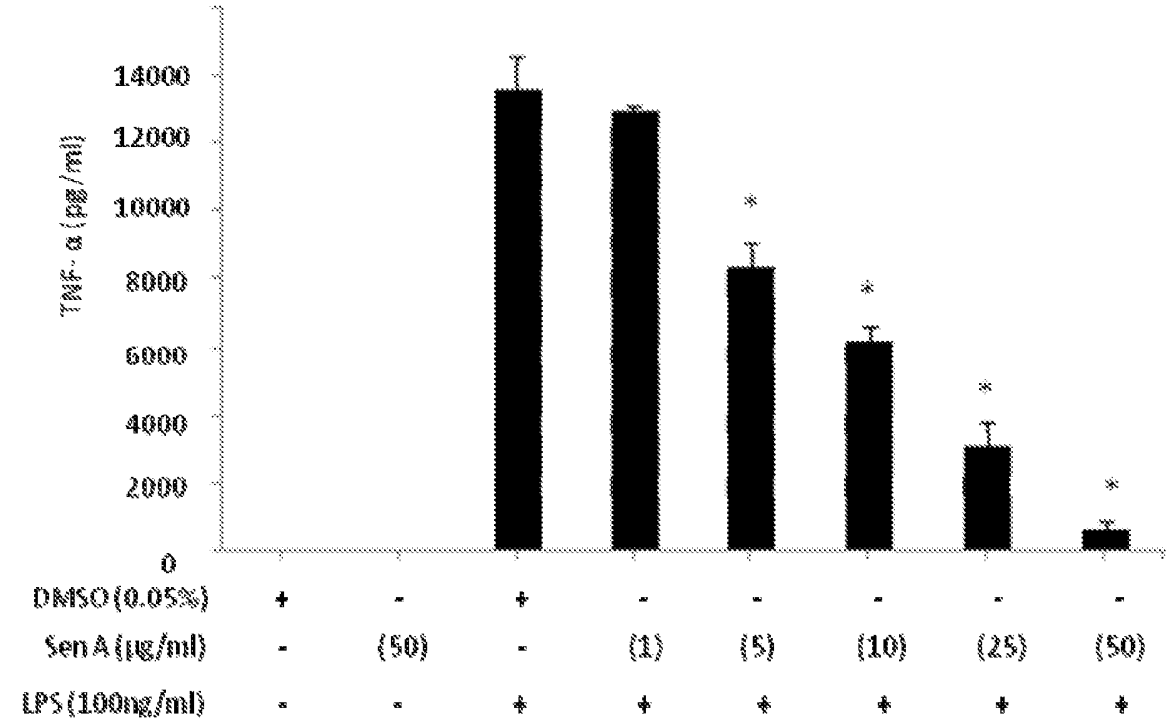


Figure 6: The dose-dependent effect of Senkyunolide A (Sen A) on the production of TNF-α protein in LPS-induced BV-2 cells.

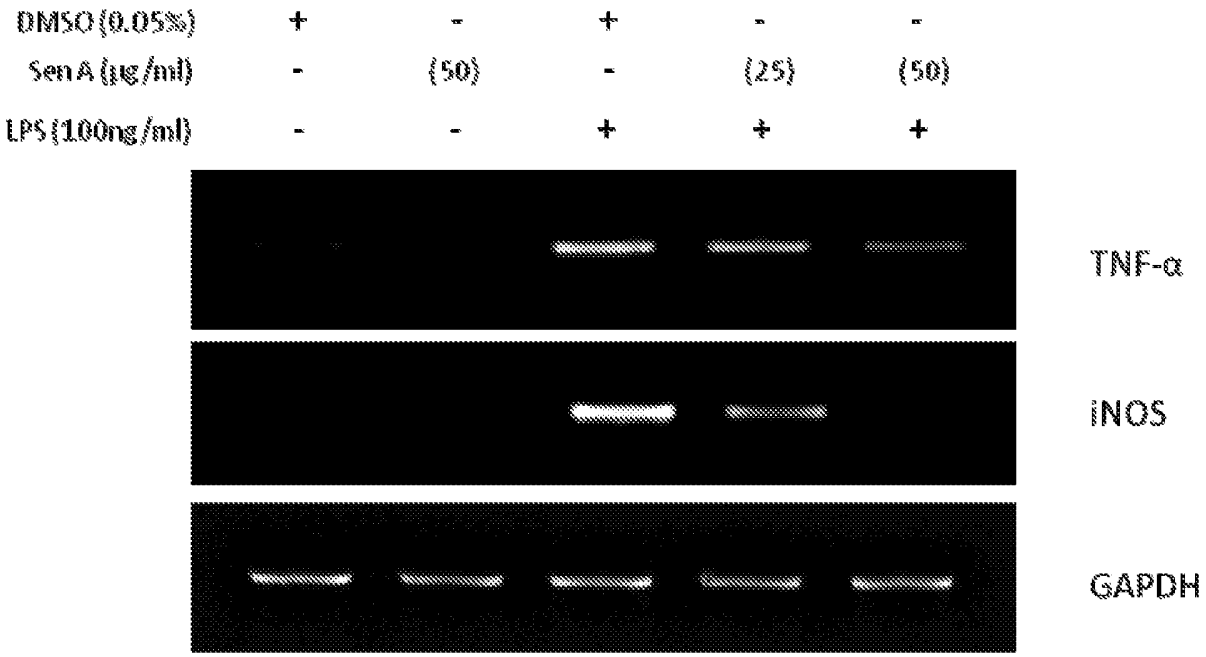


Figure 7: The effect of senkyunolide A (Sen A) on the mRNA expressions of TNF-α and iNOS in LPS-induced BV-2 cells.

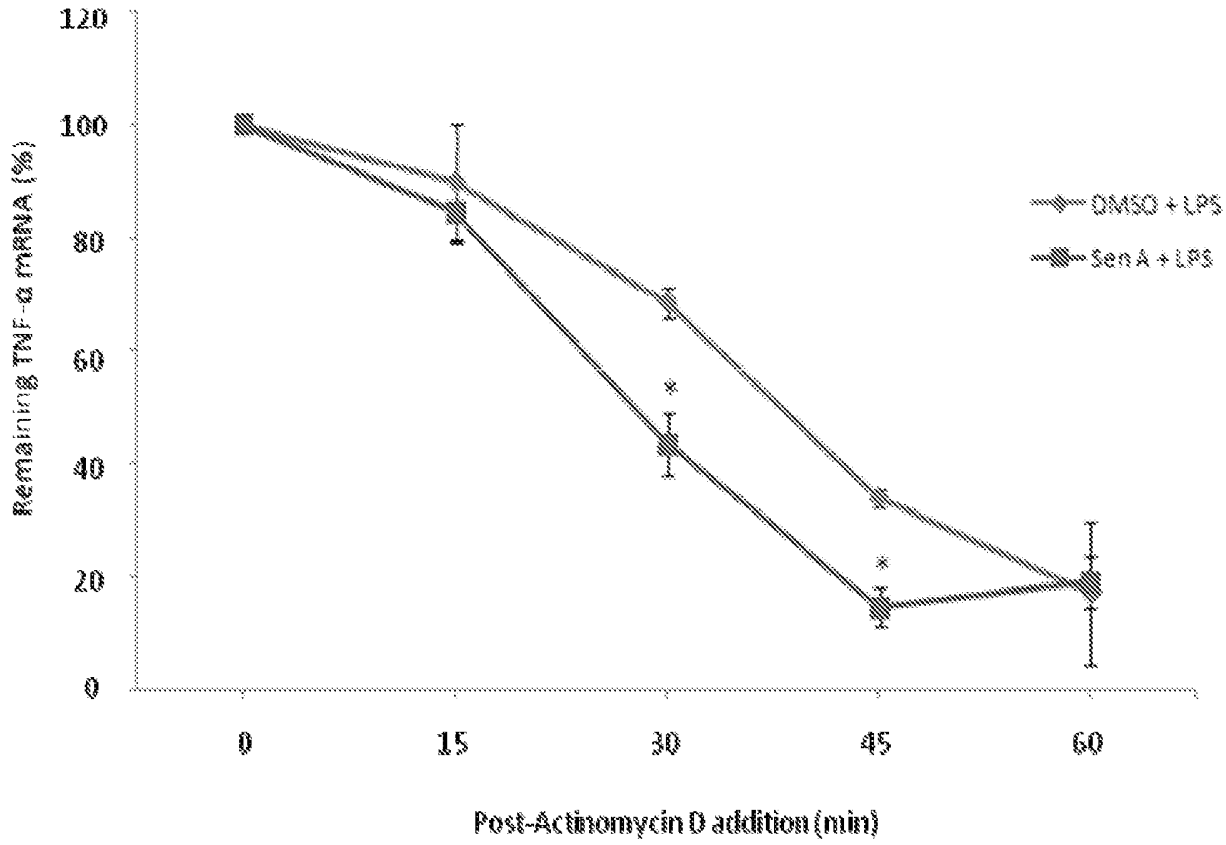


Figure 8: The effect of senkyunolide A (Sen A) on the mRNA stability of TNF-α in LPS-induced BV-2 cells.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2010/003050

A. CLASSIFICATION OF SUBJECT MATTER

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC：A61K31/-, A61P29/-, A61P37/-, A61P19/-, A61P17/-, A61P11/-

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

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

WPI, EPODOC, CNPAT, CNKI, CA, immun+, senkyunolide A, ligustilide, inflammat+, 62006-39-7, 81944-09-4

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO2006125651A2 (DSM IP ASSETS B.V.), 30 Nov. 2006 (30.11.2006) see pages 9-10 of description, table 0, examples 5-6	1-20
X	US20030165580A1 (ZHAO, Xinxian), 04 Sep. 2003 (04.09.2003) see examples 5-12	1-20
X	CN1810241A (JIANGXI QINGFENG PHARM IND CO. LT.), 02 Aug. 2006 (02.08.2006) see pages 13-17 of description	1-20
X	WO2008006581A2 (DSM IP ASSETS B.V.), 17 Jan. 2008 (17.01.2008) see pages 4-5 of description, examples 1-2	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 Feb. 2011(23.02.2011)	**31 Mar. 2011 (31.03.2011)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer KANG, Lei Telephone No. (86-10)82245571

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2010/003050

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 1-20
because they relate to subject matter not required to be searched by this Authority, namely:
Claims 1-20 are directed to methods for treatment of diseases. But the report has been established and based on the use of manufacture of medicaments of the compounds.

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2010/003050

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO2006125651A2	30.11.2006	CN101184484A	21.05.2008
		EP1937250A2	02.07.2008
		KR20080015802A	20.02.2008
		INDELNP200708512E	04.07.2008
		JP2008542226T	27.11.2008
		US2009176873A1	09.07.2009
		US2010298427A1	25.11.2010
US20030165580A1	04.09.2003	None	
CN1810241A	02.08.2006	CN100506225C	01.07.2009
WO2008006581A2	17.01.2008	CN101516364A	26.08.2009
		WO2008006581A3	05.06.2008
		EP2040696A2	01.04.2009
		KR20090028836A	19.03.2009
		INDELNP200900789E	12.06.2009
		JP2010500964T	14.01.2010
		US2010056463A1	04.03.2010

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2010/003050

Continuation of : **A. CLASSIFICATION OF SUBJECT MATTER**

A61K31/343 (2006.01)i

A61P29/00 (2006.01)i

A61P37/02 (2006.01)i

A61P37/06 (2006.01)i

A61P19/02 (2006.01)i

A61P17/02 (2006.01)i

A61P11/00 (2006.01)i