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(54) Title: INHIBITORS OF GLYCOGEN SYNTHASE KINASE-3 (GSK-3) FOR TREATING GLAUCOMA

(57) Abrégé/Abstract:
The use of inhibitors of GSK-3 useful for treating glaucoma is disclosed.

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(57) Abstract: The use of inhibitors of GSK-3 useful for treating glaucoma is disclosed.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

INHIBITORS OF GLYCOGEN SYNTHASE KINASE-3 (GSK-3) FOR TREATING GLAUCOMA

The present invention is directed to inhibitors of glycogen synthase kinase-3 for lowering and controlling normal or elevated intraocular pressure (IOP) and treating glaucoma.

Background of the Invention

The disease state referred to as glaucoma is characterized by a permanent loss of visual function due to irreversible damage to the optic nerve. The several morphologically or functionally distinct types of glaucoma are typically characterized by elevated IOP, which is considered to be causally related to the pathological course of the disease. Ocular hypertension is a condition wherein intraocular pressure is elevated, but no apparent loss of visual function has occurred; such patients are considered to be a high risk for the eventual development of the visual loss associated with glaucoma. Some patients with glaucomatous field loss have relatively low intraocular pressure. These so called normotension or low tension glaucoma patients can also benefit from agents that lower and control IOP. If glaucoma or ocular hypertension is detected early and treated promptly with medications that effectively reduce elevated intraocular pressure, loss of visual function or its progressive deterioration can generally be ameliorated. Drug therapies that have proven to be effective for the reduction of intraocular pressure include both agents that decrease aqueous humor production and agents that increase the outflow facility. Such therapies are in general administered by one of two possible routes, topically (direct application to the eye) or orally.

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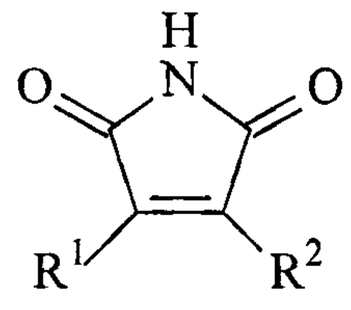
There are some individuals who do not respond well when treated with certain existing glaucoma therapies. There is, therefore, a need for other topical therapeutic agents that control IOP.

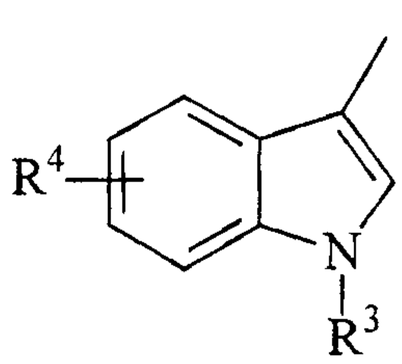
Summary of the Invention

The present invention is directed to inhibitors of GSK-3 which can be used to treat glaucomatous optic neuropathy and/or lower and control IOP associated with normal-tension glaucoma, ocular hypertension, and/or glaucoma in warm blooded animals, including man. The compounds are formulated in pharmaceutical compositions suitable for topical delivery to the eye.

According to one aspect of the present invention, there is provided use, for treating glaucomatous optic neuropathy, of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable carrier, wherein said GSK-3 inhibitor is a compound of the formula:



wherein R^1 and R^2 independently =



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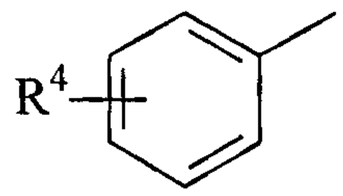

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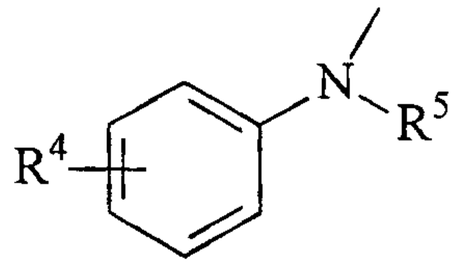

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R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkylC(O)$_2R^5$, C_{1-6}alkylC(O)NR^6R^7;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl, $-OR^6$, $-SR^6$, halogen, (un)substituted phenoxy, -CN, $-NO_2$, C_{1-6}alkyl-NR^6R^7, $-NR^6R^7$, C_{1-7}cycloalkyl, (un)substituted heterocyclyl, $-C(O)_2R^5$, C_{1-6}alkylC(O)$_2R^5$, C_{1-6}alkylC(O)NR^6R^7; and

R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl, or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

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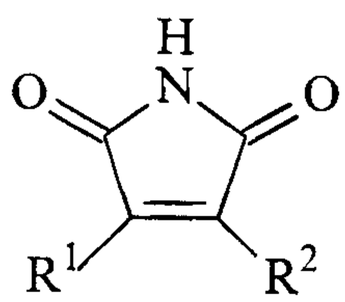

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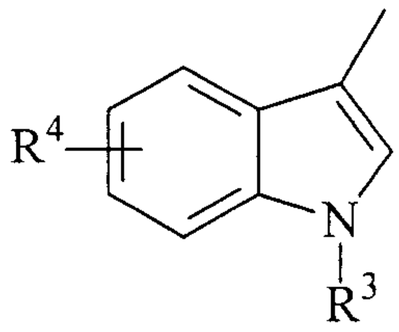

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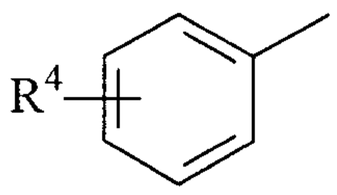

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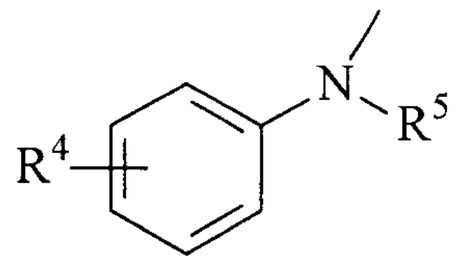

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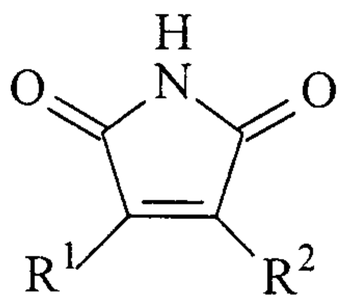

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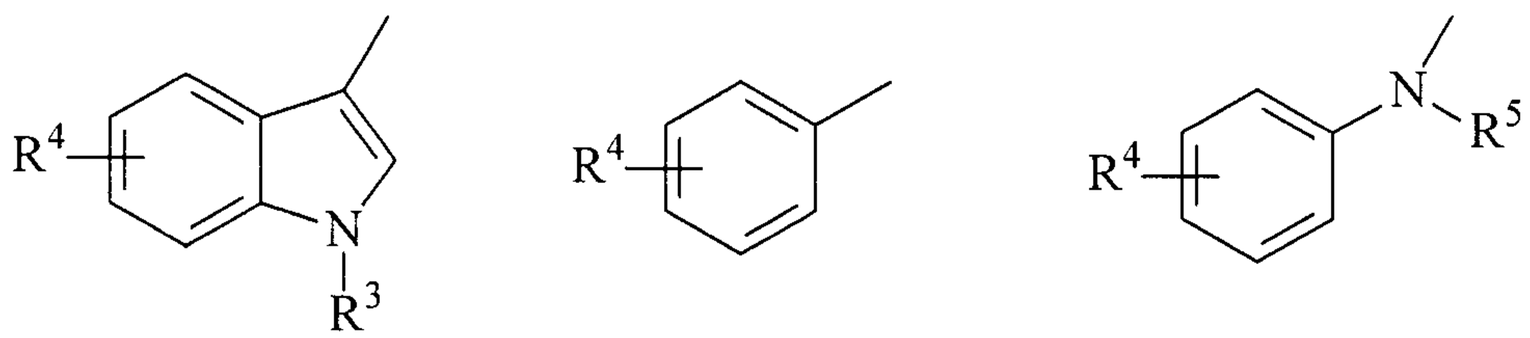

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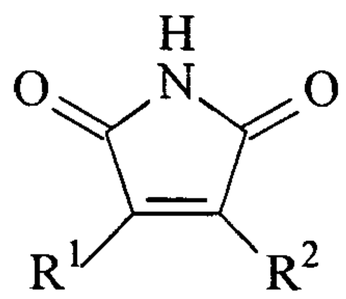

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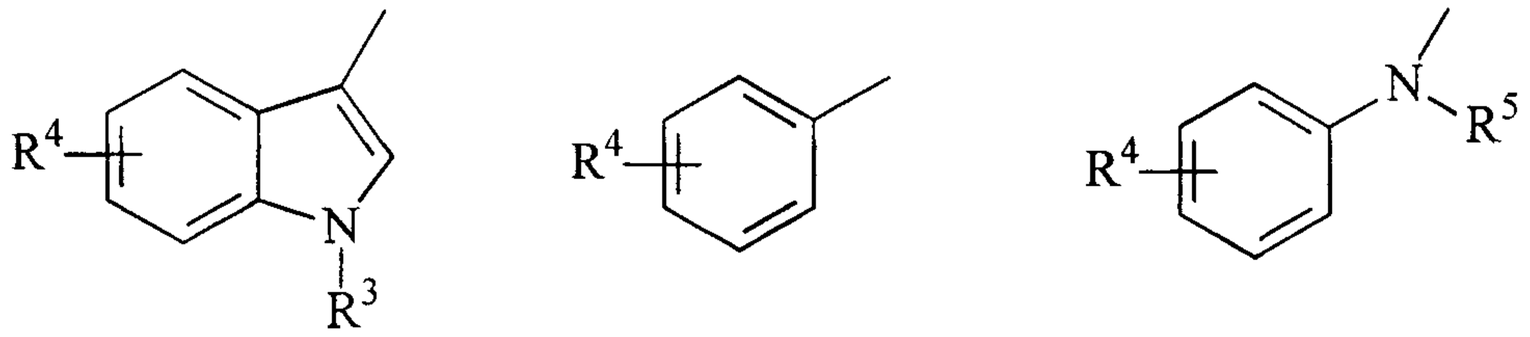

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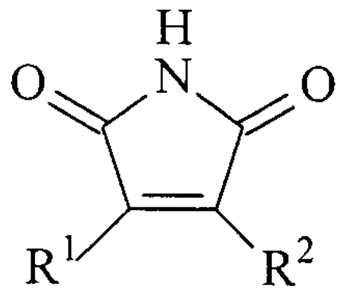

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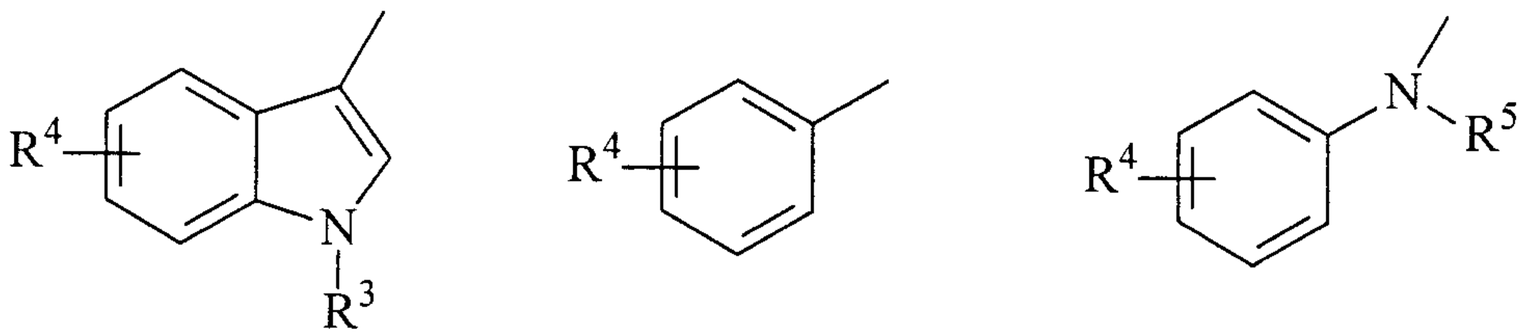

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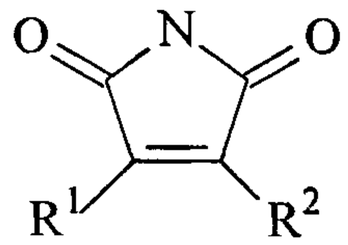

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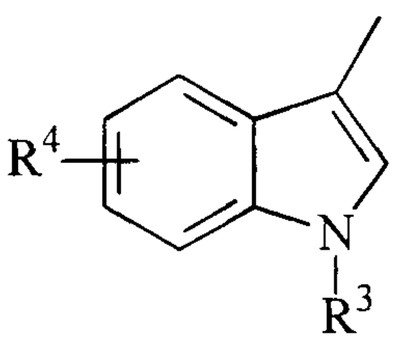

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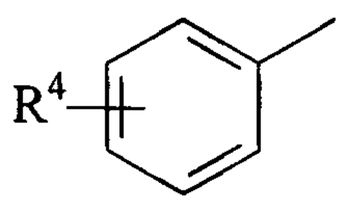

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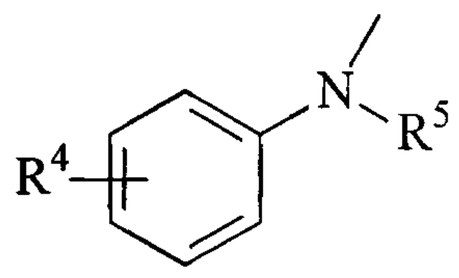

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Description of the Preferred Embodiments

Elevated intraocular pressure (IOP) is often an indicator of glaucoma. Left unchecked, continual and long term elevated IOP can contribute to the progressive deterioration of the retina and the loss of visual function. Therefore, lowering IOP is often an objective in the treatment of glaucoma patients in order to decrease the potential for or severity of glaucomatous retinopathy. It has been shown that even those glaucoma patients who do not exhibit elevated levels of IOP benefit from agents that lower and control IOP. Unfortunately, some individuals do not respond well when treated with certain existing glaucoma therapies.

Wnt proteins comprise a large family of structurally related ligands that activate the Wnt signaling pathway. The frizzle family of proteins are key components in this pathway serving as membrane bound receptors for Wnt. The frizzle proteins are a family of seven transmembrane proteins that have an N-terminal extracellular cysteine rich domain and a cytoplasmic carboxylate tail. Binding of Wnt to frizzle initiates a cascade of events one of which results in the inhibition of (GSK-3) preventing the phosphorylation of β-catenin. Phosphorylation of β-catenin leads to its degradation. Activation of the Wnt pathway increases the intracellular concentration of uncomplexed β-catenin which can

activate β-catenin- T cell factor/Lymphoid enhancer factor (TCF/Lef) dependent gene transcription.

Frizzle Related Proteins (FRP) are a family of secreted proteins with cysteine rich regions that are homologous to those of the frizzle family of proteins but lack the membrane-spanning segments of the frizzle proteins. The secreted FRP acts to antagonize the Wnt signaling pathway by binding extracelluar Wnt and preventing it from interacting with frizzle proteins or by forming a nonfunctional complexes with the frizzled receptor. Bafico *et al.* (1999).

Recently it has been discovered that frizzled related protein (FRP) is differentially expressed in a number of glaucomatous trabecular meshwork cell lines. Perfusion of FRP-1 through perfused human ocular anterior segments maintained in culture resulted in a decrease in flowrate and a corresponding decrease in β-catenin protein levels in the ciliary body and the trabecular meshwork (TM). The decreased flow rate in the cultured anterior segments models an increase in resistance to outflow (increase in intraocular pressure) in intact eye. These results show that there is an active Wnt signaling pathway in the TM and ciliary body and suggest that this pathway is responsible at least in part for maintaining outflow through the TM and thereby controlling IOP.

Since the intracellular level of β-catenin is at least partially regulated by its phosphorylation by GSK-3, inhibition of GSK-3 results in the increase in uncomplexed soluble β-catenin irrespective of the levels of FRP. GSK-3 inhibitors circumvent the FRP mediated antagonism of the Wnt signaling pathway caused by the elevated levels of FRP and counteract the increase in outflow resistance that results from the increase in production of FRP in individuals with glaucoma.

Increased expression of FRP was also detected in the retinas from human donors having retinitis pigmentosa (RP). RP is a family of degenerative diseases that effect the photoreceptors and causes blindness. Since FRP stimulates apoptosis in neurons *in vitro* the presence of elevated FRP suggests that FRP mediated disruption of Wnt signaling may

be involved in retinal degeneration. Although glaucoma is the selective loss of retinal ganglion cells and not photoreceptor cells toxicity mediated by increased expression of FRP or by other mechanism governed by a GSK-3 mediated pathway may contribute to the loss of retinal ganglion cells in glaucoma. Therefore GSK-3 inhibitors would treat the loss of retinal ganglion and also reduce intraocular pressure by increasing aqueous humor outflow.

While not being bound by theory the inventors believe that inhibition of GSK-3 will lower and control normal or elevated intraocular pressure (IOP) and treat glaucomatous optic neuropathy. Compounds that act as GSK-3 inhibitors are well known and have shown a variety of utilities, primarily for disorders or conditions associated with diabetes, dementias such as Alzheimer's disease and manic depression. U.S. Patent No. 6,057,117 discloses the use of selective inhibitors of GSK-3 for the treatment of diseases that are mediated by GSK-3 activity including diabetes mellitus. WO 00/38675 discloses a method of treatment of conditions associated with a need for the inhibition of GSK-3, such as diabetes, conditions associated with diabetes, chronic neurodegenerative conditions including dementias such as Alzheimer's disease, manic depression, mood disorders such as schizophrenia, neurotraumatic disorders such as acute stroke, hair loss and cancer. WO 00/21927 discloses certain pyrrole-2,5-dione derivatives that are GSK-3 inhibitors for the treatment of diabetes, dementias such as Alzheimer's disease and manic depression. WO 01/56567 describes 2,4-dimainothiazole derivatives and their use as GSK-3 inhibitors, WO 01/49709 describes peptide inhibitors of GSK-3, WO 01/47533 discloses the development of modulatory strategies for the treatment of various diseases. WO 01/41768 discloses the use of hymenialdisine or derivatives for inhibiting cyclin dependent kinases, GSK-3 beta and casein kinase 1 for treating neurodegenerative disorders such as Alzheimer's disease, diabetes, inflammatory pathologies and cancers. WO 01/37819 discloses the use of indirubine derivatives for making medicines inhibiting GSK-3 beta.

Certain paullones analogs have been reported (Leost *et al.* 2000) to be GSK-3 inhibitors. These compounds were proposed to be useful in the study and possible treatment of neurodegenerative and proliferative disorders.

3-Anilino-4-arylmaleimides have been reported to be potent and selective inhibitors of GSK-3 (Smith *et al.* 2001).

Hymenialdisine is an inhibitor of GSK-3. It was suggested to have potential in treating neurodegenerative disorders (Thunnissen *et al.* 2000).

The protein kinase C inhibitors GF1092 and Ro 31-8220 have been reported to be inhibitors of GSK-3 (Tavare *et al.* 1999).

Indirubines inhibit GSK-3 (Garnier *et al.* 2001). A potential application for the use of the indirubines as a treatment of neurodegenerative disorders was disclosed.

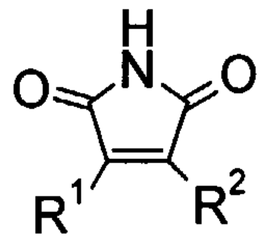
GSK-3 inhibitors SB-415286 and SB216763 protected both central and peripheral neurons grown in culture from death induced by reduced phosphatidyl inositol pathway activity (Cross *et al.* 2000).

The use of these compounds to lowering and controlling normal or elevated intraocular pressure (IOP) and to treat glaucoma has not been disclosed.

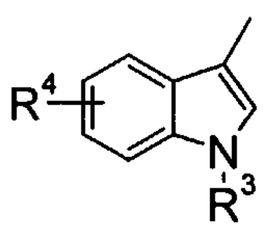
This invention is directed at the treatment of glaucoma by the inhibition of GSK-3. It is contemplated that any GSK-3 inhibiting compound will be useful in the methods of the present invention. The inventors contemplate that any of the compounds disclosed in WO 00/38675; WO 00/21927; Coglan *et al.* 2000; Leost *et al.* 2001; Smith *et al.* 2001; Garnier *et al.* 2001; Cross *et al.* 2001; Thunnissen *et al.* 2000; Tavare *et al.* 1999 (as discussed above) will be particularly useful.

In one preferred embodiment, the compound for use in the methods of the invention will be selected from compounds defined in WO 00/21927, EP 470490, WO 93/18766, WO 93/18765, EP 397060, WO 98/11103, WO 98/11102, WO 98/04552, WO 98/04551, DE 4243321, DE 4005970, DE 3914764, WO 96/04906, WO 95/07910, DE 4217964, US 5856517, US 5891901, WO 99/42100, EP 328026, EP 384349, EP 540956, DE 4005969, or EP 508792.

Preferred compounds include compounds of the formula:



wherein R^1 and R^2 independently =



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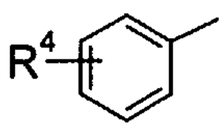

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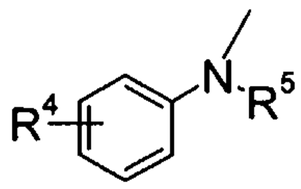

C

R^3 = H, $C_{1\text{-}6}$alkyl, (un)substituted phenyl, $C_{1\text{-}6}$alkyl-NR^6R^7, $C_{1\text{-}7}$cycloalkyl, $C_{1\text{-}6}$alkyl-OR^6, $C_{1\text{-}6}$alkyl$C(O)_2R^5$, $C_{1\text{-}6}$alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents $C_{1\text{-}6}$alkyl, (un)substituted phenyl, -OR^6, -SR^6, halogen, (un)substituted phenoxy, -CN, -NO_2 , $C_{1\text{-}6}$alkyl-NR^6R^7, -NR^6R^7, $C_{1\text{-}7}$cycloalkyl, (un)substituted heterocyclyl, -$C(O)_2R^5$, $C_{1\text{-}6}$alkyl$C(O)_2R^5$, $C_{1\text{-}6}$alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, $C_{1\text{-}6}$alkyl, (un)substituted phenyl.

Preferably,

R^1 = A, B; R^2 = B, C;

R^3 = H, $C_{1\text{-}6}$alkyl, $C_{1\text{-}6}$alkyl-NR^6R^7, $C_{1\text{-}6}$alkyl-OR^6, $C_{1\text{-}6}$alkyl$C(O)_2R^5$, $C_{1\text{-}6}$alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents $C_{1\text{-}6}$alkyl, (un)substituted phenyl, -OR^6, halogen, (un)substituted phenoxy, -NO_2 , $C_{1\text{-}6}$alkyl-NR^6R^7, -NR^6R^7, (un)substituted heterocyclyl, -$C(O)_2R^5$, $C_{1\text{-}6}$alkyl$C(O)_2R^5$, $C_{1\text{-}6}$alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, $C_{1\text{-}3}$alkyl.

The most preferred compounds for use in the methods of the invention include:

3-(1-[3-aminopropyl]-3-indoyl)-4-(2-chlorophenyl)pyrrole-2,5-dione and

3-(1-[3-hydroxypropyl]-3-indolyl)-4-(2-chlorophenyl)pyrrole-2,5-dione.

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In other embodiments, compounds useful in the methods of the invention will be selected from the indirubine analogs defined in WO 01/37819. Generally preferred compounds include indirubine, 5-iodo-indirubine-3'monoxime, 5-(hydroxyethylsulfonamide) indirubine, indirubine-3'-monoxime, 5-(methyl)sulfonamide indirubine, and 5-(dimethyl)sulfonamide indirubine.

Additional embodiments of the invention include the use of compounds selected from the 2,4-diaminothiazole analog defined in WO 01/37819. Preferred compounds include:

(4-amino-2-phenylaminothiazol-5-yl)cyclopropylmethanone,

(4-amino-2-phenylaminothiaol-5-yl)(4-fluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)phenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-3-ylmethanone,

1-(4-amino-2-phenylaminothiazol-5-yl)propan-1-one

(4-amino-2-phenylaminothiazol-5-yl)(3,4-difluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-fluorophenyl)methanone,

(4-amino-2-phenylaminothazol-5-yl)naphthalen-2-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)biphenyl-4-ylmethanone,

4-amino-2-phenylaminothiazol-5-yl)-(3-benzyloxyphenyl)methanone,

[4-amino-2-(4-bromophenylamino)thiazol-5-yl]cyclopropylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3,4-dichlorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methylbenzo[b]thiophen-2-yl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(2-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-chloro-3-methylphenyl)methanone,

(4-amino-2-propylaminothiazol-5-yl)pyridin-3-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridinyl-4-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-3-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-difluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-dichlorophenyl)methanone,

1-(4-amino-2-phenylaminothiazol-5-yl)ethanone,

[4-amino-2(pyridin-3-ylamino)thiazol-5-yl]methanone,

[4-amino-2-(pyrdin-3-ylamino)thiazol-5-yl]phenylmethanone,

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[4-amino-2-(3-methoxypropypylamino)thiazol-5-yl]pyridin-3-ylmethanone,

3-[4-amino-5(pyridine-3-carbonyl)thiazol-2-ylamino]butyric acid ethyl ester

[4-amino-2-(3,4-dichlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone,

[4-amino-2-(4-chlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone, and

(4-amino-2-ethylaminothiazol-5-yl)phenylmethanone.

In still another embodiment, compounds selected from the 1,2,4-triazole-carboxylic acid derivative or analog defined in WO 01/09106 will be useful in the methods of the invention. Preferred 1,2,4-triazole-carboxylic acid derivatives include:

3-amino-5-anilino-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(3,4-methylenedioxybenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-*trans*-(2-furylacryloyl)1,2,4-triazole,

3-amino-5-anilino-1-(3-*trans*-(2-furylacryloyl)1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid phenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid cyclohexylamide,

3-amino-5-anilino-1,2,4-triazole-1-carboxylic acid cyclohexylamide,

3-amino-5-(5-chloro-2-methylanilino)-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(4-chlorobenzoyl)1,2,4-triazole,

3-amino-5-anilino-2-(2-naphthoyl)1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-phenylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-trifluoromethylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-((3-benzoyl)benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-biphenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-theinylacetyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-phenylthioacetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(2-naphthylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(phenoxybenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-cyclohexylcarbonyl-1,2,4-triazole,

3-amino-5-anilino-2-phenylacetyl-1,2,4-triazole,

3-amino-5-anilino-2-(3-nicotinyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3,5-dichlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-acetylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-indolylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-fluorophenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(cyclopent-2-enyl)acetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylbutyroyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3,3-diphenylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid 4-biphenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-phenoxyphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-bromo-2-methylphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (1-naphthyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (3-methoxyphenyl)amide,

3-amino-5-(4-methoxyanilino)-1,2,4-triazole-2-carboxylic acid (4-chlorophenyl)amide, and

3,5-diamino2-benzoyl-1,2,4-triazole.

Hymenialdisine or derivative or analog defined in WO 01/41768 may also be useful in certain embodiments of the invention. Preferred such compounds include:

Hymenialdisine (4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one),

4-(2-amino-4-oxo-2-imidazolin-5-ylidene)—2-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one, and

(4-(2-amino-4-oxo-2-imidazolin-5-ylidene)—3-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one.

Other embodiments of the invention include the use of paullone analogs, including 9-nitropaullone, 9-bromopaullone, 9-chloropaullone, and 9-bromo-12-methoxycarbonylmethypaullone in the methods of the invention.

The Compounds of this invention, can be incorporated into various types of ophthalmic formulations for delivery to the eye (e.g., topically, intracamerally, or via an implant). The Compounds are preferably incorporated into topical ophthalmic formulations for delivery to the eye. The Compounds may be combined with ophthalmologically acceptable preservatives, surfactants, viscosity enhancers, penetration enhancers, buffers, sodium chloride, and water to form an aqueous, sterile ophthalmic suspension or solution. Ophthalmic solution formulations may be prepared by dissolving a Compound in a physiologically acceptable isotonic aqueous buffer. Further, the ophthalmic solution may include an ophthalmologically acceptable surfactant to assist in dissolving the Compound. Furthermore, the ophthalmic solution may contain an agent to increase viscosity, such as, hydroxymethylcellulose, hydroxyethylcellulose, hydroxypropylmethylcellulose, methylcellulose, polyvinylpyrrolidone, or the like, to improve the retention of the formulation in the conjunctival sac. Gelling agents can also be used, including, but not limited to, gellan and xanthan gum. In order to prepare sterile ophthalmic ointment formulations, the active ingredient is combined with a preservative in an appropriate vehicle, such as, mineral oil, liquid lanolin, or white petrolatum. Sterile ophthalmic gel formulations may be prepared by suspending the Compound in a hydrophilic base prepared from the combination of, for example, carbopol-974, or the like, according to the published formulations for analogous ophthalmic preparations; preservatives and tonicity agents can be incorporated.

The Compounds are preferably formulated as topical ophthalmic suspensions or solutions, with a pH of about 4 to 8. The establishment of a specific dosage regimen for each individual is left to the discretion of the clinicians. The Compounds will normally be

contained in these formulations in an amount 0.01% to 5% by weight, but preferably in an amount of 0.05% to 2% and most preferably in an amount 0.1 to 1.0% by weight. The dosage form may be a solution, suspension microemulsion. Thus, for topical presentation 1 to 2 drops of these formulations would be delivered to the surface of the eye 1 to 4 times per day according to the discretion of a skilled clinician.

The Compounds can also be used in combination with other agents for treating glaucoma, such as, but not limited to, β-blockers, prostaglandins, carbonic anhydrase inhibitors, α_2 agonists, miotics, and neuroprotectants.

The following examples are representative of the techniques employed by the inventors in carrying out aspects of the present invention. It should be appreciated that while these techniques are exemplary of preferred embodiments for the practice of the invention, those of skill in the art, in light of the present disclosure, will recognize that numerous modifications can be made without departing from the spirit and intended scope of the invention.

Example 1

GSK-3 inhibition

Inhibition of GSK-3 can be assayed by the methods described in WO 00/38675. Compounds are evaluated for their ability to inhibit the phosphorylation of a biotinylated peptide derived from the peptide sequence for the phosphorylation site of glycogen synthase. Biot-KYRRAAVPPSPSLSRHSSPHQ(SP)EDEEE is used as the substrate peptide where (SP) is a prephosphorylated serine and S are the three consensus phosphorylation sites for GSK-3 specific phosphorylation. GSK-3 kinase (10nM final concentration) in a pH 7.0 MOPS buffer containing Tween*-20 0.01%, glycerol 5%, 2-mercaptoethanol 7.5mM, magnesium acetate 10mM, substrate peptide 8 μM, [γ–^{33}P]-ATP 10 μM and inhibitor are incubated at room temperature for 1 hour. The reaction is stopped by the addition of an aqueous mM EDTA solution containing Strepavidin coated SPA beads. Following centrifugation radioactivity is counted using a beta scintillation counter.

*Trade-mark

Example 2

Inhibition of the FRP induced reduction in outflow rate and β-catenin levels in perfused anterior segments

Human ocular anterior segments are perfused with Dulbecco's modified Eagle's medium (DMEM) at a constant pressure of 11 mm Hg. The outflow rate of each eye is measured by weighing its reservoir at specified periods. After a stabilization period, the eyes are perfused with either vehicle or FRP-1 (10 μg/ml) and their outflow rates monitored for 2-5 days. The perfusion of FRP-1 caused a decrease in aqueous humor outflow. Inhibitor is added and the anterior segment is perfused for an additional 2-4 days. Outflow rate is measured by weighing its reservoir at specific periods.

EXAMPLE 3

Ingredients	Amount (wt %)
Compound of Example 1	0.01 – 2% **
Hydroxypropyl methylcellulose	0.5%
Dibasic sodium phosphate (anhydrous)	0.2%
Sodium chloride	0.5%
Disodium EDTA (Edetate disodium)	0.01%
Polysorbate 80	0.05%
Benzalkonium chloride	0.01%
Sodium hydroxide / Hydrochloric acid	For adjusting pH to 7.3 – 7.4
Purified water	q.s. to 100%

EXAMPLE 4

Ingredients	Amount (wt %)
Compound of Example 1	0.01 – 2%
Methyl cellulose	4.0%
Dibasic sodium phosphate (anhydrous)	0.2%
Sodium chloride	0.5%
Disodium EDTA (Edetate disodium)	0.01%
Polysorbate 80	0.05%
Benzalkonium chloride	0.01%
Sodium hydroxide / Hydrochloric acid	For adjusting pH to 7.3 – 7.4
Purified water	q.s. to 100%

EXAMPLE 5

Ingredients	Amount (wt %)
Compound of Example 1	0.01 – 2%
Guar gum	0.4- 6.0%
Dibasic sodium phosphate (anhydrous)	0.2%
Sodium chloride	0.5%
Disodium EDTA (Edetate disodium)	0.01%
Polysorbate 80	0.05%
Benzalkonium chloride	0.01%
Sodium hydroxide / Hydrochloric acid	For adjusting pH to 7.3 – 7.4
Purified water	q.s. to 100%

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EXAMPLE 6

Ingredients	Amount (wt %)
Compound of Example 1	0.01 - 2%
White petrolatum and mineral oil and lanolin	Ointment consistency
Dibasic sodium phosphate (anhydrous)	0.2%
Sodium chloride	0.5%
Disodium EDTA (Edetate disodium)	0.01%
Polysorbate 80	0.05%
Benzalkonium chloride	0.01%
Sodium hydroxide/Hydrochloric acid	For adjusting pH to 7.3 - 7.4

All of the compositions and/or methods of the invention can be made and executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the invention. More specifically, it will be apparent that certain agents which are both chemically and structurally related may be substituted for the specific agents described herein to achieve similar results. Such substitutions and modifications apparent to those skilled in the art are deemed to be within the invention.

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DE 4005970

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EP 384349

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U.S. Patent No. 5,856,517

U.S. Patent No. 5,891,901

U.S. Patent No. 6,057,117

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WO 93/18766

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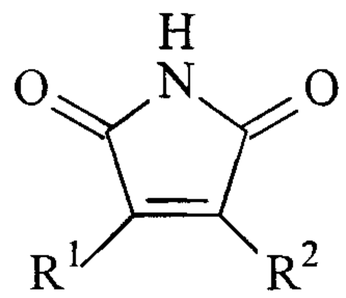
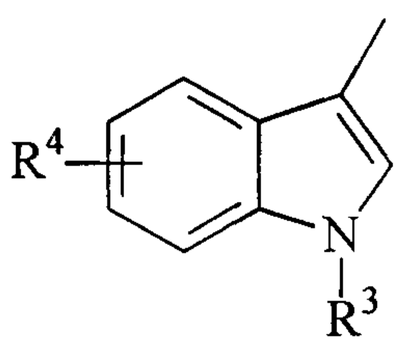
CLAIMS:

1. Use, for treating glaucomatous optic neuropathy, of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable carrier, wherein said GSK-3 inhibitor is a compound of the formula:



wherein R^1 and R^2 independently =



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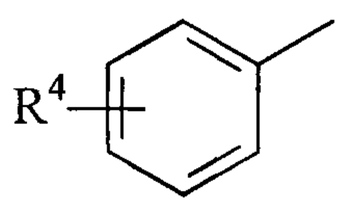

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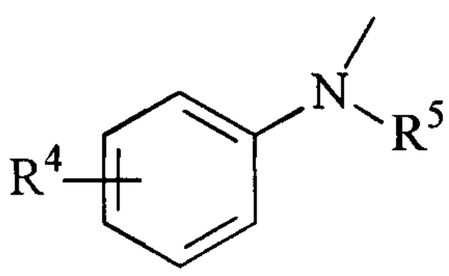

C

R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl, -OR^6, -SR^6, halogen, (un)substituted phenoxy, -CN, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, C_{1-7}cycloalkyl, (un)substituted heterocyclyl, -$C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl, or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

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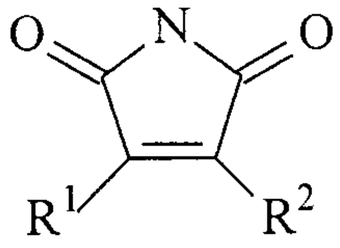
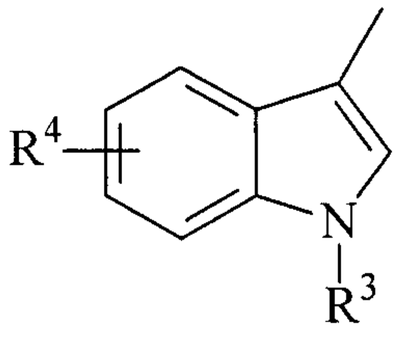
2. Use, in the manufacture of a medicament for treating glaucomatous optic neuropathy, of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable carrier, wherein said GSK-3 inhibitor is a compound of the formula:

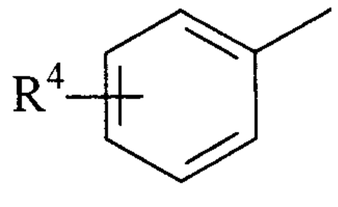
H



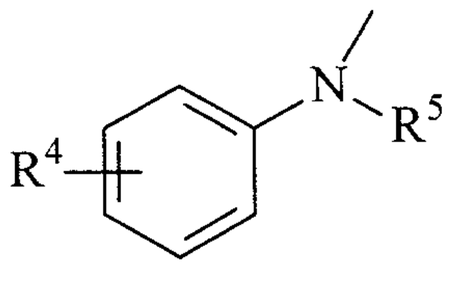
wherein R^1 and R^2 independently =



A



B



C

R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl, $-OR^6$, $-SR^6$, halogen, (un)substituted phenoxy, $-CN$, $-NO_2$, C_{1-6}alkyl-NR^6R^7, $-NR^6R^7$, C_{1-7}cycloalkyl, (un)substituted heterocyclyl, $-C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl,

or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

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3. The use of claim 1 or 2, wherein

R^1 = A, B; R^2 = B, C;

R^3 = H, C_{1-6}alkyl, C_{1-6}alkyl-NR^6R^7, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl, -OR^6, halogen, (un)substituted phenoxy, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, (un)substituted heterocyclyl, -$C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-3}alkyl.

4. The use of claim 3, wherein said GSK-3 inhibitor is 3-(1-[3-aminopropyl]-3-indoyl)-4-(2-chlorophenyl)pyrrole-2,5-dione or 3-(1-[3-hydroxypropyl]-3-indolyl)-4-(2-chlorophenyl)pyrrole-2,5-dione.

5. The use of claim 1 or 2, wherein the GSK-3 inhibitor is an indirubine.

6. The use of claim 5, wherein the indirubine is selected from the group consisting of indirubine, 5-iodo-indirubine-3'-monoxime, 5-(hydroxyethylsulfonamide) indirubine, indirubine-3'-monoxime, 5-(methyl)sulfonamide indirubine, and 5-(dimethyl)sulfonamide indirubine.

7. The use of claim 1 or 2, wherein the GSK-3 inhibitor is a 2,4-diaminothiazole.

8. The use of claim 7, wherein the 2,4-diaminothiazole is selected from the group consisting of:

(4-amino-2-phenylaminothiazol-5-yl)cyclopropylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-fluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)phenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-3-ylmethanone,

1-(4-amino-2-phenylaminothiazol-5-yl)propan-1-one,

(4-amino-2-phenylaminothiazol-5-yl)(3,4-difluorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-fluorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)naphthalen-2-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)biphenyl-4-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)-(3-benzyloxyphenyl)methanone,

[4-amino-2-(4-bromophenylamino)thiazol-5-yl]cyclopropylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3,4-dichlorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methylbenzo[b]thiophen-2-ylmethanone,

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(4-amino-2-phenylaminothiazol-5-yl)(2-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-chloro-3-methylphenyl)methanone,

(4-amino-2-propylaminothiazol-5-yl)pyridin-3-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridinyl-4-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-3-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-difluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-dichlorophenyl)methanone,

1-(4-amino-2-phenylaminothiazol-5-yl)ethanone,

[4-amino-2(pyridin-3-ylamino)thiazol-5-yl]methanone,

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[4-amino-2-(pyridin-3-ylamino)thiazol-5-yl]phenylmethanone,

[4-amino-2-(3-methoxypropylamino)thiazol-5-yl]pyridin-3-ylmethanone,

3-[4-amino-5(pyridine-3-carbonyl)thiazol-2-ylamino]butyric acid ethyl ester,

[4-amino-2-(3,4-dichlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone,

[4-amino-2-(4-chlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone, and

(4-amino-2-ethylaminothiazol-5-yl)phenylmethanone.

9. The use of claim 1 or 2, wherein the GSK-3 inhibitor is a 1,2,4-triazole-carboxylic acid.

10. The use of claim 9, wherein the 1,2,4-triazole-carboxylic acid is selected from the group consisting of:

3-amino-5-anilino-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(3,4-methylenedioxybenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-3-*trans*-(2-furylacryloyl)-1,2,4-triazole,

3-amino-5-anilino-1-3-*trans*-(2-furylacryloyl)-1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid phenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid cyclohexylamide,

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3-amino-5-anilino-1,2,4-triazole-1-carboxylic acid cyclohexylamide,

3-amino-5-(5-chloro-2-methylanilino)-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(4-chlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-naphthoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-phenylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-trifluoromethylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-((3-benzoyl)benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-biphenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-theinylacetyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-phenylthioacetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(2-naphthylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(phenoxybenzoyl)-1,2,4-triazole,

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3-amino-5-(3-chloroanilino)-2-benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-cyclohexylcarbonyl-1,2,4-triazole,

3-amino-5-anilino-2-phenylacetyl-1,2,4-triazole,

3-amino-5-anilino-2-(3-nicotinyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3,5-dichlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-acetylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-indolylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-fluorophenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(cyclopent-2-enyl)acetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylbutyroyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3,3-diphenylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid 4-biphenylamide,

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3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-phenoxyphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-bromo-2-methylphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (1-naphthyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (3-methoxyphenyl)amide,

3-amino-5-(4-methoxyanilino)-1,2,4-triazole-2-carboxylic acid (4-chlorophenyl)amide, and

3,5-diamino-2-benzoyl-1,2,4-triazole.

11. The use of claim 1 or 2, wherein the GSK-3 inhibitor is a hymenialdisine.

12. The use of claim 11, wherein the hymenialdisine is selected from the group consisting of:

hymenialdisine (4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-4,5,6,7 tetrahydropyrrolo(2,3-c)azepine-8-one),

4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-2-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one, and

(4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-3-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one.

13. The use of claim 1 or 2, wherein the GSK-3 inhibitor is a paullone.

14. The use of claim 13, wherein the paullone is selected from the group consisting of 9-nitropaullone, 9-bromopaullone, 9-chloropaullone, and 9-bromo-12-methoxycarbonylmethypaullone.

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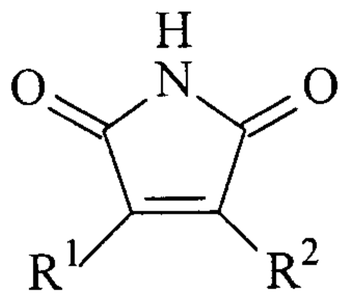
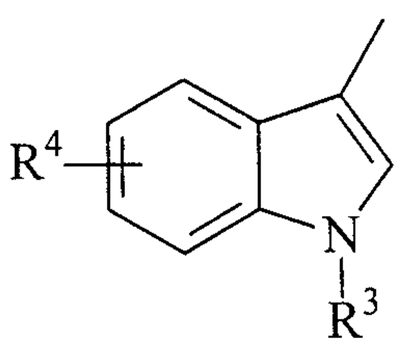
15. The use of any one of claims 1 to 14, wherein said composition is adapted for administration via topical application, intracamerally or an implant.

16. The use of any one of claims 1 to 15, wherein said GSK-3 inhibitor in said composition is in a concentration from 0.01% to 2%.

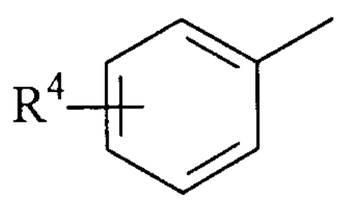
17. Use, for lowering intraocular pressure (IOP) in a patient, of a therapeutically effective amount of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable vehicle, wherein said GSK-3 inhibitor is a compound of the formula:



wherein R^1 and R^2 independently =



A



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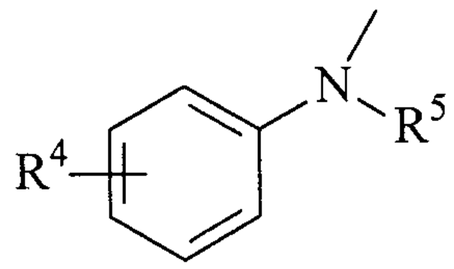


C

R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

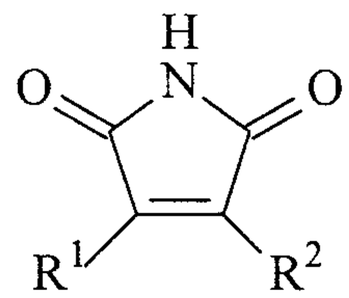
R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl,-OR^6, -SR^6, halogen, (un)substituted phenoxy, -CN, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, C_{1-7}cycloalkyl,

(un)substituted heterocyclyl, $-C(O)_2R^5$, C_{1-6}alkylC(O)$_2R^5$, C_{1-6}alkylC(O)NR^6R^7; and

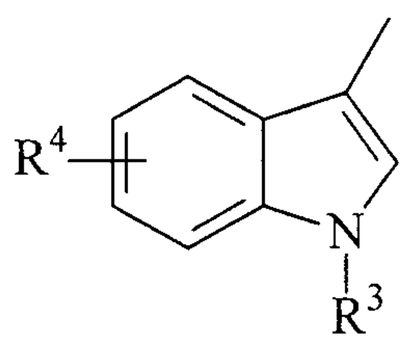
R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl,

or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

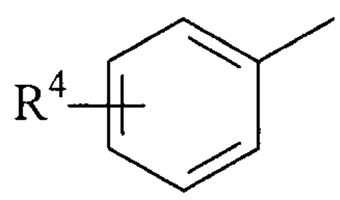
18. Use, in the manufacture of a medicament for lowering intraocular pressure (IOP) in a patient, of a therapeutically effective amount of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable vehicle, wherein said GSK-3 inhibitor is a compound of the formula:



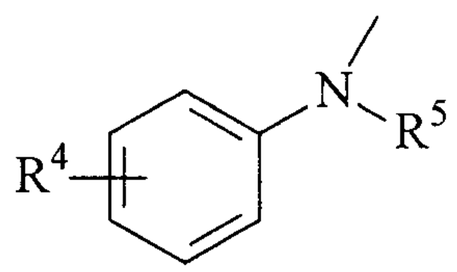
wherein R^1 and R^2 independently =



A



B



C

R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkylC(O)$_2R^5$, C_{1-6}alkylC(O)NR^6R^7;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl,-OR^6, -SR^6, halogen, (un)substituted phenoxy, -CN, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, C_{1-7}cycloalkyl,

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(un)substituted heterocyclyl, $-C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl,

or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

19. The use of claim 17 or 18, wherein

R^1 = A, B; R^2 = B, C;

R^3 = H, C_{1-6}alkyl, C_{1-6}alkyl-NR^6R^7, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl, $-OR^6$, halogen, (un)substituted phenoxy, $-NO_2$, C_{1-6}alkyl-NR^6R^7, $-NR^6R^7$, (un)substituted heterocyclyl, $-C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-3}alkyl.

20. The use of claim 19, wherein said GSK-3 inhibitor is 3-(1-[3-aminopropyl]-3-indoyl)-4-(2-chlorophenyl)pyrrole-2,5-dione or 3-(1-[3-hydroxypropyl]-3-indolyl)-4-(2-chlorophenyl)pyrrole-2,5-dione.

21. The use of claim 17 or 18, wherein the GSK-3 inhibitor is an indirubine.

22. The use of claim 21, wherein the indirubine is selected from the group consisting of indirubine, 5-iodo-indirubine-3'-monoxime, 5-(hydroxyethylsulfonamide) indirubine, indirubine-3'-monoxime, 5-(methyl)sulfonamide indirubine, and 5-(dimethyl)sulfonamide indirubine.

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23. The use of claim 17 or 18, wherein the GSK-3 inhibitor is a 2,4-diaminothiazole.

24. The use of claim 23, wherein the 2,4-diaminothiazole is selected from the group consisting of:

(4-amino-2-phenylaminothiazol-5-yl)cyclopropylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-fluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)phenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-3-ylmethanone,

1-(4-amino-2-phenylaminothiazol-5-yl)propan-1-one,

(4-amino-2-phenylaminothiazol-5-yl)(3,4-difluorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-fluorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)naphthalen-2-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)biphenyl-4-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)-(3-benzyloxyphenyl)methanone,

[4-amino-2-(4-bromophenylamino)thiazol-5-yl]cyclopropylmethanone,

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(4-amino-2-phenylaminothiazol-5-yl)(3,4-dichlorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methylbenzo[b]thiophen-2-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(2-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-chloro-3-methylphenyl)methanone,

(4-amino-2-propylaminothiazol-5-yl)pyridin-3-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridinyl-4-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-3-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-difluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-dichlorophenyl)methanone,

1-(4-amino-2-phenylaminothiazol-5-yl)ethanone,

[4-amino-2(pyridin-3-ylamino)thiazol-5-yl]methanone,

[4-amino-2-(pyridin-3-ylamino)thiazol-5-yl]phenylmethanone,

[4-amino-2-(3-methoxypropylamino)thiazol-5-yl]pyridin-3-ylmethanone,

3-[4-amino-5(pyridine-3-carbonyl)thiazol-2-ylamino]butyric acid ethyl ester,

[4-amino-2-(3,4-dichlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone,

[4-amino-2-(4-chlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone, and

(4-amino-2-ethylaminothiazol-5-yl)phenylmethanone.

25. The use of claim 17 or 18, wherein the GSK-3 inhibitor is a 1,2,4-triazole-carboxylic acid.

26. The use of claim 25, wherein the 1,2,4-triazole-carboxylic acid is selected from the group consisting of:

3-amino-5-anilino-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(3,4-methylenedioxybenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-3-*trans*-(2-furylacryloyl)-1,2,4-triazole,

3-amino-5-anilino-1-3-*trans*-(2-furylacryloyl)-1,2,4-triazole,

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3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid phenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid cyclohexylamide,

3-amino-5-anilino-1,2,4-triazole-1-carboxylic acid cyclohexylamide,

3-amino-5-(5-chloro-2-methylanilino)-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(4-chlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-naphthoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-phenylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-trifluoromethylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-((3-benzoyl)benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-biphenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-theinylacetyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-phenylthioacetyl-1,2,4-triazole,

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3-amino-5-(3-chloroanilino)-2-(2-naphthylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(phenoxybenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-cyclohexylcarbonyl-1,2,4-triazole,

3-amino-5-anilino-2-phenylacetyl-1,2,4-triazole,

3-amino-5-anilino-2-(3-nicotinyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3,5-dichlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-acetylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-indolylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-fluorophenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(cyclopent-2-enyl)acetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylbutyroyl)-1,2,4-triazole,

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3-amino-5-(3-chloroanilino)-2-(3,3-diphenylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid 4-biphenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-phenoxyphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-bromo-2-methylphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (1-naphthyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (3-methoxyphenyl)amide,

3-amino-5-(4-methoxyanilino)-1,2,4-triazole-2-carboxylic acid (4-chlorophenyl)amide, and

3,5-diamino-2-benzoyl-1,2,4-triazole.

27. The use of claim 17 or 18, wherein the GSK-3 inhibitor is a hymenialdisine.

28. The use of claim 27, wherein the hymenialdisine is selected from the group consisting of:

hymenialdisine (4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one),

4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-2-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one, and

(4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-3-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one.

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29. The use of claim 17 or 18, wherein the GSK-3 inhibitor is a paullone.

30. The use of claim 29, wherein the paullone is selected from the group consisting of 9-nitropaullone, 9-bromopaullone, 9-chloropaullone, and 9-bromo-12-methoxycarbonylmethypaullone.

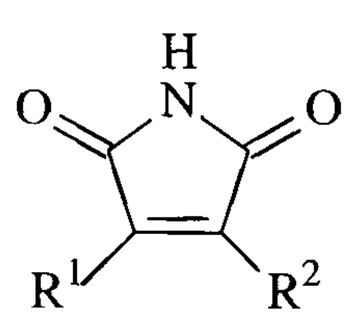
31. The use of any one of claims 17 to 30, wherein said composition is adapted for administration via topical application, intracamerally or an implant.

32. The use of any one of claims 17 to 31, wherein said GSK-3 inhibitor in said composition is in a concentration from 0.01% to 2%.

33. The use of any one of claims 17 to 32, wherein said patient suffers from glaucoma or ocular hypertension.

34. The use of claim 33, wherein said glaucoma is normal-tension glaucoma.

35. Use, for preventing or inhibiting glaucomatous optic neuropathy and controlling IOP in a patient, of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable carrier, wherein said GSK-3 inhibitor is a compound of the formula:



wherein R^1 and R^2 independently =

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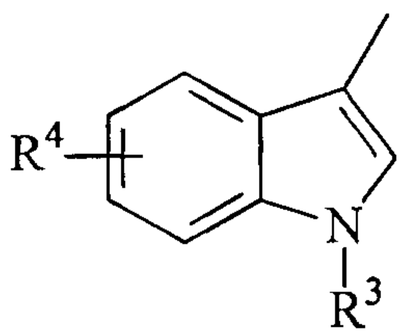
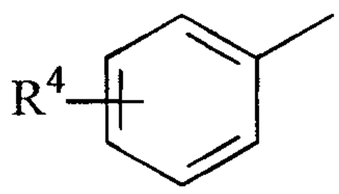
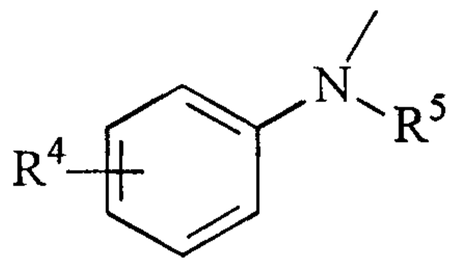


A



B



C

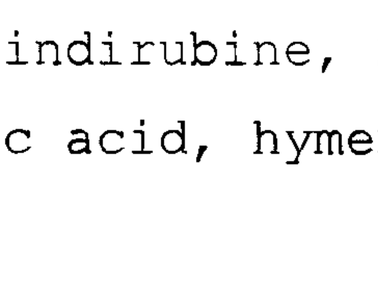
R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl,-OR^6, -SR^6, halogen, (un)substituted phenoxy, -CN, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, C_{1-7}cycloalkyl, (un)substituted heterocyclyl, -$C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl,

or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

36. Use, in the manufacture of a medicament for preventing or inhibiting glaucomatous optic neuropathy and controlling IOP in a patient, of a composition comprising at least one glycogen synthase kinase-3 (GSK-3) inhibitor in a pharmaceutically acceptable carrier, wherein said GSK-3 inhibitor is a compound of the formula:



wherein R^1 and R^2 independently =

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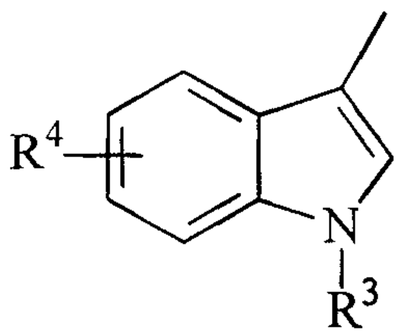
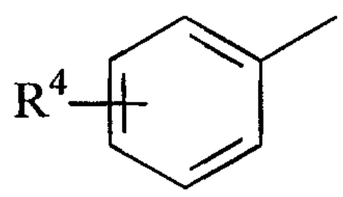
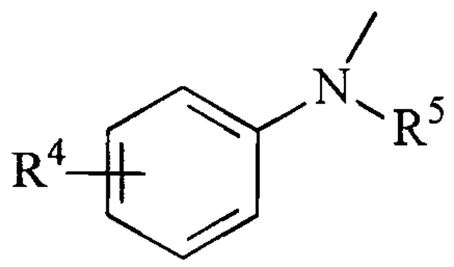


A



B



C

R^3 = H, C_{1-6}alkyl, (un)substituted phenyl, C_{1-6}alkyl-NR^6R^7, C_{1-7}cycloalkyl, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl,-OR^6, -SR^6, halogen, (un)substituted phenoxy, -CN, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, C_{1-7}cycloalkyl, (un)substituted heterocyclyl, -$C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-6}alkyl, (un)substituted phenyl,

or wherein said GSK-3 inhibitor is a compound selected from the group consisting of indirubine, 2,4-diaminothiazole, 1,2,4-triazole-carboxylic acid, hymenialdisine, and paullone.

37. The use of claim 35 or 36, wherein

R^1 = A, B; R^2 = B, C;

R^3 = H, C_{1-6}alkyl, C_{1-6}alkyl-NR^6R^7, C_{1-6}alkyl-OR^6, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$;

R^4 = H, or one or more substituents C_{1-6}alkyl, (un)substituted phenyl,-OR^6, halogen, (un)substituted phenoxy, -NO_2, C_{1-6}alkyl-NR^6R^7, -NR^6R^7, (un)substituted heterocyclyl, -$C(O)_2R^5$, C_{1-6}alkyl$C(O)_2R^5$, C_{1-6}alkyl$C(O)NR^6R^7$; and

R^5, R^6, R^7 = H, C_{1-3}alkyl.

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38. The use of claim 37, wherein said GSK-3 inhibitor is 3-(1-[3-aminopropyl]-3-indoyl)-4-(2-chlorophenyl)pyrrole-2,5-dione or 3-(1-[3-hydroxypropyl]-3-indolyl)-4-(2-chlorophenyl)pyrrole-2,5-dione.

39. The use of claim 35 or 36, wherein the GSK-3 inhibitor is an indirubine.

40. The use of claim 39, wherein the indirubine is selected from the group consisting of indirubine, 5-iodo-indirubine-3'monoxime, 5-(hydroxyethylsulfonamide) indirubine, indirubine-3'-monoxime, 5-(methyl)sulfonamide indirubine, and 5-(dimethyl)sulfonamide indirubine.

41. The use of claim 35 or 36, wherein the GSK-3 inhibitor is a 2,4-diaminothiazole.

42. The use of claim 41, wherein the 2,4-diaminothiazole is selected from the group consisting of:

(4-amino-2-phenylaminothiazol-5-yl)cyclopropylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-fluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)phenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-3-ylmethanone,

1-(4-amino-2-phenylaminothiazol-5-yl)propan-1-one,

(4-amino-2-phenylaminothiazol-5-yl)(3,4-difluorophenylmethanone,

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(4-amino-2-phenylaminothiazol-5-yl)(3-fluorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)naphthalen-2-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)biphenyl-4-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)-(3-benzyloxyphenyl)methanone,

[4-amino-2-(4-bromophenylamino)thiazol-5-yl]cyclopropylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3,4-dichlorophenylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methylbenzo[b]thiophen-2-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(2-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(3-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(4-methoxyphenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)-(4-chloro-3-methylphenyl)methanone,

(4-amino-2-propylaminothiazol-5-yl)pyridin-3-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)pyridin-2-yl-methanone,

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(4-amino-2-phenylaminothiazol-5-yl)pyridinyl-4-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-2-yl-methanone,

(4-amino-2-phenylaminothiazol-5-yl)thiophen-3-ylmethanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-difluorophenyl)methanone,

(4-amino-2-phenylaminothiazol-5-yl)(2,6-dichlorophenyl)methanone,

1-(4-amino-2-phenylaminothiazol-5-yl)ethanone,

[4-amino-2(pyridin-3-ylamino)thiazol-5-yl]methanone,

[4-amino-2-(pyridin-3-ylamino)thiazol-5-yl]phenylmethanone,

[4-amino-2-(3-methoxypropylamino)thiazol-5-yl]pyridin-3-ylmethanone,

3-[4-amino-5(pyridine-3-carbonyl)thiazol-2-ylamino]butyric acid ethyl ester,

[4-amino-2-(3,4-dichlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone,

[4-amino-2-(4-chlorophenylamino)thiazol-5-yl](3-benzyloxyphenyl)methanone, and

(4-amino-2-ethylaminothiazol-5-yl)phenylmethanone.

43. The use of claim 35 or 36, wherein the GSK-3 inhibitor is a 1,2,4-triazole-carboxylic acid.

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44. the use of claim 43, wherein the 1,2,4-triazole-carboxylic acid is selected from the group consisting of:

3-amino-5-anilino-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(3,4-methylenedioxybenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-*trans*-(2-furylacryloyl)-1,2,4-triazole,

3-amino-5-anilino-1-(3-*trans*-(2-furylacryloyl)-1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid phenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid cyclohexylamide,

3-amino-5-anilino-1,2,4-triazole-1-carboxylic acid cyclohexylamide,

3-amino-5-(5-chloro-2-methylanilino)-2-benzoyl-1,2,4-triazole,

3-amino-5-anilino-2-(4-chlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-naphthoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-phenylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-trifluoromethylbenzoyl)-1,2,4-triazole,

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3-amino-5-anilino-2-((3-benzoyl)benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-biphenylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(2-theinylacetyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-phenylthioacetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(2-naphthylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(phenoxybenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-benzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-cyclohexylcarbonyl-1,2,4-triazole,

3-amino-5-anilino-2-phenylacetyl-1,2,4-triazole,

3-amino-5-anilino-2-(3-nicotinyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3,5-dichlorobenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-acetylbenzoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(3-indolylacetyl)-1,2,4-triazole,

3-amino-5-anilino-2-(4-fluorophenylacetyl)-1,2,4-triazole,

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3-amino-5-anilino-2-(3-bromobenzoyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-2-(cyclopent-2-enyl)acetyl-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3-benzoylbutyroyl)-1,2,4-triazole,

3-amino-5-(3-chloroanilino)-2-(3,3-diphenylpropanoyl)-1,2,4-triazole,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid 4-biphenylamide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-phenoxyphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (4-bromo-2-methylphenyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (1-naphthyl)amide,

3-amino-5-anilino-1,2,4-triazole-2-carboxylic acid (3-methoxyphenyl)amide,

3-amino-5-(4-methoxyanilino)-1,2,4-triazole-2-carboxylic acid (4-chlorophenyl)amide, and

3,5-diamino-2-benzoyl-1,2,4-triazole.

45. The use of claim 35 or 36, wherein the GSK-3 inhibitor is a hymenialdisine.

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46. The use of claim 45, wherein the hymenialdisine is selected from the group consisting of:

hymenialdisine (4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one),

4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-2-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one, and

4-(2-amino-4-oxo-2-imidazolin-5-ylidene)-3-bromo-4,5,6,7-tetrahydropyrrolo(2,3-c)azepine-8-one.

47. The use of claim 35 or 36, wherein the GSK-3 inhibitor is a paullone.

48. The use of claim 47, wherein the paullone is selected from the group consisting of 9-nitropaullone, 9-bromopaullone, 9-chloropaullone, and 9-bromo-12-methoxycarbonylmethypaullone.

49. The use of any one of claims 35 to 48, wherein said composition is adapted for administration via topical application, intracamerally or an implant.

50. The use of any one of claims 35 to 49, wherein said GSK-3 inhibitor in said composition is in a concentration from 0.01% to 2%.

51. The use of any one of claims 35 to 50, wherein said patient suffers from glaucoma or ocular hypertension.

52. The use of claim 51, wherein said glaucoma is normal-tension glaucoma.

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53. A topical ophthalmic pharmaceutical composition comprising a GSK-3 inhibitor as defined in claim 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14, and a pharmaceutically acceptable carrier for treatment of glaucomatous optic neuropathy.

54. A topical ophthalmic pharmaceutical composition comprising a GSK-3 inhibitor as defined in claim 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14, and a pharmaceutically acceptable carrier for lowering intraocular pressure.

55. A topical ophthalmic pharmaceutical composition comprising a GSK-3 inhibitor as defined in claim 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14, and a pharmaceutically acceptable carrier for the prevention or inhibition of glaucomatous optic neuropathy and controlling IOP.

56. Use of a GSK-3 inhibitor as defined in claim 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14 for treatment of glaucomatous optic neuropathy.

57. Use of a GSK-3 inhibitor as defined in claim 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14 for lowering intraocular pressure.

58. Use of a GSK-3 inhibitor as defined in claim 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14 for the prevention or inhibition of glaucomatous optic neuropathy and controlling IOP.