(19) DANMARK

(10) DK/EP 2835131 T3

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *A 61 K 31/00 (2006.01)* *A 61 K 31/437 (2006.01)* *A 61 K 31/4439 (2006.01)* *A 61 K 31/506 (2006.01)* *A 61 P 25/28 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2017-12-04**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2017-09-06**

(86) Europæisk ansøgning nr.: **14190691.7**

(86) Europæisk indleveringsdag: **2011-12-14**

(87) Den europæiske ansøgnings publiceringsdag: **2015-02-11**

(30) Prioritet: **2010-12-14 GB 201021161** **2011-06-01 GB 201109162**

(62) Stamansøgningsnr: **11804754.7**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **Electrophoretics Limited, Hamilton House , Mabledon Place, London WC1H 9BB, Storbritannien**

(72) Opfinder: **Sheridan, Joseph M., c/o Electrophoretics Limited, Hamilton House, Mabledon Place, Londo WC1H 9BB, Storbritannien**
Heal, Jonathan R., c/o Electrophoretics Limited, Hamilton House, Mabledon Place, London WC1H 9BB, Storbritannien
Hamilton, William D.O., c/o Electrophoretics Limited, Hamilton House, Mabledon Place, London WC1H 9BB, Storbritannien
Pike, Ian, c/o Electrophoretics Limited, Hamilton House, Mabledon Place, London WC1H 9BB, Storbritannien

(74) Fuldmægtig i Danmark: **NORDIC PATENT SERVICE A/S, Bredgade 30, 1260 København K, Danmark**

(54) Benævnelse: **Inhibitorer af kaseinkinase 1 delta (CK1delta)**

(56) Fremdragne publikationer:
WO-A1-2008/156715
WO-A1-2011/091153
WO-A2-2009/021750
JP-A- 2003 212 859
KR-A- 20100 075 079
US-A1- 2008 027 051
Lee ET AL: "Product subclass 4: nitrogen- and phosphorus-substituted benzo-1,4-quinones", , 1 January 2006 (2006-01-01), pages 71-86, XP055158753, Retrieved from the Internet: URL:http://theodorakisgroup.ucsd.edu/publi cations folder/2005-present/ET82-SOS2814.pdf [retrieved on 2014-12-15]
DATABASE CA [Online] CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; 2010, DONG, JIA JIA ET AL: "Carbonates: eco-friendly solvents for palladium-catalyzed direct arylation of heteroaromatics", XP002733837, retrieved from STN Database accession no. 2010:1372517
THAKAK, K. A. ET AL: "Reaction of guanidine with 3-formylchromones", JOURNAL OF THE INDIAN CHEMICAL

Fortsættes ...

SOCIETY (1984), 61(6), 550-2 CODEN: JICSAH; ISSN: 0019-4522, 1984, - 1984, XP009181718,

DESCRIPTION

[0001] The invention relates to pharmaceutical compositions comprising the casein kinase 1 delta (CK1δ) inhibitors of claim 1 and to the use of said inhibitors in the treatment of neurodegenerative disorders such as Alzheimer's disease.

[0002] Alzheimer's disease (AD; also known as senile dementia of the Alzheimer type (SDAT), primary degenerative dementia of the Alzheimer's type (PDDAT), or Alzheimer's) is the most common form of dementia. Most often, Alzheimer's disease is diagnosed in people over 65 years of age, although the less-prevalent early-onset Alzheimer's can occur much earlier. In 2006, there were 26.6 million sufferers worldwide. Alzheimer's is predicted to affect 1 in 85 people globally by 2050.

[0003] Alzheimer's disease is a neurodegenerative disease characterised by the presence of senile plaques and neurofibrillary tangles in the brain. The degree of dementia at death correlates better with neurofibrillary tangle numbers than with senile plaques counts. The presence of neurofibrillary tangles in neurons results in the death of those neurons, implying that prevention of tangle formation is an important therapeutic goal. The principal protein that forms the neurofibrillary tangle is the microtubule-associated protein, tau, which assembles into filaments that have the appearance of twisting about each other in pairs and are referred to as paired helical filaments (PHF). PHF are present in different locations in degenerating neurons in the Alzheimer brain and when many aggregate in the neuronal cell body, they produce the neurofibrillary tangle (Lee *et al,* 2001).

[0004] Intraneuronal deposits of tau in the form of typical neurofibrillary tangles of AD or other morphologically distinct tau aggregates in a number of other neurodegenerative diseases, is the basis for grouping these conditions as tauopathies. Thus, in addition to AD, the main examples of the tauopathies are frontotemporal dementia with Parkinsonism linked to chromosome 17 (FTDP-17), progressive supranuclear palsy (PSP), Pick's disease, corticobasal degeneration, and multisystem atrophy (MSA). The intracellular tau deposits (usually neuronal but can also be glial) are all filamentous and mostly in a hyperphosphorylated state compared to the level of phosphorylation of tau from control human brain. In the case of AD, this hyperphosphorylated tau is often referred to as PHF-tau because it is derived from the PHF.

[0005] Tau is a phosphoprotein, the function of phosphorylation remaining to be unequivocally established. However, increased phosphorylation of tau on multiple serine and threonine residues reduces the ability of tau to promote microtubule assembly and to stabilise assembled microtubules, effects that have been demonstrated both *in vitro* and in cells. Many studies have shown that PHF-tau from AD brain is more heavily phosphorylated on serine and threonine than tau from control brain. This has been demonstrated partly by protein sequencing and partly by demonstrating that certain monoclonal antibodies only label either PHF-tau or non-phosphorylated tau and not PHF-tau; the epitopes for many of these

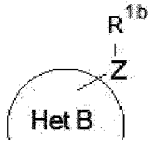
antibodies have been mapped to particular phosphorylated residues present in PHF-tau and absent from control brain tau. The pathological tau from most other cases of other tauopathies seems to be similarly hyperphosphorylated to PHF-tau.

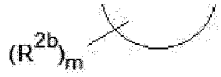
[0006] These findings strongly imply that similar abnormalities in regulating phosphorylation of tau are shared by all the tauopathies including AD.

[0007] A number of proline-directed and non-proline directed protein kinases have been suggested to have a role in the generation of PHF-tau in Alzheimer brain, including casein kinase 1. Mammalian casein kinase-1 exists as multiple isoforms CK1α, CK1β, CK1y1, CK1 y2, CK1 y3, CK1δ and CK1ε. The role of CK1δ as a potential tau kinase is of particular interest since it has been reported that CK1δ protein is increased more than 30-fold in the hippocampus of Alzheimer brain compared to equivalent controls (Ghoshal, N. et al (1999) Am. J. Pathol 155, 1163-1172) while its mRNA content is increased 24-fold (Yasojima, K. et al (2000) Brain Res 865, 116-120) and CK1 has also been shown to be tightly associated with PHF (Kuret, J.et al (1997) J. Neurochem 69, 2506-2515). CK1δ has also been reported to phosphorylate tau at two epitopes detecting using phospho-specific monoclonal antibodies to tau, and exogenous expression of CK1δ in non-neuronal cells reduces binding of tau to microtubules (Li, G. et al (2004) J. Biol. Chem. 279, 15938-15945). Of note in the context of Alzheimer's disease is a report that CK1 activity is stimulated by amyloid beta-peptide (Aβ), a component of the senile neuritic plaques that, together with tangles, characterise Alzheimer brain (Chauhan, A. et al (1993) Brain Res. 629, 47-52). Additional evidence for possible involvement of CK1 in Alzheimer's disease comes from the reported influence of CK1 in the regulation of Aβ production in neurons (Flajolet, M. et al (2007) PNAS USA 104, 4159-4164). Further work has confirmed that at least 6 newly identified phosphorylation sites in PHF-tau (all on serine or threonine residues) can be generated by CK1δ. The finding that a number of phosphorylation sites in PHF-tau for which CK1 is a strong candidate kinase, including three for which it is the only known kinase, implies that CK1 may make an important contribution to the pathogenesis of Alzheimer's disease (Hanger et al (2007) J. Biol. Chem. 282, 23645-23654).US 2008/027051 describes a series of heteroaryl substituted benzoxazole derivatives and therapeutic uses for such compounds.

[0008] There is therefore a need for CK1δ inhibitors which may be of potential therapeutic benefit in the treatment of neurodegenerative diseases, such as tauopathies including Alzheimer's disease, frontotemporal dementia with Parkinsonism linked to chromosome 17 (FTDP-17), progressive supranuclear palsy (PSP), Pick's disease, corticobasal degeneration, and multisystem atrophy (MSA).

[0009] According to a first aspect of the disclosure there is provided a pharmaceutical composition comprising a compound of formula (IB) or a pharmaceutically acceptable salt or solvate thereof:





(IB)

wherein

"Het B" represents benzoxazolyl;

Z represents a bond;

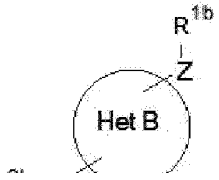
R^{1b} represents pyrimidinyl, wherein R^{1b} may be substituted by one or more (e.g. 1, 2 or 3) R^{4b} groups;

R^{4b} represents halogen, C_{1-6} alkyl, C_{1-6} alkenyl, C_{1-6} alkynyl, C_{3-8} cycloalkyl, haloC_{1-6} alkyl, hydroxyl, C_{1-6} alkoxy, -O-C_{1-6} alkenyl, haloC_{1-6} alkoxy, -COOH, -CO-C_{1-6} alkyl, -COO-C_{1-6} alkyl, -$CONH_2$, -CH_2-$CONH_2$, -NH-C_{1-6} alkyl, -NH-C_{2-6} alkenyl, -NH-CO-C_{1-6} alkyl, -CO-NH-C_{1-6} alkyl, -O-CH_2-CO-NH-C_{1-6} alkyl, -CH_2-CH_2-CO-NH-C_{1-6} alkyl, -S-C_{1-6} alkyl, -SO-C_{1-6} alkyl, -SO_2-C_{1-6} alkyl, -SO_2-NH_2, -SO_2-NH-C_{1-6} alkyl, -S-CH_2-CO-C_{2-6} alkenyl, -SO_2-OH, amino, cyano, NO_2, =O, -CO-NH-$(CH_2)_2$)-OMe, -NH-C_{3-8} cycloalkyl, -CH_2-CO-NH-C_{3-8} cycloalkyl, -CO-heterocyclyl, -CO-heteroaryl, -COO-$(CH_2)_2$-heterocyclyl, -CH_2-aryl, - OCH_2-aryl, -OCH_2-heteroaryl, -CH_2-O-CO-aryl, -O-aryl, -NH-CO-aryl, -NH-CO-heteroaryl, -NH-CO-CH_2-aryl, -NH-aryl, aryl or heteroaryl groups, wherein said aryl, heterocyclyl or heteroaryl groups of R^{4b} may be optionally substituted by one or more halogen, C_{1-6} alkyl, C_{1-6} alkoxy, =S or hydroxyl groups and wherein said C_{1-6} alkyl or C_{2-6} alkenyl groups of R^{4b} may be optionally substituted by one or more hydroxyl, amino, cyano, C_{1-6} alkoxy, $CONH_2$ or -COO-C_{1-6} alkyl groups;

m represents an integer from 0 to 3;

R^{2b} represents halogen, haloC_{1-6} alkyl, C_{1-6} alkyl, C_{3-8} cycloalkyl, hydroxyl, C_{1-6} alkoxy, -S-C_{1-6} alkyl, -CH_2-S-C_{1-6} alkyl, -S-C_{2-6} alkynyl, amino, cyano, NO_2, =O, =S, -SO_2-C_{1-6} alkyl, - $CONH_2$, -CO-C_{1-6} alkyl, -COO-C_{1-6} alkyl, -NH-C_{1-6} alkyl, -NH-CO-C_{1-6} alkyl, -NH-CO-CH=CH-CH_2-$N(Me)_2$, C_{1-6} alkyl, -CO-NH-C_{1-6} alkyl, -CO-NH-CH(Me)-COOH, -S-CH_2-$CON(Et)_2$, -NH-$(CH_2)_2$-OH, -NH-$(CH_2)_3$-OH, -NH-CH(Et)-CH_2-OH, -CO-NH-$(CH_2)_3$-OH, - $CH(CH_2OH)_2$ or-S-CH_2-CO-NH-CO-NH-C_{1-6} alkyl, wherein said C_{1-6} alkyl groups of R^{2b} may be optionally substituted by one or more cyano or hydroxyl groups.

[0010] According to one particular aspect of the disclosure which may be mentioned there is provided a compound of formula (IB) or a pharmaceutically acceptable salt or solvate thereof:



(IB)

wherein

"Het B" represents benzoxazolyl;

Z represents a bond;

R^{1b} represents pyrimidinyl, wherein R^{1b} may be substituted by one or more (e.g. 1, 2 or 3) R^{4b} groups;

R^{4b} represents halogen, C_{1-6} alkyl, C_{1-6} alkenyl, C_{1-6} alkynyl, C_{3-8} cycloalkyl, haloC_{1-6} alkyl, hydroxyl, C_{1-6} alkoxy, -O-C_{1-6} alkenyl, haloC_{1-6} alkoxy, -COOH, -CO-C_{1-6} alkyl, -COO-C_{1-6} alkyl, -$CONH_2$, -CH_2-$CONH_2$, -NH-C_{1-6} alkyl, -NH-C_{2-6} alkenyl, -NH-CO-C_{1-6} alkyl, -CO-NH-C_{1-6} alkyl, -O-CH_2-CO-NH-C_{1-6} alkyl, -CH_2-CH_2-CO-NH-C_{1-6} alkyl, -S-C_{1-6} alkyl, -SO-C_{1-6} alkyl, -SO_2-C_{1-6} alkyl, -SO_2-NH-C_{1-6} alkyl, -S-CH_2-CO-C_{2-6} alkenyl, -SO_2-OH, amino, cyano, NO_2, =O, -CO-NH-$(CH_2)_2$)-OMe, -NH-C_{3-8} cycloalkyl, -CH_2-CO-NH-C_{3-8} cycloalkyl, - CO-heterocyclyl, -CO-heteroaryl, -COO-$(CH_2)_2$-heterocyclyl, -OCH_2-aryl, -OCH_2-heteroaryl, -CH_2-O-CO-aryl, -O-aryl, -NH-CO-aryl, -NH-CO-heteroaryl, -NH-CO-CH_2-aryl, - NH-aryl, aryl or heteroaryl groups, wherein said aryl, heterocyclyl or heteroaryl groups of R^{4b} may be optionally substituted by one or more halogen, C_{1-6} alkyl, C_{1-6} alkoxy, =S or hydroxyl groups and wherein said C_{1-6} alkyl or C_{2-6} alkenyl groups of R^{4b} may be optionally substituted by one or more hydroxyl, amino, cyano, C_{1-6} alkoxy, $CONH_2$ or -COO-C_{1-6} alkyl groups;

m represents an integer from 0 to 3;

R^{2b} represents halogen, haloC_{1-6} alkyl, C_{1-6} alkyl, hydroxyl, C_{1-6} alkoxy, -S-C_{1-6} alkyl, -CH_2-S-C_{1-6} alkyl, -S-C_{2-6} alkynyl, amino, cyano, NO_2, =O, =S, -SO_2-C_{1-6} alkyl, -$CONH_2$, -CO-C_{1-6} alkyl, -COO-C_{1-6} alkyl, -NH-C_{1-6} alkyl, -NH-CO-C_{1-6} alkyl, -NH-CO-CH=CH-CH_2-$N(Me)_2$, C_{1-6} alkyl, -CO-NH-C_{1-6} alkyl, -CO-NH-CH(Me)-COOH, -S-CH_2-CO-$N(Et)_2$, -NH-$(CH_2)_2$-OH, -NH-$(CH_2)_3$-OH, -NH-CH(Et)-CH_2-OH, -CO-NH-$(CH_2)_3$-OH, -$CH(CH_2OH)_2$ or -S-CH_2-CO-NH-CO-NH-C_{1-6} alkyl, wherein said C_{1-6} alkyl groups of R^{2b} may be optionally substituted by one or more hydroxyl groups;

for use as a casein kinase 1 delta (CK1δ) inhibitor in the treatment of a neurodegenerative disorder, such as tauopathies, preferably in the treatment of Alzheimer's disease.

[0011] In one embodiment of the compound of formula (IB) according to the disclosure
"Het B" represents benzoxazolyl;
Z represents a bond;
R^{1b} represents pyrimidinyl, wherein R^{1b} may be substituted by one or more (e.g. 1, 2 or 3) R^{4b} groups;

R^{4b} represents halogen, hydroxyl, -O-C_{1-6} alkenyl, -COO-C_{1-6} alkyl, -NH-C_{1-6} alkyl, -SO_2-NH_2, amino, cyano, =O, -CH_2-CO-NH-C_{3-8} cycloalkyl, -CH_2-aryl, -OCH_2-heteroaryl, -O-aryl, -NH-CO-aryl, -NH-aryl or heteroaryl groups, wherein said aryl, heterocyclyl or heteroaryl groups of R^{4b} may be optionally substituted by one or more halogen, C_{1-6} alkyl, C_{1-6} alkoxy, =S or hydroxyl groups and wherein said C_{1-6} alkyl or C_{2-6} alkenyl groups of R^{4b} may be optionally substituted by one or more hydroxyl, amino, cyano, C_{1-6} alkoxy, $CONH_2$ or -COO-C_{1-6} alkyl groups;
m represents an integer from 0 to 2; and
R^{2b} represents halogen, haloC_{1-6} alkyl, C_{1-6} alkyl, C_{3-8} cycloalkyl, hydroxyl, C_{1-6} alkoxy, -S-C_{1-6} alkyl, amino, cyano, NO_2, =O, -$CONH_2$, -CO-C_{1-6} alkyl, -COO-C_{1-6} alkyl, C_{1-6} alkyl, - CO-NH-C_{1-6} alkyl or-CO-NH-CH(Me)-COOH, wherein said C_{1-6} alkyl groups of R^{2b} may be optionally substituted by one or more cyano or hydroxyl groups.

[0012] In one embodiment of the compound of formula (IB):

"Het B" represents benzoxazolyl;

Z represents a bond;

R^{1b} represents pyrimidinyl, wherein R^{1b} is substituted by two R^{4b} groups.

R^{4b} represents amino and pyridine; and

m represents 0.

[0013] Thus, according to a further aspect of the invention, there is provided a pharmaceutical composition comprising a compound of formula (IB) or a pharmaceutically acceptable salt or solvate thereof, wherein "Het B" represents benzoxazolyl; Z represents a bond; R^{1b} represents pyrimidinyl, wherein R^{1b} is substituted by two R^{4b} groups; R^{4b} represents amino and pyridine; and m represents 0.

[0014] In an embodiment of the disclosure, R^{1b} represents pyrimidinyl optionally substituted by one or more (e.g. 1 or 2) R^{4b} groups.

[0015] In one embodiment of the disclosure, R^{4b} represents halogen, hydroxyl, -O-C_{1-6} alkenyl, - COO-C_{1-6} alkyl, -NH-C_{1-6} alkyl, -SO_2-NH_2, amino, cyano, =O, -CH_2-CO-NH-C_{3-8} cycloalkyl, -CH_2-aryl, -OCH_2-heteroaryl, -O-aryl, -NH-CO-aryl, -NH-aryl or heteroaryl groups, wherein said aryl, heterocyclyl or heteroaryl groups of R^{4b} may be optionally substituted by one or more halogen, C_{1-6} alkyl, C_{1-6} alkoxy, =S or hydroxyl groups and wherein said C_{1-6} alkyl or

C_{2-6} alkenyl groups of R^{4b} may be optionally substituted by one or more hydroxyl, amino, cyano, C_{1-6} alkoxy, $CONH_2$ or-$COO-C_{1-6}$ alkyl groups.

[0016] In a further embodiment of the disclosure, R^{4b} represents halogen (e.g. fluorine), amino or heteroaryl (e.g. pyridyl).

[0017] In one embodiment of the invention or disclosure, m represents an integer from 0 to 2. In one embodiment of the invention, m represents 0. In an alternative embodiment of the disclosure, m represents 2.

[0018] In one embodiment of the disclosure, R^{2b} represents halogen, haloC_{1-6} alkyl, C_{1-6} alkyl, C_{3-8} cycloalkyl, hydroxyl, C_{1-6} alkoxy, $-S-C_{1-6}$ alkyl, amino, cyano, NO_2, =O, $-CONH_2$, $-CO-C_{1-6}$ alkyl, $-COO-C_{1-6}$ alkyl, C_{1-6} alkyl, $-CO-NH-C_{1-6}$ alkyl or -CO-NH-CH(Me)-COOH, wherein said C_{1-6} alkyl groups of R^{2b} may be optionally substituted by one or more cyano or hydroxyl groups.

[0019] In a further embodiment of the disclosure, R^{2b} represents amino or $-CONH_2$.

[0020] In one aspect of the invention, there is provided a pharmaceutical composition comprising a compound of formula (IB), wherein said compound is compound 5-(1,3-benzoxazol-2-yl)-4-(pyridin-4-yl)pyrimidin-2-amine (Compound 324) as described herein or a pharmaceutically acceptable salt or solvate thereof.

[0021] The compound of this embodiment was tested in the CK1δ inhibition assay as described herein and exhibited inhibition of greater than 5%, such as greater than 50%, in particular greater than 90%, and also demonstrated significant and selective inhibition for CK1δ when compared with other kinases.

[0022] For example, compound number 324 (5-(1,3-benzoxazol-2-yl)-4-(pyridin-4-yl)pyrimidin-2-amine) demonstrated selectivity for CK1δ over ABL2/ARG, ALK4/ACVR1 B, ALK5/TGFBR1, CDK5/p25, CK1a1, CK1g1, CK1g3, CLK2, c-SRC, EGFR, EPHA2, FGFR1, GSK3b, HGK/MAP4K4, JNK2, KDR/VEGFR2, LCK, MSK1/RPS6KA5, PDK1/PDPK1, PIM3, PKA, PKCa, PKCb2, RIPK2, ROCK1, TNIK and YES/YES1 each of which were inhibited at levels lower than 40%.

[0023] Compound 324 has been demonstrated to have a protective effect on cell viability in a dose dependent manner as can be seen in the data presented herein and in particular within Figure 1. The compound has also been demonstrated to inhibit phosphorylation of two different amino acid residues within Tau proteins (i.e. Ser 396 and Thr 391) as shown in Figures 3A and 4.

[0024] In the present context, the term "pharmaceutically acceptable salt" is intended to

indicate salts which are not harmful to the patient. Such salts include pharmaceutically acceptable acid addition salts, pharmaceutically acceptable metal salts and pharmaceutically acceptable alkaline addition salts. Acid addition salts include salts of inorganic acids as well as organic acids.

[0025] Representative examples of suitable inorganic acids include hydrochloric, hydrobromic, hydroiodic, phosphoric, sulfuric, nitric acids and the like. Representative examples of suitable organic acids include formic, acetic, trichloroacetic, trifluoroacetic, propionic, benzoic, cinnamic, citric, fumaric, glycolic, lactic, maleic, malic, malonic, mandelic, oxalic, picric, pyruvic, salicylic, succinic, methanesulfonic, ethanesulfonic, tartaric, ascorbic, pamoic, bismethylene salicylic, ethanedisulfonic, gluconic, citraconic, aspartic, stearic, palmitic, EDTA, glycolic, p-aminobenzoic, glutamic, benzenesulfonic, p-toluenesulfonic acids and the like. Further examples of pharmaceutically acceptable inorganic or organic acid addition salts include the pharmaceutically acceptable salts listed in J. Pharm. Sci. 1977, 66, 2, which is incorporated herein by reference. Examples of metal salts include lithium, sodium, potassium, magnesium salts and the like. Examples of ammonium and alkylated ammonium salts include ammonium, methylammonium, dimethylammonium, trimethylammonium, ethylammonium, hydroxyethylammonium, diethylammonium, butylammonium, tetramethylammonium salts and the like.

[0026] Representative examples of alkaline salts include, for example, sodium, potassium, lithium, calcium, magnesium or ammonium or organic bases such as, for example, methylamine, ethylamine, propylamine, trimethylamine, diethylamine, triethylamine, N,N-dimethylethanolamine, tris(hydroxymethyl)aminomethane, ethanolamine, pyridine, piperidine, piperazine, picoline, dicyclohexylamine, morpholine, benzylamine, procaine, lysine, arginine, histidine, N-methylglucamine.

[0027] According to the invention or disclosure, the compounds of formula (IB) can be in racemic forms, as well as in the form of pure enantiomers or non racemic (scalemic) mixture of enantiomers, including when the compounds of formula (IB) have more than one stereogenic centre. In case the compounds of formula (IB) have unsaturated carbon carbon double bonds, both the cis (Z) and trans (E) isomers and their mixtures belong to the invention or disclosure.

[0028] References herein to "halogen" means a fluorine, chlorine, bromine or iodine atom.

[0029] References herein to "C_{1-6} alkyl" means any linear, branched hydrocarbon groups having 1 to 6 carbon atoms, or cyclic hydrocarbon groups having 3 to 6 carbon atoms. Representative examples of such alkyl groups include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl and t-butyl, n-pentyl, isopentyl, neopentyl, cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. References to "haloC_{1-6}alkyl" mean a C_{1-6} alkyl group substituted by one or more halogen atoms as herein defined.

[0030] References herein to "C_{2-6} alkenyl" means any linear, branched hydrocarbon groups of 2 to 6 carbon atoms, or cyclic hydrocarbon group having 3 to 6 carbon atoms having at least

one double bond. Representative examples of such alkenyl groups include ethenyl, propenyl, butenyl and cyclohexenyl.

[0031] References herein to "C_{2-6} alkynyl" means any linear, or branched hydrocarbon groups of 2 to 6 carbon atoms, having at least one triple bond. Representative examples of such alkynyl groups include ethynyl, propargyl and butynyl.

[0032] References herein to 'C_{1-6} alkoxy' means an -O-C_{1-6} alkyl group wherein C_{1-6} alkyl is as defined herein. Examples of such groups include methoxy, ethoxy, propoxy, butoxy, pentoxy or hexoxy and the like.

[0033] References herein to 'C_{3-8} cycloalkyl' means a saturated monocyclic hydrocarbon ring of 3 to 8 carbon atoms. Examples of such groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl or cyclooctyl and the like.

[0034] References herein to 'aryl' means a C_{6-12} monocyclic or bicyclic hydrocarbon ring wherein at least one ring is aromatic. Examples of such groups include phenyl, indyl or naphthyl and the like.

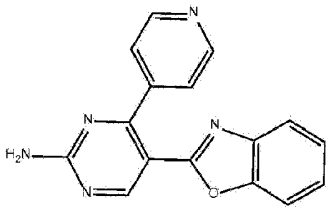
[0035] References herein to "heteroatom" means a nitrogen, sulphur, or oxygen atom.

[0036] References herein to "heterocyclyl" means a saturated or unsaturated non-aromatic ring containing from 1 to 4 heteroatoms as member atoms in the ring. Heterocyclyl groups containing more than one heteroatom may contain different heteroatoms. Heterocyclyl groups may be optionally substituted with one or more substituents as defined herein. Heterocyclyl groups are monocyclic ring systems or fused bicyclic or polycyclic ring systems or bicyclic structures known as heterocyclic "spiro" ring systems. In certain embodiments, heterocyclyl is saturated. In other embodiments, heterocyclyl is unsaturated and non-aromatic. Non-limiting examples of monocyclic heterocyclyl ring systems include pyrrolidinyl, tetrahydrofuranyl, dihydrofuranyl, pyranyl, tetrahydropyranyl, dihydropyranyl, tetrahydrothienyl, pyrazolidinyl, oxazolidinyl, thiazolidinyl, piperidinyl, homopiperidinyl, piperazinyl, morpholinyl, thiamorpholinyl, 1 ,3-dioxolanyl, 1 ,3-dioxanyl, 1 ,4-dioxanyl, 1 ,3- oxathiolanyl, 1 ,3-oxathianyl, 1 ,3-dithianyl, and azetidinyl.

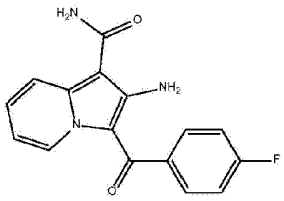
[0037] References herein to "heteroaryl" means an aromatic ring containing from 1 to 4 heteroatoms as member atoms in the ring. Heteroaryl groups containing more than one heteroatom may contain different heteroatoms. Heteroaryl groups may be optionally substituted with one or more substituents as defined herein. Heteroaryl groups are monocyclic ring systems or are fused bicyclic or polycyclic ring systems. Monocyclic heteroaryl rings have 5 or 6 member atoms. Bicyclic heteroaryl rings have from 7 to 11 member atoms. Bicyclic heteroaryl rings include those rings wherein phenyl and a monocyclic heterocyclyl ring are attached forming a fused bicyclic ring system, and those rings wherein a monocyclic heteroaryl ring and a monocyclic cycloalkyl, cycloalkenyl, heterocyclyl, or heteroaryl ring are attached

forming a fused bicyclic ring system. Non-limiting examples of heteroaryl includes pyrrolyl, pyrazolyl, imidazolyl, oxazolyl, isoxazolyl, thiazolyl, isothiazolyl, furanyl, furazanyl, thienyl, triazolyl, pyridinyl, pyrimidinyl, pyridazinyl, pyrazinyl, triazinyl, tetrazinyl, indolyl, isoindolyl, indolizinyl, indazolyl, purinyl, quinolinyl, isoquinolinyl, quinoxalinyl, quinazolinyl, pteridinyl, cinnolinyl, benzimidazolyl, benopyranyl, benzoxazolyl, benzofuranyl, isobenzofuranyl, benzothiazolyl, benzothienyl, furopyridinyl, and napthyridinyl.

[0038] A representative compound of formula (IB) is set forth below:

Compound Number	Structure
324	

[0039] A comparative compound is set forth below:

987	

[0040] According to a further aspect of the invention or disclosure, there is provided a compound of formula (IB) for use as a casein kinase 1 delta (CK1δ) inhibitor in the treatment of a neurodegenerative disorder, such as tauopathies.

[0041] In particular, the compound for use as a casein kinase 1 delta (CK1d) inhibitor in the treatment of a neurodegenerative disorder is 5-(1,3-benzoxazol-2-yl)-4-(pyridine-4-yl)pyrimidin-2-amine (Compound 324). Preferably, the neurodegenerative disorder is a tauopathy, more preferably Alzheimer's disease.

[0042] The compound of formula 324 is either commercially available or may be prepared in accordance with known synthetic procedures.

[0043] According to a further aspect of the invention or disclosure there is provided a pharmaceutical composition comprising a compound of formula (IB) for use in the treatment of a neurodegenerative disorder, such as tauopathies.

[0044] In particular, the pharmaceutical composition for use in the treatment of a neurodegenerative disorder according to the invention comprises 5-(1,3-benzoxazol-2-yl)-4-

(pyridin-4-yl)pyrimidin-2-amine (Compound 324). Preferably, the neurodegenerative disorder is a tauopathy, more preferably Alzheimer's disease.

[0045] The pharmaceutical compositions of the invention may comprise, in addition to one of the above substances, a pharmaceutically acceptable excipient, carrier, buffer, stabiliser or other materials well known to those skilled in the art. Such materials should be non-toxic and should not interfere with the efficacy of the active ingredient. The precise nature of the carrier or other material may depend on the route of administration, e. g. oral, intravenous, cutaneous or subcutaneous, nasal, intramuscular, intraperitoneal routes.

[0046] Pharmaceutical compositions for oral administration may be in tablet, capsule, powder or liquid form. A tablet may include a solid carrier such as gelatin or an adjuvant.

[0047] Liquid pharmaceutical compositions generally include a liquid carrier such as water, petroleum, animaL or vegetable oils, mineral oil or synthetic oil.

[0048] Physiological saline solution, dextrose or other saccharide solution or glycols such as ethylene glycol, propylene glycol or polyethylene glycol may be included.

[0049] For intravenous, cutaneous or subcutaneous injection, or injection at the site of affliction, the active ingredient will be in the form of a parenterally acceptable aqueous solution which is pyrogen-free and has suitable pH, isotonicity and stability. Those of relevant skill in the art are well able to prepare suitable solutions using, for example, isotonic vehicles such as Sodium Chloride Injection, Ringer's Injection, Lactated Ringer's Injection. Preservatives, stabilisers, buffers, antioxidants and/or other additives may be incLuded, as required.

[0050] The compounds of formula (IB) are believed to be casein kinase 1 delta (CK1δ) inhibitors. Certain compounds of formula (IB) have inhibitory activity of greater than 5%, in particular greater than 10%, more particularly greater than 25%, yet more particularly greater than 50%, especially greater than 75%, such as greater than 90%. Such compounds may be useful in the treatment in neurodegenerative disorders such as tauopathies. Tauopathies are conditions which are characterised by neurofibrillary tangles or aggregates of the tau protein. Tauopathies are a recognised class of conditions known to those skilled in the art and include Alzheimer's disease, frontotemporal dementia with Parkinsonism linked to chromosome 17 (FTDP-17), progressive supranuclear palsy (PSP), Pick's disease, corticobasal degeneration, multisystem atrophy (MSA), neurobasal degeneration with iron accumulation, type 1 (Hallervorden-Spatz), argyrophilic grain dementia, Down's syndrome, diffuse neurofibrillary tangles with calcification, dementia pugilistica, Gerstmann-Straussler-Scheinker disease, myotonic dystrophy, Niemann-Pick disease type C, progressive subcortical gliosis, prion protein cerebral amyloid angiopathy, tangle only dementia, postencephalitic parkinsonism, subacute sclerosing panencephalitis, Creutzfeldt-Jakob disease, amyotrophic lateral sclerosis/parkinsonism-dementia complex, non-Guamanian motor neuron disease with neurofibrillary tangles/dementia, and Parkinson's disease. The intracellular tau deposits are usually neuronal or glial and are filamentous and generally in a hyperphosphorylated state as

compared to the level of phosphorylation in tau from control human brain. In the case of AD, this hyperphosphorylated tau is often referred to a paired helical filament tau (PHF) tau because it is derived from the PHF. In one embodiment, the tauopathy comprises Alzheimer's disease.

[0051] According to a further aspect of the disclosure, there is provided a method of treating a neurodegenerative disorder, such as tauopathies, which comprises administering a therapeutically effective amount of a compound of formula (IB).

Biological Data

1. CK1δ Inhibition Assay

[0052] The compound of the invention may be tested for inhibition of casein kinase 1 delta (CK1δ) in accordance with the assay protocols described in US 2010/0152157, EP 1,636,375 or Hanger et al (2007) J. Biol. Chem. 282, 23645-23654. In particular, the assay was conducted in accordance with the following protocol:

Reaction Buffer:

[0053] Base Reaction buffer; 20 mM Hepes (pH 7.5), 10 mM $MgCl_2$, 1 mM EGTA, 0.02% Brij35, 0.02 mg/ml BSA, 0.1 mM Na_3VO_4, 2 mM DTT, 1% DMSO
It should be noted that required cofactors are added individually to each kinase reaction.

Reaction Procedure:

[0054]

1. 1. Prepare indicated substrate in freshly prepared Base Reaction Buffer as described above
2. 2. Deliver any required cofactors to the substrate solution
3. 3. Deliver indicated kinase into the substrate solution and gently mix
4. 4. Deliver compounds in DMSO into the kinase reaction mixture
5. 5. Deliver ^{33}P-ATP (specific activity 0.01 µCi/µl final) into the reaction mixture to initiate the reaction
6. 6. Incubate kinase reaction for 120 min. at room temperature
7. 7. Reactions are spotted onto P81 ion exchange paper (Whatman # 3698-915)
8. 8. Wash filters extensively in 0.75% Phosphoric acid

Kinase information:

[0055] CK1d - Genbank Accession # NP_620693
Recombinant human full-length construct. GST-tagged, expressed in insect cells.
Final concentration in assay = 4 nM
Substrate: CK1tide
Substrate sequence: [KRRRAL[pS]VASLPGL]
Final substrate concentration in assay = 20 μM
It should be noted that no additional cofactors are added to the reaction mixture.

[0056] Compound 324 was tested in the CK1δ inhibition assay and exhibited inhibition of greater than 5%.

[0057] In particular, compound 324 exhibited inhibition of greater than 50%.

[0058] Yet more particularly, compound 324 exhibited inhibition of greater than 90%.

2. Measurement of Compound Effect on Ck1d-mediated Tau Phosphorylation

[0059] The *in vivo* phosphorylation of Tau protein is complex with a number of putative protein kinases involved. It is widely accepted that the kinases GSK3b and CDK5 are significant players in the generation of PHF Tau, the pathogenic form found in neurofibrillary tangles in Alzheimer's disease. More recently, there has been growing evidence supporting the role of other kinases, particularly CK1δ in Tau hyperphosphorylation *in vivo*. Hanger et al. 2007 (J. Biol. Chem. 282, 23645-23654) identified 37 phosphorylation sites in human PHF Tau and were able to recapitulate these *in vitro* using recombinant tau and various purified kinase preparations. These studies identified that certain sites were uniquely phosphorylated by CK1δ and that certain other sites required CK1δ and another kinase with CK1δ providing upstream phosphorylation to render the targeted site available for the second kinase. Thus, to assess whether candidate compounds selective inhibit CK1δ activity either directly or through blocking its priming for other kinases a number of different screens have been developed. The general concept of these screens is provided in WO2005/001114.

[0060] To measure the effect of putative CK1δ inhibitors on the levels of CK1δ -mediated phosphorylation selected-reaction monitoring assays were performed that provide quantitative relative measurement of phosphate group occupancy at specific sites in transgenic human and endogenous murine forms of Tau.

[0061] The PhosphoTau SRM V2 assay measures total tau and relative phosphorylation levels

at five of the most commonly studied sites on Tau and was obtained from Proteome Sciences plc (Cobham, England). None of the sites in the V2 assay is uniquely phosphorylated by CK1δ and there is a possibility that compound-induced inhibition of phosphorylation measured by this method may be achieved through promiscuous inhibition of other kinases such as GSK3b and/or CDK5. To address this limitation, Proteome Sciences has developed a V3 assay that measures total tau and two sites that are exclusively phosphorylated by CK1δ in addition to four others that have been shown to be phosphorylated *in vitro* by at least one other Tau kinase in addition to CK1δ. Table 1 lists the various sites covered and the candidate Tau kinases reported in Hanger et al. (2007).

Table 1: Tau phosphorylation sites covered by Tau Phosphorylation SRM V2 and V3 assays

Site number	**Candidate Kinases**
Assay V2	
Ser181	GSK3b
Ser199	CK2, GSK3b, PKA
Thr231	GSK3b, PKA
Ser262	CK1δ, GSK3b, PKA
Ser396	CK1δ, CK2, GSK3b
Assay V3	
Ser46	CK1δ, GSK3b
Thr50	CK1δ, GSK3b
Ser113*	CK1δ
Ser396	CK1δ, CK2, GSK3b
Ser404	CK1δ, CK2, GSK3b
Ser433*	CK1δ
Numbering based on human 2N4R tau. * - CK1d unique site	

SH-SY5Y-TMHT Cell Line

[0062] The SH-SY5Y-TMHT cell line (JSW Life Sciences, Graz, Austria) represents an *in vitro* model of tauopathy. The cell line is created by stably transfecting the human neuroblastoma derived SH-SY5Y cell line with a vector containing the full length human 2N4R Tau isoform which carries two common disease associated mutations (V337M/R406W). In recent studies (Flunkert et al. 2011 submitted, Loeffler et al. 2011 submitted) both the SH-SY5Y-TMHT cell line and a transgenic mouse line carrying the same human transgene were shown to express high levels of human Tau which becomes hyperphosphorylated at multiple epitopes previously demonstrated to be phosphorylated in various human tauopathies including Alzheimer's

disease. Furthermore, in SH-SY5Y-TMHT cells exposed to different kinase inhibitors, including JNK-Inhibitor SP600125, and CK1 inhibitor IC261 levels of Tau phosphorylation at key pathogenic sites were reduced in patterns consistent with the known site-specificity of the targeted kinase. Thus, the SH-SY5Y-TMHT cell line is ideally suited to the screening of novel Tau kinase inhibitors.

Compound screening in SH-SY5Y-TMHT Cells

[0063] SH-SY5Y-TMHT cells are kept in culture medium (DMEM medium, 10% FCS, 1% NEAA, 1% L-Glutamine, 100 µg/ml Gentamycin, 300 µg/ml Geneticin G-418) for 2 days until 80-90% confluency. Cells are then differentiated in culture medium supplemented with 10 µM retinoic acid (RA) for 7 days changing medium every 2 to 3 days. Differentiated cells are seeded onto 6-well plates and 96-well plates at a cell density of 1.25 x 10^6 and 8 x 10^5 cells per well, respectively. On day 8 post-differentiation, the test compounds, reference compounds and vehicle control were added to the culture medium. After 6 h of compound exposure one plate of cells is subjected to a MTT assay to evaluate the effect of test and reference items on cell viability. Remaining wells are washed once with cold PBS and harvested in 300 µl RIPA-Buffer [50 mM Tris pH 7.4, 1% Nonident P40, 0.25% Na-deoxycholate, 150 mM NaCl, 1 mM EDTA, 1 µM NaF, 1 µM Na-ortho-vanadate, 80 mM Glycerophosphate, supplemented with freshly added protease (Calbiochem) and phosphatase (Sigma) inhibitor cocktail]. The cell suspension is transferred into a 1.5 ml tube and additionally lysed by sonication on ice. An aliquot of 20 µl is taken for the determination of the protein concentration (BCA assay). Subsequently, the lysates are snap frozen and stored at -80°C until shipment.

[0064] Two independent experiments in three (four) technical replicates are performed as depicted in Table 2.

Table 2

Experiment	Cells	Treatment	Concentration	Evaluation	
ExpA	SH-SY5Y-TMHT	Vehicle	-	MTT	BSA
		Compound 324	10-5-1-0.5-0.1-0.05 µM		TauP V2
		Compound 987	10-5-1-0.5-0.1-0.05 µM		TauP V3
		PF670462	1-0.5-0.1 µM		
ExpB	SH-SY5Y-TMHT	Vehicle	-	MTT	BSA
		Compound 324	10-5-1-0.5-0.1-0.05 µM		TauP V2
		Compound 987	10-5-1-0.5-0.1-0.05 µM		TauP V3
		PF670462	1-0.5-0.1 µM		

Cell Viability Testing

[0065] To determine compound activity, it is necessary to control for potential cell toxicity of all molecules. Viability of cultures is determined by the MTT assay. This assay allows the measurement of the mitochondrial dehydrogenase activity which reduces yellow MTT to dark blue formazan crystals. Since this reaction is catalyzed in living cells only this assay is used for the determination of cell viability. MTT solution is added to each well in a final concentration of 0.5 mg/ml. After 2 hours, the MTT containing medium is aspired. Cells are lysed in 3% SDS and the formazan crystals are dissolved in isopropanol/HCl. Optical density is measured with a plate-reader at wavelength 570 nm. Cell survival rate is expressed as optical density (OD). Values are calculated as percent of control values.

Quantitative determination of total protein content

[0066] Prior to assessment of specific Tau phosphorylation status the concentration of total protein in each cell lysate is determined using a standard BCA assay (Pierce Biotechnology, Rockford, USA). Briefly, 20 µl of cell lysate was used in the assay according to the manufacturer's instructions.

Quantitative determination of total Tau & phosphorylated Tau

Mass spectrometric assays

[0067] Total cell lysates from TMHT cell lines treated with Compound 324, comparative compounds Compound 987 (2-amino-3-[(4-fluorophenyl)carbonyl]indolizine-1-carboxamide) and PF670462 and relevant vehicle control respectively are first subjected to 1-dimensional SDS-PAGE to purify the protein fraction. Stacking gels are loaded with approximately 100 µg total protein based on BCA assay results. Gels are run until the total protein content forms a single discrete band in the stacking gel. Each protein band is then cut from the gel and digested with either trypsin or Asp-N and analysed using the PhosphoTau SRM assay V2 or V3 respectively. Each assay method quantifies the phosphorylation in pre-clinical material using a triple quadrupole mass spectrometer (TSQ Vantage, Thermo Scientific, Hemel Hempstead, UK). Prior to SRM analysis phosphopeptides and pre-clinical samples were resolved by RP-chromatography (XBridge column, Waters, Manchester, UK) over a 9 minute gradient 0-30% ACN (buffer A; 0.1% FA, buffer B; ACN, 0.1% FA). Light and heavy versions for each peptide and phosphopeptide were monitored by several SRM transitions, using optimised S Lens values and collision energy settings. The area under the SRM LC peak was used to quantitate the amount of analyte present in each cell lysate as a single point reference to the signal of the

heavy peptide spike. An 11 point calibration curve of light phosphopeptides with each point in the curve spiked with 100 fmol heavy phosphopeptides was also produced to determine assay characteristics (LOD, LOQ, precision and accuracy). For each specified tau population, the endogenous level of each tau phosphopeptide was quantified against its calibration curve (0.25-1000 fmol on column). Prior to LC-SRM analysis each tau population was spiked with 100fmol of the heavy phosphopeptide standards. All data was processed using Pinpoint software (Thermo Scientific) and results reported as pg phospho-peptide/µg total protein.

Western Blotting

[0068] Lysates of treated cells were prepared in Laemmli buffer and 10 µg loaded into each lane of a 10% Nu-PAGE gel (Invitrogen, UK). Samples were run until the coomassie blue dye fromt was within 1 cm of the bottom of the gel. The separated proteins were transferred onto nitrocellulose and blots developed using antibodies specific for total tau (Polyclonal Rabbit Anti-Human Tau, Dako, UK (cat # A0024)) and phopho-Threonine 231 (Tau (Phospho-Thr231) Antibody, Signalway Antibody, USA (cat # 11110)) respectively. In each case the bound antibody was detected using ECL Rabbit IgG, HRP-Linked (from donkey) (GE Healthcare, UK (cat # NA934))

Results

Effect of test and reference compounds on the cell viability of SH-SY5Y-TMHT cells

[0069] Cell viability was determined in differentiated SH-SY5Y-TMHT cells by the MTT assay. Test and reference compounds were applied in a concentration range from 0.05 µM to 10 µM and from 0.1 µM to 1 µM, respectively. Upon 6 h of treatment, cell viability was evaluated. Figure 1 shows the effect of Compound 324 on the cell viability of SH-SY5Y-TMHT cells wherein the graph represents effect of Compound 324 on cell viability of SH-SY5Y-TMHT cells in % of the vehicle control (VC, white bar). Statistical significance is indicated by *<0.05, ** <0.01, ***<0.001 as determined by One-Way ANOVA. Data are shown from two independent experiments as group mean +/- SEM (n=8). It can be seen from Figure 1 that Compund 324 exhibited a protective effect on the cell viability of SH-SY5Y-TMHT cells in a dose dependent manner although the effect was only statistically significant at a concentration of 10 µM. Figure 2 shows the effect of PF670462 on the cell viability of SH-SY5Y-TMHT cells wherein the graph represents effect of PF670462 on cell viability of SH-SY5Y-TMHT cells in % of the vehicle control (VC, white bar). Statistical significance is indicated by *<0.05, **<0.01, ***<0.001 as determined by One-Way ANOVA. Data are shown from two independent experiments as group mean +/- SEM (n=8). It can be seen from Figure 2 that the reference compound PF 670462 only displayed a significant protective effect on the cell viability of SH-SY5Y-TMHT cells at a concentration of 0.5 µM.

Protein determination of SH-SY5Y-TMHT cells following treatment

[0070] Protein concentration of cell lysates of the treated SH-SY5Y-TMHT cells was determined using a standard BCA assay. Protein amount was determined from all samples in duplicates. The protein concentration of the samples was in the expected range according to the amount of cells seeded per 12-well plate ranging between 150 - 350 µg/ml.

Determination of compound treatment effect on specific phosphorylation sites

Mass Spectrometric Assay

[0071] Testing of SH-SY5Y-TMHT cell lysates was performed using the PhosphoTau SRM assay V2 and V3. When the relative level of phosphorylation at each site is compared with the ratio in vehicle treated controls there was a distinct reduction in the level of phosphopeptide in cells treated with Compound 324 (data shown for 10µM) and comparative compound 2-amino-3-[(4-fluorophenyl)carbonyl]indolizine-1-carboxamide (Compound 987) (data shown for 10µM). An example showing reduction of phosphorylation on Serine 396 is shown in Figure 3. This Figure shows mass spectrometric determination of CK1d-selective compounds on phosphorylation of Serine 396 in SH-SY5Y-TMHT cells. Panel A shows cells treated with Vehicle Control (VC) or Compound 324 (T.I.1_10µM) and Panel B shows cells treated with Vehicle Control (VC) or Compound 987 (T.I.2_10µM).

[0072] In cells exposed to the vehicle control approximately 83% of Tau is phosphorylated at S396. Treatment with 10 µM Compound 324 reduced this to 38% whilst 10 µM Compound 987 reduced pS396 levels to 24%. These results confirm the inhibition of pS396 by CK1d selective reagents.

Western Blot Assay

[0073] Levels of total Tau and Tau phosphorylated at Threonine 231 in SH-SY5Y-TMHT cell lysates treated with vehicle control, Compound 324 (10µM), comparative compounds Compound 987 (10µM) and PF670462 (5µM) were quantified by Western Blotting. Figure 4 shows the Western Blot measurement of pT231 (panel A) and total Tau (panel B) levels in SH-SY5Y-TMHT cells treated with selective CK1d inhibitors. As shown in Figure 4, all three compounds reduced the detectable level of pT231 in Tau protein whereas this epitope was strongly present in vehicle-treated cells. There was no significant difference in the detectable levels of total Tau between the preparations other than for the PF670462-treated lysate which appeared to contain marginally less total Tau than the others. These results confirm the

inhibition of pT231 by CK1d selective reagents.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US2008027051A [0007]
- US20100152157A [0052]
- EP1636375A [0052]
- WO2005001114A [0059]

Non-patent literature cited in the description

- **GHOSHAL, N. et al.**Am. J. Pathol, 1999, vol. 155, 1163-1172 [0007]
- **YASOJIMA, K. et al.**Brain Res, 2000, vol. 865, 116-120 [0007]
- **KURET, J. et al.**J. Neurochem, 1997, vol. 69, 2506-2515 [0007]
- **LI, G. et al.**J. Biol. Chem., 2004, vol. 279, 15938-15945 [0007]
- **CHAUHAN, A. et al.**Brain Res., 1993, vol. 629, 47-52 [0007]
- **FLAJOLET, M. et al.**PNAS USA, 2007, vol. 104, 4159-4164 [0007]
- **HANGER et al.**J. Biol. Chem., 2007, vol. 282, 23645-23654 [0007] [0052] [0059]
- J. Pharm. Sci., 1977, vol. 66, 2- [0025]

PATENTKRAV

1. En farmaceutisk sammensætning omfattende en forbindelse 5-(1,3-benzoxazol-2-yl)-4-(pyridin-4-yl)pyrimidin-2-amin (forbindelse 324) eller et farmaceutisk acceptabelt salt eller solvat deraf.

2. Den farmaceutiske sammensætning ifølge krav 1 til brug i behandling.

3. Den farmaceutiske sammensætning eller forbindelse ifølge krav 1 til brug som en inhibitor af kaseinkinase delta (CK1δ) i behandlingen af neurodegenerative lidelser, såsom tauopatier.

4. Den farmaceutiske sammensætning eller forbindelse til brug som defineret ifølge krav 3, hvor tauopatien er valgt blandt Alzheimers sygdom, frontotemporal demens med parkisonisme koblet til kromosom 17 (FTDP-17), progressiv supranukleær parese (PSP), Picks sygdom, kortikobasal degeneration, multisystem atrofi (MSA), neurobasal degeneration med jernophobning, type 1 (Hallervorden-Spatz), argyrophilic grain dementia, Downs syndrom, udbredte neurofibrillære knuder med forkalkninger, dementia pugilistica, Gerstmann-Straussler-Scheinker sygdom, myotonia atrophicans, Niemann-Pick sygdom type C, progressiv subkortikal gliose, prionprotein cerebral amyloid angiopati, såkaldt tangle only-demens, postencephalitisk parkisonisme, subakut skleroserende panencephalit, Creutzfeldt-Jakobs sygdom, amyotrofisk lateral sklerose/parkinsonisme-demens-kompleks, non-Guamanian motorneuronsygdom med neurofibrillære knuder /demens og Parkinsons sygdom.

5. Den farmaceutiske sammensætning eller forbindelse som defineret i krav 3 eller krav 4, hvor tauopatien omfatter sygdommen Alzheimers.

DRAWINGS

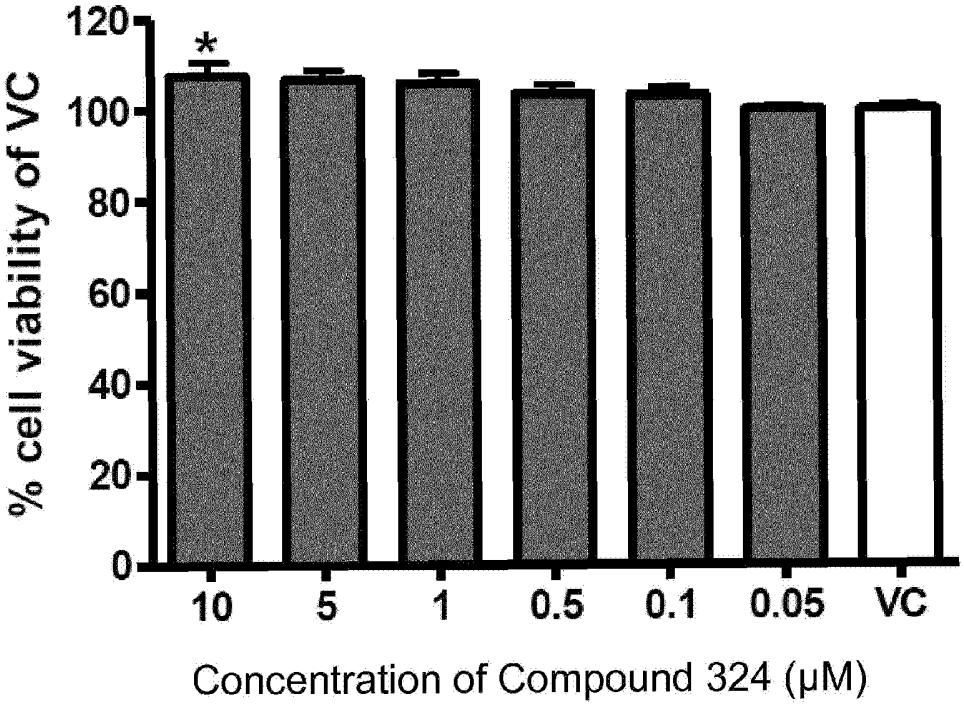


FIGURE 1

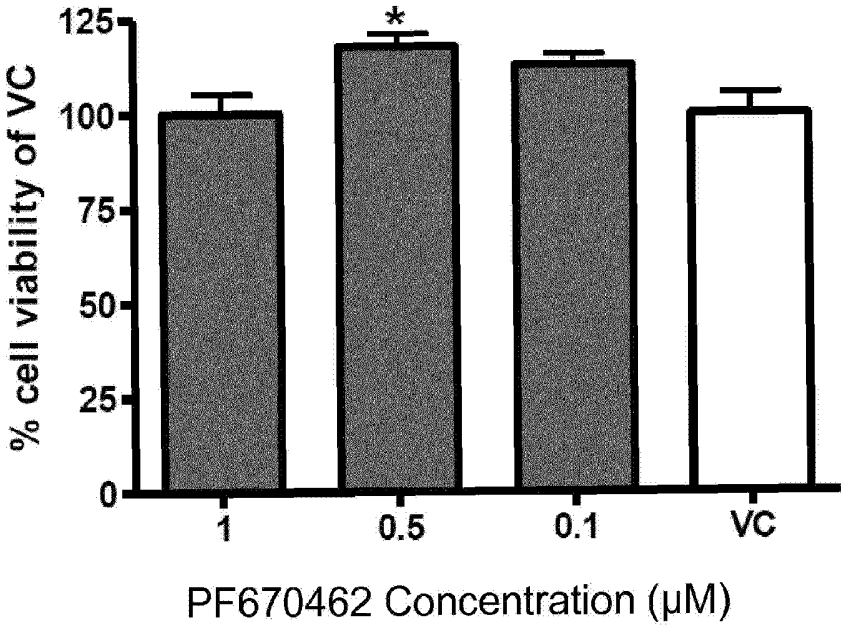
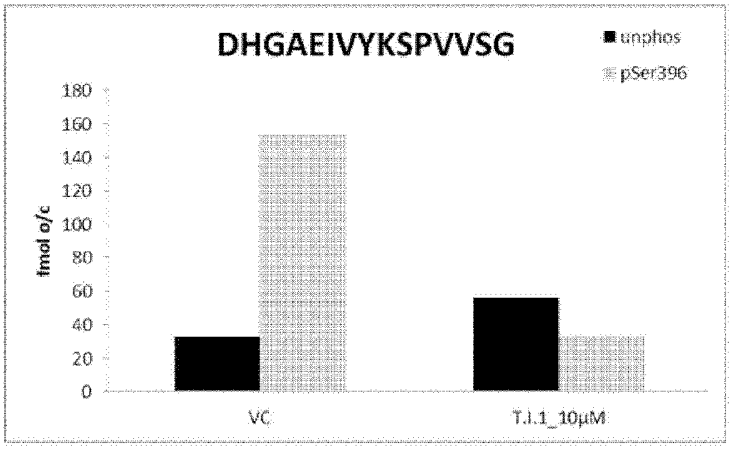

125
100
75
50
25
0
% cell viability of VC
*
1
0.5
0.1
VC
PF670462 Concentration (μM)

FIGURE 2

A


DHGAEIVYKSPVVSG
unphos
pSer396
fmol o/c
180
160
140
120
100
80
60
40
20
0
VC
T.I.1_10µM

B

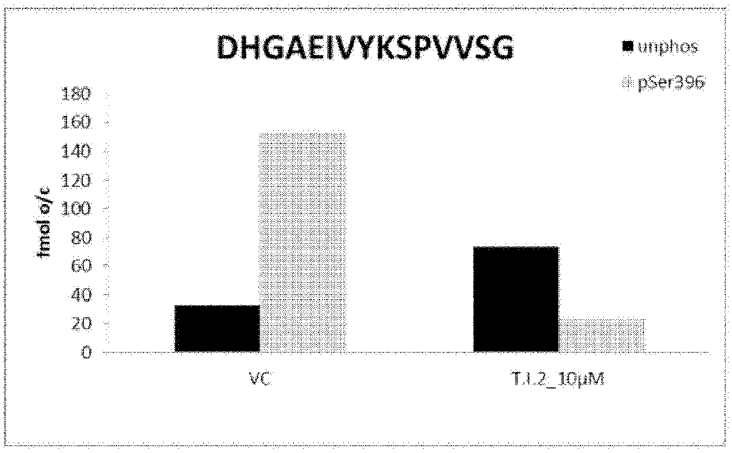
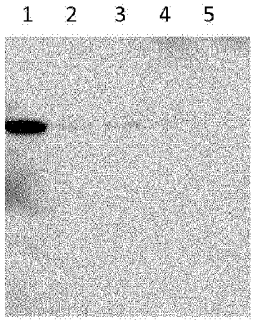

DHGAEIVYKSPVVSG
unphos
pSer396
fmol o/c
180
160
140
120
100
80
60
40
20
0
VC
T.I.2_10µM

FIGURE 3

A

Phospho-Thr231



1. Vehicle Control
2. Compound 324 @ 10μM
3. Compound 987 @ 10μM
4. PF670462 @ 1μM
5. Rec Tau (-ve control)

1 min Exposure

B

Total Tau – Dako

1. Vehicle Control
2. Compound 324 @ 10μM
3. Compound 987 @ 10μM
4. PF670462 @ 1μM
5. Rec Tau (-ve control)

30secExposure

FIGURE 4