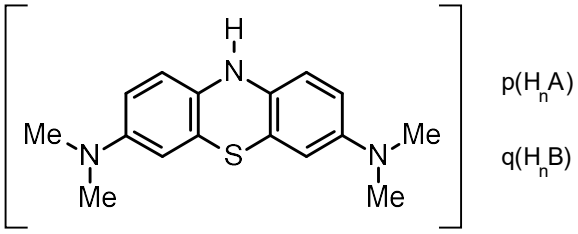
Nevertheless it is well known that there is inter-individual variability between subjects in respect of how a given dosage of a drug will translate into the concentration of the drug in the subject's body fluids. It is advantageous that any dosing regimen which is to be applied to populations of such subjects can as far as possible take such variability into account, in order to ensure maximal therapeutic benefit for all subjects, without the need for personalised regimes, and while nevertheless maintaining a desirable clinical profile.

Summary of Invention

The present disclosure refers to a use of an methylthioninium ("MT")-containing compound in the manufacture of a medicament for therapeutic or prophylactic treatment of a neurodegenerative disorder in a human subject, which treatment provides a total daily dose of between 20.5 and 60 mg of MT to the subject per day, optionally split into 2 or more doses, wherein the MT-containing compound is an LMTX compound of the following formula:



wherein each of H_nA and H_nB (where present) are protic acids which may be the same or different, and wherein p = 1 or 2; q = 0 or 1; n = 1 or 2; (p + q) × n = 2,
and wherein the disorder is selected from the list consisting of: Alzheimer's disease; Pick's disease, progressive supranuclear palsy; disinhibition-dementia-parkinsonism-amyotrophy complex, pallido-ponto-nigral degeneration, Guam-ALS syndrome, pallido nigro luysian degeneration, cortico-basal degeneration, dementia with argyrophilic grains, dementia pugilistica or chronic traumatic encephalopathy, Down's syndrome, subacute sclerosing panencephalitis, Niemann-Pick disease, type C, Sanfilippo syndrome type B, or a myotonic dystrophy DM1 or DM2.

Disclosure of the invention

The present inventors have devised a novel pharmacokinetic (PK) model for dosing MT compounds in patient populations. This versatile model was derived from a Phase 1 study in elderly volunteers, and is described in the Examples hereinafter.

The novel population PK model was then used to estimate Cmax of parent MT in patients who received LMTM in the two phase 3 trials of AD studies described in WO2018/019823 (Studies "005" and "015", for treatment of mild, or mild to moderate, AD patients respectively). Once the Cmax was estimated in each of the subjects, a distribution of Cmax estimates for each of the treated population could be derived.

As expected, there was substantial variability in the MT Cmax values across the population for the given low dosage. Analysis of this distribution confirmed the findings in WO2018/019823 that low dosages (4 mg MT bid) were efficacious (as measured, for example, by reduced decline on the Alzheimer's Disease Assessment Scale – cognitive subscale (ADAS-cog). It further confirmed that monotherapy gave a substantial benefit by this criterion compared to add-on therapy with AChEIs and\or memantine (with the mean benefit of between monotherapy and add-on being ~ 4 ADAS-cog units over 65 weeks)(see Figure 3a).

However, unexpectedly in view of the published literature which described a lack of recognisable *dose* response, the novel analysis revealed that there exists a *concentration* response within the low dose treated population. This can be shown for patients receiving the 8 mg/day using a sigmoid E_{max} analysis for for ADAS-cog_{11} decline over 65 weeks in patients pooled from Studies 015 and 005 (Figure 12).

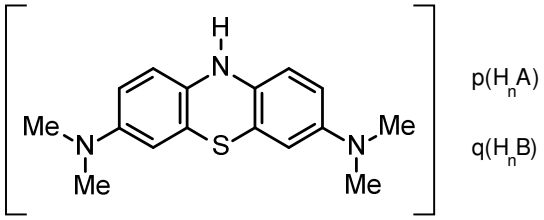
Based on a *median* Cmax threshold split of the population, the group of individuals with "high" estimated Cmax showed an improvement of around ~ 2 to 3 ADAS-cog units compared to the group of individuals with "low" estimated Cmax (see Figure 3a).

However based on splitting of patients according to the threshold of 0.373 ng/ml, that encompasses the 35% of patients with the lowest values, the treatment difference in patients receiving the 8 mg/day dose is -3.4 ADAS-cog units (see Figure 14).

These insights suggest that it is advantageous to adopt a dosing regimen which both maximises the proportion of subjects in which the MT concentration will exceed the C_{max} or C_{ave} threshold, and also maximises the expected therapeutic efficacy of LMTM whether it is taken alone or in combination with (or at least preceded by) symptomatic treatments, while

Claims

1 Use of an methylthioninium ("MT")-containing compound in the manufacture of a medicament for therapeutic or prophylactic treatment of a neurodegenerative disorder in a human subject,
which treatment provides a total daily dose of between 20.5 and 60 mg of MT to the subject per day, optionally split into 2 or more doses,
wherein the MT-containing compound is an LMTX compound of the following formula:



wherein each of H_nA and H_nB (where present) are protic acids which may be the same or different,
and wherein p = 1 or 2; q = 0 or 1; n = 1 or 2; (p + q) × n = 2,
and wherein the disorder is selected from the list consisting of: Alzheimer's disease; Pick's disease, progressive supranuclear palsy; disinhibition-dementia-parkinsonism-amyotrophy complex, pallido-ponto-nigral degeneration, Guam-ALS syndrome, pallido nigro luysian degeneration, cortico-basal degeneration, dementia with argyrophilic grains, dementia pugilistica or chronic traumatic encephalopathy, Down's syndrome, subacute sclerosing panencephalitis, Niemann-Pick disease, type C, Sanfilippo syndrome type B, and a myotonic dystrophy DM1 or DM2.

2 The use as claimed in claim 1 wherein the total daily dosage is 21 to 40mg; 21 to 32 mg; or 24 to 32 mg.

3 The use as claimed in claim 1 wherein the total daily dose is about 20.5, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40 mg.

4 The use as claimed in any one of claims 1 to 3 wherein the total daily dose of the MT-containing compound is once a day, or a split dose twice a day or three times a day.

***

5 The use as claimed in any one of claims 1 to 4 wherein the subject:
(a) has not historically received treatment with an acetylcholinesterase inhibitor or an N-methyl-D-aspartate receptor antagonist, or
(b) has historically received treatment an acetylcholinesterase inhibitor or an N-methyl-D-aspartate receptor antagonist, but ceased that treatment at least 1, 2, 3, 4, 5, 6, 7 days, or 2, 3, 4, 5, 6, 7, 8, weeks prior to treatment with the MT-containing compound, or

(c) is selected as one who is receiving treatment with an acetylcholinesterase inhibitor or an N-methyl-D-aspartate receptor antagonist, wherein said treatment is discontinued prior to treatment with the MT-containing compound.

6 The use as claimed in any one of claims 1 to 5 wherein the therapeutic treatment is not combined with an acetylcholinesterase inhibitor or an N-methyl-D-aspartate receptor antagonist.

***

7 The use as claimed in any one of claims 1 to 5 wherein the therapeutic treatment is combined with an acetylcholinesterase inhibitor or an N-methyl-D-aspartate receptor antagonist.

***

8 The use as claimed in any one of claims 5 to 7, wherein the acetylcholinesterase inhibitor is selected from the list consisting of donepezil; rivastigmine; and galantamine and/or the N-methyl-D-aspartate receptor (NMDA) receptor antagonist is memantine.

***

~~9 The use as claimed in any one of claims 1 to 8 wherein the disorder is a tauopathy.~~

~~10 The use as claimed in any one of claims 1 to 9 wherein the disorder is selected from the list consisting of: Alzheimer's disease; Pick's disease, progressive supranuclear palsy, frontotemporal dementia, FTD with parkinsonism linked to chromosome 17, frontotemporal lobar degeneration syndromes; disinhibition-dementia-parkinsonism-amyotrophy complex, pallido-ponto-nigral degeneration, Guam-ALS syndrome, pallido nigro luysian degeneration, cortico-basal degeneration, dementia with argyrophilic grains, dementia pugilistica or chronic traumatic encephalopathy, Down's syndrome, subacute sclerosing panencephalitis, mild cognitive impairment, Niemann-Pick disease, type C, Sanfilippo syndrome type B, or a myotonic dystrophy DM1 or DM2.~~

~~***~~

~~11 The use as claimed in any one of claims 1 to 8 wherein the disorder is an FTLD syndrome.~~

~~12 The use as claimed in claim 11 wherein the FTLD syndrome is a TAR DNA-binding protein 43 (TDP-43) proteinopathy and/or is FTLD with tau pathology or FTLD with TDP-43 pathology and/or is selected from behavioral-variant frontotemporal dementia (bvFTD), primary progressive aphasia, and semantic dementia.~~

~~***~~

~~13 The use as claimed in any one of claims 1 to 8 wherein the disorder is a polyglutamine disorder, which is optionally selected from Huntington's disease, spinal bulbar muscular atrophy, dentatorubropallidoluysian atrophy or spinocerebellar ataxias.~~

***

~~14 The use as claimed in any one of claims 1 to 8 wherein the disorder is a synucleinopathy, which is optionally selected from Parkinson's disease, dementia with Lewy bodies and multiple system atrophy.~~

***

~~15 The use as claimed in any one of claims 1 to 8 wherein the disorder is hereditary cerebral angiopathy, amyotrophic lateral sclerosis, familial encephalopathy with neuronal inclusion bodies or Lafora disease.~~

***

~~16~~9 The use as claimed in any one of claims 1 to 8 ~~claim 10~~ wherein the disorder is Alzheimer's disease.

10 The use as claimed in claim 9, wherein ~~and~~ the treatment is ~~optionally~~ a combination treatment of a first agent which is the MT-containing compound at the specified dosage in combination with a second agent which is an inhibitor of the processing of amyloid precursor protein to beta-amyloid.

~~17~~11 The use as claimed in claim 9 or claim 10 ~~16~~ wherein the treatment is part of a treatment regimen which comprises:
(i) treatment of said subject the MT-containing compound for a first period of time, wherein said administration provides a total daily dose of between 1 and 10 mg of MT to the subject per day;
(ii) treatment of said subject the MT-containing compound for a further period of time, wherein said administration provides a total daily dose of between 20.5 and 60 mg of MT to the subject per day.

***

~~18 The use as claimed in claim 12 wherein the FTLD syndrome is behavioral-variant frontotemporal dementia (bvFTD) optionally where the total daily dose is between 20.5 and 40 mg of MT to the subject per day, optionally split into 2 or more doses.~~

~~19 The use as claimed in claim 18 wherein the treatment is part of a treatment regimen which comprises:~~
~~(i) treatment of said subject the MT-containing compound for a first period of time, wherein said administration provides a total daily dose of between 1 and 10 mg of MT to the subject per day;~~

~~(ii) treatment of said subject the MT-containing compound for a further period of time, wherein said administration provides a total daily dose of between 20.5 and 40 mg of MT to the subject per day;~~
~~(iii) combining the treatment in (ii) with treatment with an acetylcholinesterase inhibitor or an N-methyl-D-aspartate receptor antagonist for a further period of time.~~

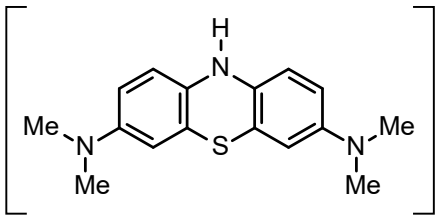
~~***~~

~~20 The use as claimed in any one of claims 1 to 19 wherein the subject is a human who has been diagnosed as having said neurodegenerative disorder, or wherein said method comprises making said diagnosis.~~

~~21 The use as claimed in any one of claims 1 to 19 wherein the subject is a human who has been assessed as being susceptible to, or at risk of, the disorder, optionally based on familial or genetic or other data.~~

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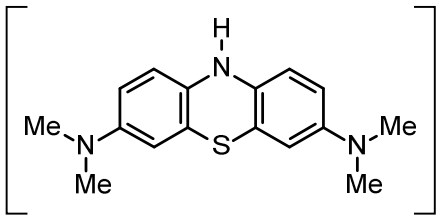
~~22~~12 The use as claimed in any one of claims 1 to ~~21~~ 11 wherein the MT-containing compound has the following formula, where HA and HB are different mono-protic acids:



HA

HB

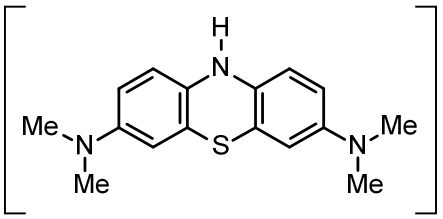
~~23~~13 The use as claimed in any one of claims 1 to ~~21~~ 11 wherein the MT-containing compound has the following formula:



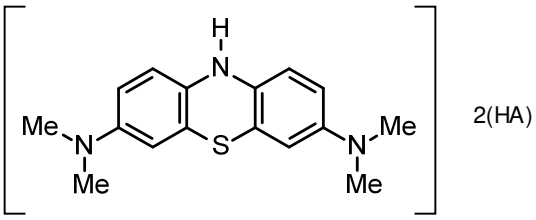
$p(H_nX)$

wherein each of H_nX is a protic acid.

~~24~~14 The use as claimed in any one of claims 1 to ~~21~~ 11 wherein the MT-containing compound has the following formula and H_2A is a di-protic acid:



~~25~~15 The use as claimed in any one of claims 1 to ~~21~~ 11 wherein the MT-containing compound has the following formula and is a bis-monoprotic acid:



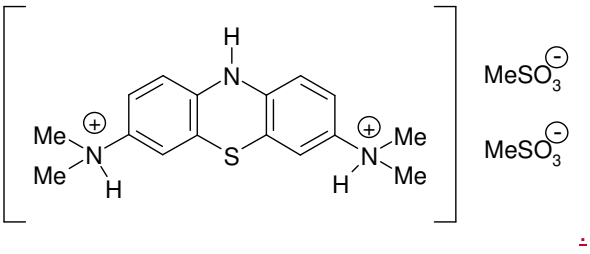
~~26~~16 The use as claimed in any one of claims ~~22~~ 12 to ~~25~~ 15 wherein the or each protic acid is an inorganic acid.

~~27~~17 The use as claimed in claim ~~26~~ 16 wherein each protic acid is a hydrohalide acid.

~~28~~18 The use as claimed in any one of claims ~~22~~ 12 to ~~25~~ 15 wherein the or each protic acid is an organic acid.

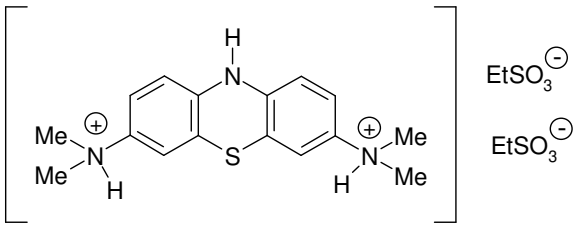
~~29~~19 The use as claimed in claim ~~27~~ 17 or claim ~~28~~ 18 wherein the or each protic acid is selected from H_2CO_3; CH_3COOH; methanesulfonic acid, 1,2-ethanedisulfonic acid, ethansulfonic acid, naphthalenedisulfonic acid, and p-toluenesulfonic acid.

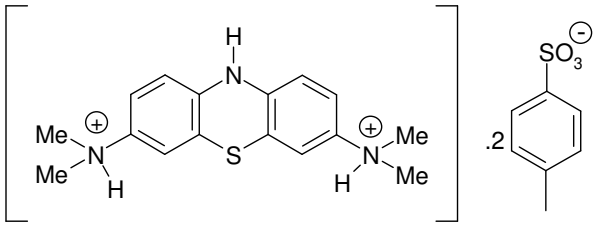
~~30~~20 The use as claimed in any one of claims 1 to ~~21~~11, or claim ~~29~~ 19 wherein the MT-containing compound is LMTM:

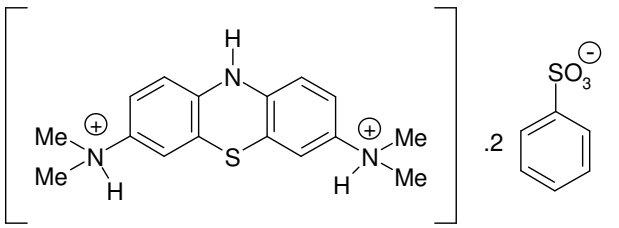


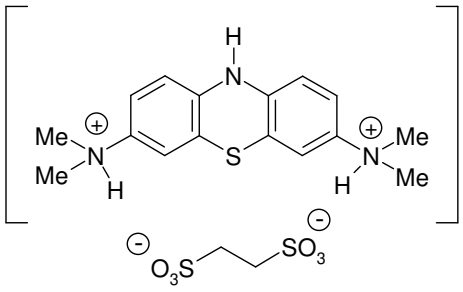
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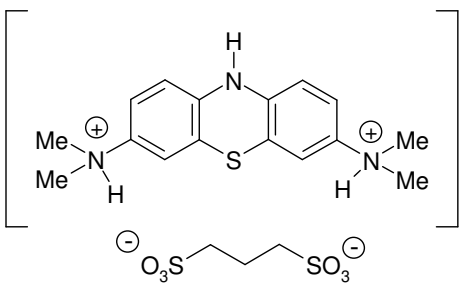
~~31~~21 The use as claimed in any one of claims 1 to ~~21~~ 11 wherein the MT-containing compound is selected from the list consisting of:


H
N
Me
N
Me
H
S
N
H
Me
Me
EtSO3
EtSO3

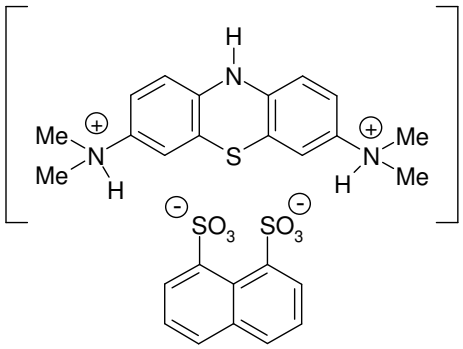

H
N
Me
N
Me
H
S
N
H
Me
Me
SO3
.2


H
N
Me
N
Me
H
S
N
H
Me
Me
SO3
.2


H
N
Me
N
Me
H
S
N
H
Me
Me
O3S
SO3


H
N
Me
N
Me
H
S
N
H
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Me
O3S
SO3

, and



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