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(54) **Title:** PROLONGED RELEASE FORMULATIONS COMPRISING AN 2-OXO-1-PYRROLIDINE DERIVATE

(57) **Abstract:** The present invention relates to a pharmaceutical composition comprising Brivaracetam or Seletacetam as active ingredient, the invention relates specifically to a prolonged release formulation made of granules containing the active ingredient in their inner core.

PROLONGED RELEASE FORMULATIONS COMPRISING AN 2-OXO-1-PYRROLIDINE DERIVATE

The present invention concerns a pharmaceutical oral composition of 2-oxo-1-pyrrolidine derivatives, a process of the preparation thereof and therapeutic uses
5 thereof.

International patent application having publication number WO 01/62726 discloses 2-oxo-1-pyrrolidine derivatives and methods for their preparation. It particularly discloses compound (2S)-2-[(4R)-2-oxo-4-propyl-pyrrolidin-1-yl]butanamide known under the international non propriety name of Brivaracetam.

10 International patent application having publication number WO 2005/121082 describes a process of preparation of 2-oxo-1-pyrrolidine derivatives and particularly discloses a process of preparation of (2S)-2-[(4S)-4-(2,2-difluorovinyl)-2-oxo-pyrrolidin-1-yl]butanamide known under the international non propriety name of Seletacetam.

2-oxo-1-pyrrolidine derivatives are therefore particularly useful in the
15 pharmaceutical industry.

Brivaracetam is effective in the treatment of epilepsy. A clinical trial evaluated the efficacy and safety of Brivaracetam (5, 20 and 50 mg per day) in the adjunctive treatment of adult patients with refractory partial onset seizures, with or without secondary generalization. Brivaracetam is also effective in the treatment of patients
20 with post-herpetic neuralgia.

Seletacetam is effective in the treatment of epilepsy. Two studies were conducted with Seletacetam in epilepsy evaluating the efficacy and safety of Seletacetam in the adjunctive treatment of partial onset seizures in highly refractory adult patients currently receiving up to three concomitant anti-epileptic drugs.

25 A prolonged release formulation would be particularly desirable for administration in some patients. A prolonged release formulation could be advantageously used in order to reduce the difference between plasmatic C_{max} and C_{min} and consequently to lower sides effects. Moreover, a prolonged release formulation improves the patient's compliance as the administration frequency could be
30 reduced.

A same formulation which can be easily adapted for various dosages of active ingredient would be also desirable.

Moreover, a formulation easily ingested would be particularly desirable for administration in children and also in some elderly adult patients.

35 A prolonged release formulation once a day would be particularly desirable.

International patent application WO 2006/088864 and US application US 2007/298098 disclose controlled release compositions which deliver levetiracetam, (S)-(-)-alpha-ethyl-2-oxo-1-pyrrolidine acetamide, in a pulsatile manner, comprising a

first component comprising a first population of levetiracetam particles and a second component comprising a subsequent population of levetiracetam particles coated with a modified release coating.

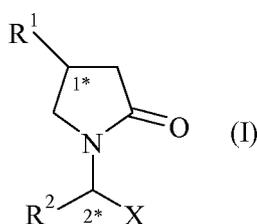
It has now surprisingly been found that sustained release behaviour could be obtained from sufficiently small size pellets and an accurate control of the release could be obtained thanks to the use of a controlled release coating.

One of the objectives of the invention is a pharmaceutical composition which can be administered orally to control the release of pharmaceutically active substances so that it can be administered in a few daily doses, ideally in a single daily dose and so to provide a therapeutic effect for at least 16 hours when administered to a patient.

Considering Brivaracetam and Seletacetam are classified as BCS I, in order to achieve a prolonged therapeutic plasmatic drug level the resulting *in vitro* dissolution (USP <711> apparatus n°2) in a buffered aqueous media has to show a drug release of no more than 40% after 1 hour of dissolution, of 25% - 80% after 4 hours of dissolution and of no less than 80% after 16 hours of dissolution. Preferably, a profile of no more than 35% after 1 hour of dissolution, of 35% - 75% after 4 hours of dissolution and of no less than 80% after 16 hours of dissolution. More preferably a profile of no more than 30% after 1 hour of dissolution, of 45% - 70% after 4 hours of dissolution and of no less than 80% after 16 hours of dissolution.

However, as Brivaracetam and Seletacetam have a very high water solubility (their solubility exceeds 500 mg/ml), it is therefore not obvious to slow down their release to such an extent, above all when non-monolithic forms are used, as the total surface area is consequently dramatically increased. Brivaracetam and Seletacetam do not require high doses to maintain target plasma concentrations.

Accordingly, the present invention relates to a pharmaceutical composition comprising a granulate which contains an active ingredient and which is coated with a controlled release layer, the active ingredient being an 2-oxo-1-pyrrolidine derivative of formula (I),



30

wherein,

R¹ is C₁₋₁₀ alkyl or C₂₋₆ alkenyl;

R² is C₁₋₁₀ alkyl or C₂₋₆ alkenyl;

X is $-\text{CONR}^4\text{R}^5$, $-\text{COOH}$, $-\text{COOR}^3$ or $-\text{CN}$;

R^3 is C_{1-10} alkyl;

R^4 is hydrogen or C_{1-10} alkyl;

R^5 is hydrogen or C_{1-10} alkyl.

5 The term "active ingredient" as used herein is defined as a substance or a drug which has a therapeutic effect. It can also be a mixture of substances having a therapeutic effect.

The amount of the active ingredient present in the pharmaceutical composition of the invention may vary depending on the patient to which the compositions are administered and the disease to be treated.

10 The term "alkyl", as used herein, is a group which represents saturated, monovalent hydrocarbon radicals having straight (unbranched), branched or cyclic moieties, or combinations thereof. Preferred alkyl comprises 1 to 10 carbons. More preferred alkyl comprises 1 to 4 carbons. Optionally, alkyl groups may be substituted by 1 to 5 substituents independently selected from the group consisting of halogen, hydroxy, alkoxy, ester, acyl, cyano, acyloxy, acid, amide or amino group. Preferred alkyl groups are methyl, ethyl, n-propyl, trifluoromethyl and trifluoroethyl.

15 The term "alkenyl" as used herein represents unsubstituted or substituted branched, unbranched or cyclic hydrocarbon radicals or combinations thereof having at least one double bond. Preferred alkenyl comprises 2 to 6 carbons. More preferred alkenyl comprises 2 to 4 carbons. "Alkenyl" moieties may be optionally substituted by 1 to 5 substituents independently selected from the group consisting of halogen, hydroxy, alkoxy, ester, acyl, cyano, acyloxy, carboxylic acid, amide or amino group.

20 The term "halogen", as used herein, represents an atom of fluorine, chlorine, bromine, or iodine.

The term "hydroxy", as used herein, represents a group of formula $-\text{OH}$.

The term "alkoxy", as used herein, represents a group of formula $-\text{OR}^a$ wherein R^a is C_{1-4} alkyl as defined above.

25 The term "acyl" as used herein, represents a group of formula $\text{R}^b\text{CO}-$, wherein R^b represents a C_{1-4} alkyl as defined above.

The term "ester", as used herein, represents a group of formula $-\text{COOR}^c$ wherein R^c represents a C_{1-4} alkyl as defined above.

The term "cyano" as used herein represents a group of formula $-\text{CN}$.

30 The term "acyloxy" as used herein represents a group of formula $-\text{O-COR}^d$, wherein R^d is a C_{1-4} alkyl as defined above or an aryl group.

The term "aryl" as used herein, represents an organic radical derived from an aromatic hydrocarbon by removal of one hydrogen, for example a phenyl.

The term "carboxylic acid" as used herein represents a group of formula –COOH.

The term "amino group", as used herein, represents a group of formula $-NH_2$, NHR^e or NR^fR^e wherein R^e and R^f are alkyl groups as defined above in the specification.

The term "amide", as used herein, refers to a group of formula $-CO-NH_2$, $-CO-NHR^g$, or $-CO-NR^gR^h$, wherein R^g and R^h are alkyl groups as defined above in the specification.

The term "sulfonate group" as used herein represents a group of formula $-O-SO_2-R^i$ wherein R^i is an alkyl or an aryl as defined here above in the specification. Preferred sulfonate groups are methanesulfonate, *para*-toluenesulfonate group or trifluoromethanesulfonate.

Compounds of formula (I) have at least two stereogenic centers in their structure which are indicated by (1*) and (2*). These stereogenic centers may be present in a R or S configuration, said R and S notation being used in accordance with the rules described in Pure. Appl. Chem., 45 (1976) 11-30.

In one embodiment, according to first aspect of the present invention, R^1 is C_{1-4} alkyl or C_{2-4} alkenyl. In a further embodiment according to first aspect of the present invention, R^1 is n-propyl or 2,2-difluorovinyl.

In one embodiment according to first aspect of the present invention, R^2 is C_{1-4} alkyl. In another embodiment according to first aspect of the present invention, R^2 is ethyl.

In one embodiment according to first aspect of the present invention, X is $-CONR^4R^5$, $-COOH$ or $-COOR^3$, wherein R^3 is a C_{1-4} alkyl. In another embodiment according to first aspect of the present invention, X is $-CONR^4R^5$.

In one embodiment according to first aspect of the present invention, X is $-CONR^4R^5$ or $-COOR^3$, wherein R^3 is a C_{1-4} alkyl. In another embodiment according to first aspect of the present invention, X is $COOR^3$, wherein R^3 is a C_{1-4} alkyl.

In one embodiment according to first aspect of the present invention, X is $-CONR^4R^5$ or $-COOR^3$, wherein R^3 is a C_{1-4} alkyl. In another embodiment according to first aspect of the present invention, X is $COOR^3$, wherein R^3 is a C_{1-4} alkyl.

In a particular embodiment, R^3 is methyl.

In one embodiment according to first aspect of the present invention, R^4 is hydrogen or C_{1-4} alkyl. In another embodiment according to first aspect of the present invention, R^4 is hydrogen.

In one embodiment according to first aspect of the present invention, R^5 is hydrogen or C_{1-4} alkyl. In another embodiment according to the first aspect of the present invention, R^5 is hydrogen.

Preferably R¹ is n-propyl or 2,2-difluorovinyl; R² is ethyl; and X is -CONH₂ .

The best results have been obtained with brivaracetam and seletracetam.

Accordingly, the present invention relates to a pharmaceutical composition comprising a granulate which contains an active ingredient and which is coated with a controlled release layer. Usually, the weight percentage of the controlled release layer is comprised between 1.0% and 60%, relative to the weight of the pharmaceutical composition. Preferably, the weight percentage of the controlled release layer is comprised between 2.0% and 50%. More preferably, the weight percentage of the controlled release layer is comprised between 5.0% and 40%, relative to the weight of the pharmaceutical composition.

According to the invention, the controlled release layer comprises at least a controlled release polymer. By controlled release polymer, it is understood a polymer that could control the release rate of the active ingredient thanks to its solubility/permeability properties in an aqueous environment.

Generally, the controlled release polymer consists in ammonioalkyl methacrylate ethyl acrylate copolymers, or in ethylacrylate methyl methacrylate copolymer , or in ethylcellulose, or in cellulose acetate having a level of acetyl group comprised between 32% and 44%, or in a mix of thereof. Preferably, the controlled release polymer is chosen among a copolymer of ammonioalkyl methacrylate and ethyl acrylate, having an average molecular weight comprised between 75000 and 200.000 da, and having a level of ammonioalkyl methacrylate moieties comprised between 6% and 14%; or a copolymer of ethyl acrylate and methyl methacrylate in a molar ratio of 2:1 of the two monomers and having an average molecular weight comprised between 500000 and 1000000. Best results have been obtained with a copolymer of ammonioalkyl methacrylate and ethyl acrylate, sold under the trade name Eudragit® RS or Eudragit® RL and marketed by Evonik Industries AG; and with a copolymer of ethyl acrylate and methyl methacrylate sold under the trade name Eudragit® NE 30 D and marketed by Evonik Industries AG , as a 30% aqueous dispersion.

Usually, the controlled release layer contains at least an excipient, such as a co-binder, an antisticking agent, an antifoam, a flavoring agent, a pigment, a processing aid agent, like a plasticizer, an emulsifier or a stabilizer.

Generally the controlled release layer comprises a co-binder. Generally, the co-binder is chosen among cellulose derivatives, polyvinylalcohol or polyvinylpyrrolidone or a mixture thereof. Preferably, the co-binder is a cellulose derivative. More preferably it is hydroxypropylmethylcellulose (HPMC). The best results have been obtained with hydroxypropylmethylcellulose USP 28 designation type 2910 as co-binder.

Generally the controlled release layer comprises an antisticking agent. Generally, the antisticking agent is chosen among talc, colloidal silicon dioxide,

magnesium trisilicate, starch, tribasic calcium phosphate, or a mixture thereof.

Preferably, it is talc.

Usually, the pharmaceutical composition according to the present invention comprises 30 to 100% per weight of controlled release polymer with respect to the total dry mass of the controlled release layer. Preferably, the pharmaceutical composition
5 according to the present invention comprises 40 to 90 % per weight of controlled release polymer, more preferably 60 to 75% per weight of controlled release polymer with respect to the total dry mass of the controlled release layer.

Usually, the pharmaceutical composition according to the present invention
10 comprises 0 to 15% per weight of co-binder with respect to the total dry mass of the controlled release layer. Preferably, the pharmaceutical composition according to the present invention comprises 1 to 10 % per weight of co-binder, more preferably 3 to 5% per weight of co-binder with respect to the total dry mass of the controlled release layer.

Usually, the pharmaceutical composition according to the present invention
15 comprises 0 to 50 % per weight of the antisticking agent with respect to the total dry mass of the controlled release layer. Preferably, the pharmaceutical composition according to the present invention comprises 10 to 45 % per weight of the antisticking agent, more preferably 25 to 35 % per weight of the antisticking agent with respect to
20 the dry mass of the controlled release layer.

According to the invention, the granulate is an active core which comprises the active ingredient and at least one excipient.

Generally, the active core has a sphericity degree comprised between 0.5 and 1.0, preferably between 0.6 and 1.0. Generally, the average particle size of the active
25 core is between 75 and 1400 μm . Preferably, the average particle size of the active core is between 400 and 1100 μm . More preferably, the average particle size of the active core is between 500 and 1000 μm .

Usually, the active core comprises one or several binders as excipient. The term "binder" as used herein is defined as an agent used to increase the cohesion of
30 the granules, or used to act as processing aid during the granulation process. The binder may be present in the pharmaceutical composition in the form of a single compound or in the form of a mixture of compounds. Examples of binders are, but not limited to, starch, pregelatinized starch, gelatin, polyvinylpyrrolidone, methylcellulose, hydroxypropyl methylcellulose, hydroxypropylcellulose, sodium
35 carboxymethylcellulose, ethyl cellulose, microcrystalline cellulose, saccharide moieties like hydrogenated palatinose, hydrogenated maltose, polydextrose, or sucrose, polyacrylamides, polyvinylloxazolidone, polyvinyl alcohols, polyvinylpyrrolidone-vinyl

acetate. Preferred binders are polyvinylpyrrolidone, hydroxypropyl methylcellulose and microcrystalline cellulose

Usually, the active core comprises one or several diluents, as excipient. The term "diluents" as used herein is defined as an agent used as filler in order to achieve
5 the desired volume or weight. The diluent may be present in the pharmaceutical composition in the form of a single compound or in the form of a mixture of compounds. Diluents could also play a role of binder or release rate modulator agent. Examples of diluents are, but not limited to, lactose, starch, pregelatinized starch, microcrystalline cellulose, silicified microcrystalline cellulose, cellulose acetate, dextrose, mannitol,
10 sodium phosphate, potassium phosphate, calcium phosphate, fructose, maltose, sorbitol, or sucrose. Preferred diluents are microcrystalline cellulose, lactose and starch.

Optionally, the active core comprises a preservative agent. Examples of preservative agents are, but not limited to, disodium edetate, sodium metabisulfite,
15 ascorbic acid, citric acid or a mixture thereof.

Optionally, the active core comprises an organic or an inorganic salt as release modulator agent. By release modulator agent, it is understood an ingredient that could modulate the release rate of the active ingredient thanks to its specific action on the controlled release polymer properties. Examples of salts are, but not limited to salt of
20 acetate, citrate, succinate, or chloride.

Optionally, the active core comprises an antisticking agent. Examples of antisticking agents are, but not limited to, talc, colloidal silicon dioxide, magnesium trisilicate, starch, tribasic calcium phosphate or a mixture thereof.

Usually, the pharmaceutical composition according to the present invention
25 comprises 0 to 98 % per weight of binder with respect to the total weight of the dry mass of the active core. Preferably, the pharmaceutical composition according to the present invention comprises 0.5 to 80 % per weight of binder with respect to the dry mass of the active core.

Usually, the pharmaceutical composition according to the present invention
30 comprises 0 to 98 % per weight of diluents with respect to the dry mass of the active core. Preferably, the pharmaceutical composition according to the present invention comprises 0.5 to 80 % per weight of diluents, more preferably 1 to 60 % per weight of diluents with respect to the dry mass of the active core.

Optionally, the pharmaceutical composition according to the present invention
35 comprises 0 to 40 % per weight of the antisticking agent with respect to the dry mass of the active core. Preferably, the pharmaceutical composition according to the present invention comprises 5 to 30 % per weight of the antisticking agent, more preferably 10

to 20 % per weight of the antisticking agent with respect to the dry mass of the active core.

Optionally, the pharmaceutical composition according to the present invention comprises 0 to 5 % per weight of the preservative agent with respect to the dry mass of the active core. Preferably, the pharmaceutical composition according to the present invention comprises 0 to 3 % per weight of the preservative agent, more preferably 0 to 2 % per weight of the preservative agent with respect to the dry mass of the active core.

Optionally, the pharmaceutical composition according to the present invention comprises 0 to 80% per weight of release modulator agent with respect to the dry mass of the active core. Preferably, the pharmaceutical composition according to the present invention comprises 0 to 60 % per weight of release modulator agent, more preferably 0 to 40 % per weight of release modulator agent with respect to the dry mass of the active core.

In another embodiment of the invention, an intermediate layer is added before the controlled release layer, in order to prevent any diffusion of the active ingredient into the controlled release layer, or to better protect the active ingredient against external chemical aggression. The granulate is coated with the intermediate layer. Generally, the intermediate layer comprises a binder, an anti-sticking agent, pigments, and/or processing aid agents like plasticizers.

Usually, the weight percentage of the intermediate layer is comprised between 1.0 % and 30%, relative to the total weight of the core and the first layer.

Preferably, the weight percentage of the intermediate layer is comprised between 2.5 % and 20%, relative to the total weight of the core and the first layer. More preferably, the weight percentage of the intermediate layer is comprised between 5% and 15%, relative to the total weight of the core and the first layer.

Usually, the intermediate coating layer comprises a binder. Generally, the binder is chosen among cellulose derivatives, polyvinylalcohol, polyvinylpyrrolidone, or a mixture therefore. Preferably, the binder is a cellulose derivative. More preferably it is hydroxypropylmethylcellulose (HPMC). The best results have been obtained with hydroxypropylmethylcellulose USP 28 designation type 2910.

Usually, the intermediate layer comprises an antisticking agent. Generally, the antisticking agent is chosen among talc, colloidal silicon dioxide, magnesium trisilicate, starch, tribasic calcium phosphate, or a mixture thereof. Preferably, it is talc.

Optionally, the intermediate layer comprises a plasticizer. Generally, the plasticizer is chosen among glycerol, fatty acids, phthalate, low molecular weight polyethylene glycol, citrate or a mixture thereof. Preferably it is polyethylene glycol.

By low molecular weight polyethylene glycol, it is understood polymer having a molecular weight lower than 12000 da.

Usually, the pharmaceutical composition according to the present invention comprises 30 to 95 % per weight of binder with respect to the dry mass of the intermediate layer. Preferably, the pharmaceutical composition according to the present invention comprises 40 to 90 % per weight of binder, more preferably 60 to 80 % per weight of binder with respect to the dry mass of the intermediate layer.

Usually, the pharmaceutical composition according to the present invention comprises 0 to 40 % per weight of the anti-sticking agent with respect to the dry mass of the intermediate layer. Preferably, the pharmaceutical composition according to the present invention comprises 5 to 35 % per weight of the anti-sticking agent, more preferably 15 to 25 % per weight of the anti-sticking agent with respect to the dry mass of the intermediate layer.

Usually, the pharmaceutical composition according to the present invention comprises 0 to 30 % per weight of plasticizer with respect to the dry mass of the intermediate layer. Preferably, the pharmaceutical composition according to the present invention comprises 2 to 25 % per weight of plasticizer, more preferably 5 to 15 % per weight of plasticizer with respect to the dry mass of the intermediate layer.

In another embodiment of the invention, a final layer is added after the controlled release layer. The granulate coated with the controlled release layer is further coated with the final layer. The final layer comprises a binder, an antisticking agent, pigments, and / or processing aid agents.

Usually, the weight percentage of the final layer is comprised between 1.0 % and 30%, relative to the total weight of the pharmaceutical composition. Preferably, the weight percentage of the final layer is comprised between 2.5 % and 20%. More preferably, the weight percentage of the final layer is comprised between 5% and 15%, relative to the total weight of the pharmaceutical composition.

In another embodiment of the invention, an external phase is added to the coated pellets. Several pharmaceutically acceptable excipients may be added to the composition, as external phase ingredient, such as pigment, preservatives or processing aid agents.

Examples of processing aid agents are talc, starches, stearic acid and anhydrous colloidal silica. Preferred processing aid agent according to the present invention is anhydrous colloidal silica, such as AEROSIL 200 ®.

Usually, the pharmaceutical composition according to the present invention comprises 0.0 to 3.0 % per weight of processing aid agent. Preferably, the pharmaceutical composition according to the present invention comprises 0.0 to 2.0 %

per weight of processing aid agent, more preferably 0.25 to 1.0 % per weight of processing aid agent with respect to the total weight of the composition.

According to the invention, optionally the composition also contains sweeteners, flavours, palatability agents.

- 5 In an embodiment of the invention, the pharmaceutical composition comprises
- an active core containing Brivaracetam or Seletacetam having an average particle size between 75 μm and 1400 μm ;
 - a controlled release layer which is a controlled release layer with a weight percentage, relative to the total weight of the pharmaceutical composition, between 1.0 and 60%, and containing 30 to 100% of controlled release copolymer, 1 to 15 % of binder, 0 to 50% of antisticking agent, respective to the total weight of the controlled release layer; and
 - an external phase containing a processing aid agent at level of 0.0 to 3.0% respective to the total weight of the pharmaceutical composition.

- 15 Particularly, the present invention relates to a pharmaceutical composition comprising
- a active core containing Brivaracetam or Seletacetam and having an average particle size between 400 μm and 1100 μm ;
 - a controlled release layer with a weight percentage, relative to the total weight of the pharmaceutical composition between 2.0 and 50%, and containing 40 to 90% of controlled release copolymer, 1 to 10 % of binder, 10 to 45% of antisticking agent, respective to the total weight of the controlled release layer; and
 - an external phase containing a processing aid agent at level of 0.0 to 2.0% respective to the total weight of the composition.

- 25 More particularly the present invention relates to a pharmaceutical composition comprising
- an active core containing Brivaracetam or Seletacetam and having an average particle size between 500 μm and 1000 μm ;
 - a controlled release layer with a weight percentage, relative to the total weight of the pharmaceutical composition, between 5.0 and 40%, and containing 60 to 75% of controlled release copolymer, 3 to 5 % of binder, 25 to 35% of antisticking agent, respective to the total weight of the controlled release layer; and
 - an external phase containing a processing aid agent at level of 0.25 to 1.0% respective to the total weight of the composition.

- 35 In a particular embodiment, the present invention relates to a pharmaceutical composition comprising
- an active core containing Brivaracetam or Seletacetam and having an average particle size between 75 μm and 1400 μm ;

- a controlled release layer with a weight percentage, relative to the total weight of the pharmaceutical composition, between 1.0 and 60%, and containing 30 to 100% of ethylacrylate–methylmethacrylate copolymer, 1 to 15 % of hydroxypropylmethylcellulose, 0 to 50% of talc, respective to the total weight of the controlled release layer and
- 5 - an external phase containing colloidal anhydrous silica at level of 0.0 to 3.0% respective to the total weight of the composition.

In another particular embodiment, the present invention relates to a pharmaceutical composition comprising

- 10 - an active core containing Brivaracetam or Seletacetam having an average particle size between 400 μm and 1100 μm ;
- a controlled release layer with a weight percentage, relative to the total weight of the pharmaceutical composition, between 2.0 and 50%, and containing 40 to 90% of ethylacrylate–methylmethacrylate copolymer, 1 to 10 % of hydroxypropylmethylcellulose, and 10 to 45% of talc respective to the total weight of the controlled release layer; and
- 15 - an external phase containing colloidal anhydrous silica at level of 0.0 to 2.0% respective to the total weight of the composition.

More particularly the present invention relates to a pharmaceutical composition comprising

- 20 - an active core containing Brivaracetam or Seletacetam and having an average particle size between 500 μm and 1000 μm ;
- a controlled release layer with a weight percentage, relative to the total weight of the pharmaceutical composition, between 5.0 and 40%, and containing 60 to 75% of ethylacrylate–methylmethacrylate copolymer, 3 to 5 % of hydroxypropylmethylcellulose, 25 to 35% of talc, respective to the total weight of the controlled release layer ; and
- 25 - an external phase containing colloidal anhydrous silica at level of 0.25 to 1.0% respective to the total weight of the composition.

30 The pharmaceutical composition of the invention can be manufactured by any process according to conventional methods known to the man skilled in the art, such as compression, extrusion, wet or dry granulation, by binding of powders, by means of spray processes, rotor granulation or fluidized bed granulation.

Optionally, the controlled release layer could require to be cured at a
35 temperature comprised between 20°C and 75°C, for a duration comprised between 1h and 5 days. Preferably, the controlled release layer could require to be cured at a temperature comprised between 30°C and 70°C, for a duration comprised between 2h and 3 days. More preferably, the controlled release layer could require to be cured at a

temperature comprised between 40°C and 65°C, for a duration comprised between 8h and 1 day.

In a further particular embodiment, the present invention relates to a pharmaceutical composition comprising 0.20 to 70 % per weight of Brivaracetam, with
5 respect to the total weight of the composition.

Usually, in this further particular embodiment, the present invention relates to a pharmaceutical composition comprising 0.40 to 60 % per weight of Brivaracetam with respect to the total weight of the composition.

Particularly, in this further particular embodiment, the present invention relates
10 to a pharmaceutical composition comprising 0.60 to 50 % per weight of Brivaracetam with respect to the total weight of the composition.

The pharmaceutical composition according to the present invention is preferably administered orally.

The pharmaceutical composition according to the present invention is preferably
15 administered in the form of a capsule, a sachet or a tablet.

Optionally, the pharmaceutical composition according to the present invention may contain an external diluent or a processing aid, such as (but not limited to) starch, lactose, microcrystalline cellulose, talc.

Optionally, the pharmaceutical composition according to the present invention
20 may contain a sweetening agent such as sucrose or saccharine, a coloring agent or a flavoring agent.

Optionally, the pharmaceutical composition according to the present invention may comprise a taste-masking agent.

In another further particular embodiment, the present invention relates to a
25 pharmaceutical composition comprising 0.20 to 70 % per weight of Seletacetam, with respect to the total weight of the composition.

Usually, in this further particular embodiment, the present invention relates to a pharmaceutical composition comprising 0.40 to 60 % per weight of Seletacetam with respect to the total weight of the composition.

Particularly, in this further particular embodiment, the present invention relates
30 to a pharmaceutical composition comprising 0.60 to 50 % per weight of Seletrecetam with respect to the total weight of the composition.

The pharmaceutical composition according to the present invention is preferably administered orally.

The pharmaceutical composition according to the present invention is preferably
35 administered in the form of a capsule, a sachet or a tablet.

Optionally, the pharmaceutical composition according to the present invention contains a diluent or a processing aid, such as (but not limited to) starch, lactose, microcrystalline cellulose, talc.

Optionally, the pharmaceutical composition according to the present invention
5 contains a sweetening agent such as sucrose or saccharine, a coloring agent or a flavoring agent.

Optionally, the pharmaceutical composition according to the present invention comprises a taste-masking agent.

The present invention also concerns a use of a pharmaceutical composition for
10 the treatment of disease.

In another aspect the present invention relates to a pharmaceutical composition comprising an active ingredient useful for the treatment or prevention of a disease.

By the term "disease", we understand a disease selected from the group consisting of epileptogenesis, seizure disorders, convulsions, Parkinson's disease,
15 dyskinesia induced by dopamine replacement therapy, tardive dyskinesia induced by administration of neuroleptic drugs, Huntington Chorea, and other neurological disorders including bipolar disorders, mania, depression, anxiety, attention deficit hyperactivity disorder (ADHD), migraine, trigeminal and other neuralgia, chronic pain, neuropathic pain, cerebral ischemia, cardiac arrhythmia, myotonia, cocaine abuse,
20 stroke, myoclonus, tremor, essential tremor, simple or complex tics, Tourette syndrome, restless leg syndrome and other movement disorders, neonatal cerebral haemorrhage, amyotrophic lateral sclerosis, spasticity and degenerative diseases,.

The term "treatment" as used herein, includes curative treatment and prophylactic treatment.

By "curative" is meant efficacy in treating a current symptomatic episode of a
25 disorder or condition.

By "prophylactic" is meant prevention of the occurrence or recurrence of a disorder or condition.

The present invention concerns also a method for treatment of a human patient
30 by using the pharmaceutical composition.

The present invention concerns also the pharmaceutical composition for use as a medicament for curing the said disease.

The present invention concerns also the use of the pharmaceutical composition for the manufacture of a medicament for a therapeutic application in the said disease.

35 Preferably said disease is selected from the group consisting essentially of epilepsy, Parkinson's disease, dyskinesia, migraine, tremor, essential tremor, bipolar disorders, chronic pain, neuropathic pain. More preferably said disease is epilepsy.

The present invention concerns also a method for manufacturing a medicament intended for therapeutic application in the said disease, characterized in that the pharmaceutical composition according to the present invention is used.

A large dose range can be covered by varying the quantity of the pharmaceutical composition of the invention and the active ingredient load. Either immediate release (IR) or prolonged release (PR) behavior can be achieved, as IR compositions are preliminary to the PR compositions. Finally, the dissolution profile can be easily modulated by varying the thickness of the PR coating. Moreover, prolonged release multi-particulate forms generally offer an enhanced robustness and reliability on the release profile of the active ingredient.

The pharmaceutical composition of the invention releases at least 50 % of the active ingredient in less than 8 hours in order to achieve acceptable drug absorption *in vivo*.

The following examples illustrate the invention without however limiting its scope.

Example 1. Seletracetam sustained release formulation

Seletracetam pellets were prepared according to the composition given in Table1.

Table 1. Core compositions of Seletracetam pellets

Step		Material	Quantity
Step 1	Active core	Seletracetam	20%
		Microcrystalline cellulose	79%
		Pharmacoat 606	1%
Step 2	Controlled release coating	Pellets from step 1	70%
		Eudragit NE 30D	20.0%
		Talc	8.6%
		Pharmacoat 606 Simethicone	1.2% 0.1%
Step 3	External process aid agent	Colloidal anhydrous silica	0.50% relative to final pellets weight
Step 4	Curing	Pellets from step 3 are placed at 60°C for 24 h	

The obtained active core had a mean particle size of 770 µm. Hydropropyl methylcellulose sold under the trademark Pharmacoat® 606 is used as a binder agent. The grade 606 was preferred.

Microcrystalline cellulose is used as diluent

5 Talc is an antisticking agent.

Ethylacrylate –methylmethacrylate copolymer is sold under the trademark Eudragit® NE 30D. It is used as controlled release polymer.

Demethylpolysiloxane , sold under the trade mark Simethicone was used as an antifoam agent

10 Anhydrous colloidal silica is sold under the trademark Aerosil® 200. it is used as antisticking and gliding agent.

The obtained pellets show a sustained release profile for Seletracetam what comply with the *in vitro* dissolution requirements.

15

Table 10: results in %

Time Hours	1.00.00	4.00.00	16.00.00
Seletracetam pellets	3%	45%	90%

20 The *in vitro* dissolution profiles in water were determined according to the USP <711> (apparatus n° 2, 50 rpm, aqueous medium 900 ml) over an interval of time of 16 h. The dissolution was conducted at 37°C in a pH 6.4 phosphate buffer.

Example 2: All experiments were performed in accordance with the Guidelines of the local Ethical Committee for Animal Experimentation.

25 Epileptiform responses in hippocampal slices: Levetiracetam reduces epileptiform responses induced in rat hippocampal slices by high-K⁺/low-Ca²⁺ concentrations in the perfusion fluid and induced by bicuculline. The effect of brivaracetam on epileptiform responses induced by high-K⁺/low-Ca²⁺ concentrations or by bicuculline was examined in transverse hippocampal slices prepared from Sprague–Dawley rats according to previously reported standard procedures. The
30 epileptiform responses were induced by passing from a normal perfusion of artificial cerebrospinal fluid (ACSF) (K⁺ 3 mM; Ca²⁺ 2.4 mM) to either high-K⁺/low-Ca²⁺ fluid (HKLCF) (K⁺ 7.5 mM; Ca²⁺ 0.5 mM) or to 5 M bicuculline methiodide (BMI)-containing ACSF.

Extracellular field potentials (FPs) were recorded in the CA3 area of the slices with 2 M NaCl-filled glass microelectrodes. The evoked FPs were recorded at 10-min intervals in response to fimbrial stimulation with constant current rectangular pulses that elicit a single population spike (PS) of 50–75% of the maximal amplitude when the slice is in ACSF. In the HKLCF model, 2 min of spontaneous activity were also recorded, in the middle of each 10-min interval between the recordings of evoked responses.

Either brivaracetam or levetiracetam was added to the bathing fluid of the slices 20 min before shifting from ACSF to either HKLCF or 5 M BMI-containing ACSF, and was kept in the perfusion fluid throughout the experiment.

Audiogenic seizures in mice: Genetically sound-sensitive male mice (16–28 g; n=10 per group), responding with wild running, clonic and tonic convulsions to an acoustic stimulation, were used. Audiogenic seizures were induced by an acoustic stimulus (90 dB, 10–20 kHz) applied for 30 s. The mice were pretreated with either saline, brivaracetam (i.p., 30 min) or levetiracetam (i.p., 60 min), and the proportion of mice protected against clonic convulsions was used as the end point to assess anticonvulsant activity.

Chemically induced seizures in mice: Pentylentetrazol, 83 mg kg⁻¹ s.c., was used to evaluate the anticonvulsant properties of brivaracetam. The dose was selected based on dose–effect curves in saline-treated animals as the convulsive dose inducing clonic convulsions of all four extremities in 97% of the animals. Immediately after administration of the chemoconvulsant, the mice were placed individually in small plastic cages (25 × 13 × 8 cm) and observed for the presence of clonic convulsions in all four extremities, for 60 min. The occurrence of tonic convulsions (hindlimb extension) and mortality was also recorded during this interval. The proportion of mice protected against clonic convulsions was calculated and used as the end point for anticonvulsant activity.

Results

Epileptiform responses in hippocampal slices: Changing the perfusion of rat hippocampal slices from the normal ACSF to HKLCF produced increasingly epileptiform FPs in the CA3 area in response to constant-current fimbrial stimulation. In control slices exposed to HKLCF alone, the PS1 amplitude progressively increased, reaching plateau values within 20 min (4.250.77 mV), nearly twofold higher than those recorded under ACSF perfusion (2.180.15 mV; means.d. for n=10 slices). Also, constant-current single stimuli-evoked bursts of repetitive PSs (that is, PS2, PS3 and so on) increased markedly in number in the first 30 min of HKLCF perfusion from the single PS1 to an average of 7.62.3 PS per evoked burst, and continued to increase slightly up to the end of the records, reaching an average of 8.81.6 PS per evoked

burst after 80-min perfusion of HKLCF. Both brivaracetam and levetiracetam reduced these epileptiform responses. Upon 15-min perfusion of HKLCF, spontaneous field bursts occurred in 4 out of the 10 control slices exposed to HKLCF alone, whereas from 25 min in HKLCF to the end of the records, all control slices presented regular field bursting. Brivaracetam (3.2 M), but not levetiracetam (32 M), reduced the rate of this spontaneous bursting.

In vivo studies: In fully amygdala-kindled rats, brivaracetam induced a significant suppression in motor-seizure severity from a dose of 21.2 mg kg⁻¹, whereas levetiracetam induced a similar effect from a dose of 170 mg kg⁻¹. Brivaracetam also significantly reduced the after-discharge duration at the highest dose tested (212.3 mg kg⁻¹), whereas levetiracetam was inactive on this parameter up to 1700 mg kg⁻¹.

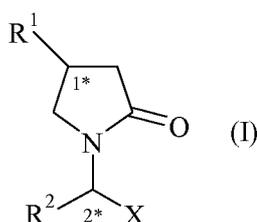
Audiogenic seizure-susceptible mice were protected against the expression of clonic convulsions by brivaracetam and levetiracetam; ED50 values are shown in Table 2. Brivaracetam, administered i.p. 30 min before seizure induction in mice, also protected against clonic convulsions induced by pentylenetetrazol and against tonic hindlimb extension induced by a maximal electroshock in mice, although with higher ED50 values.

Brivaracetam significantly suppressed spontaneous SWDs in GAERS rats from a dose of 2.1 mg kg⁻¹ with complete inhibition appearing at the highest dose tested (67.9 mg kg⁻¹). Levetiracetam, on the other hand, induced significant suppression of SWDs from a dose of 5.4 mg kg⁻¹.

Pretreatment with brivaracetam during corneal kindling of mice resulted in a significant reduction in the incidence of generalized motor seizures, and a similar incidence reduction was observed with levetiracetam at higher doses. Continued corneal stimulations following termination of treatment showed a persistent reduction in the incidence of generalized motor seizures in the group previously treated with the highest dose of brivaracetam.

CLAIMS

1. A pharmaceutical composition comprising a granulate which contains an active ingredient and which is coated with a controlled release layer, the active ingredient
5 being an 2-oxo-1-pyrrolidine derivative of formula (I),



wherein,

- 10 R^1 is C_{1-10} alkyl or C_{2-6} alkenyl;
 R^2 is C_{1-10} alkyl or C_{2-6} alkenyl;
 X is $-\text{CONR}^4\text{R}^5$, $-\text{COOH}$, $-\text{COOR}^3$ or $-\text{CN}$;
 R^3 is C_{1-10} alkyl;
 R^4 is hydrogen or C_{1-10} alkyl;
 R^5 is hydrogen or C_{1-10} alkyl.

15

2. The pharmaceutical composition according to claim 1, wherein R^1 is n-propyl or 2,2-difluorovinyl; R^2 is ethyl; and X is $-\text{CONH}_2$.
3. The pharmaceutical composition according to claim 1 or 2, wherein the weight
20 percentage of the controlled release layer is comprised between 1.0% and 60%, relative to the weight of the pharmaceutical composition.
4. The pharmaceutical composition according to claim 1, 2 or 3, wherein the controlled release layer contains at least a polymer consisting in ammonioalkyl methacrylate ethyl
25 acrylate copolymers, or in ethylacrylate methyl methacrylate copolymer, or in ethylcellulose, or in cellulose acetate having a level of acetyl group comprised between 32% and 44%, or in a mix of thereof.
5. The pharmaceutical composition according to claim 4, wherein the controlled release
30 polymer is chosen among a copolymer of ammonioalkyl methacrylate and ethyl acrylate, having an average molecular weight comprised between 75000 and 200.000 da, and having a level of ammonioalkyl methacrylate moieties comprised between 6% and 14%; or a copolymer of ethyl acrylate and methyl methacrylate in a molar ratio of

2:1 of the two monomers and having an average molecular weight comprised between 500000 and 1000000.

5 6. The pharmaceutical composition according to claim 1, wherein the controlled release layer contains at least an excipient, such as co-binder, anti-sticking agent, antifoam, flavoring agent, pigment, processing aid agent, like plasticizer, emulsifier or stabilizer.

10 7. The pharmaceutical composition according to any of the claims 1 to 6, wherein the granulate is an active core which comprises the active ingredient and at least one excipient.

15 8. The pharmaceutical composition according to claim 7, wherein the active core has a sphericity degree comprised between 0.5 and 1.0 and the average particle size of the active core is between 75 and 1400 μm .

9. The pharmaceutical composition according to any of the preceding claims, wherein the granulate is coated with an intermediate layer.

20 10. The pharmaceutical composition according to any of the preceding claims, wherein the granulate coated with the controlled release layer is further coated with the final layer.

11. The pharmaceutical composition according to any of the preceding claims, wherein an external phase is added.

25

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/065270

A. CLASSIFICATION OF SUBJECT MATTER INV. A61K9/50 A61K31/4015		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A61K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, EMBASE, BIOSIS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/027993 A (EURAND INC [US]; VENKATESH GOPI [US]; BOLTRI LUIGI [IT]; COLOMBO ITALO) 6 March 2008 (2008-03-06) page 2, line 28 - page 5, line 2 page 9, lines 14-19 claims	1-11
X	WO 2006/088864 A (ELAN PHARMA INT LTD [IE]; JENKINS SCOTT [US]; LIVERSIDGE GARY [US]) 24 August 2006 (2006-08-24) cited in the application paragraphs [0010], [0022], [0023], [0038], [0046], [0047], [0051], [0053] claims 1,7	1-11
<p align="center">----- -/-- -----</p>		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
Date of the actual completion of the international search <p align="center">9 December 2009</p>		Date of mailing of the international search report <p align="center">15/12/2009</p>
Name and mailing address of the ISA/ European Patent Office, P.E. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer <p align="center">Paul Soto, Raquel</p>

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/065270

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