Composition containing Apomorphine and a Divalent Metal Cation

The present invention relates to a composition containing apomorphine and a divalent metal cation, a process for preparing this composition, a composition obtainable by this process, and the use of said compositions as a medicament, in particular for diagnosing, preventing and treating Parkinson's disease.

Apomorphine (systematical name: (6aR)-6-methyl-5,6,6a,7-tetrahydro-4H-dibenzo[de,g]quinoline-10,11-diol) is used as an emetic, as an antidote and for the diagnosis and the treatment of the Parkinson's disease. In case of the treatment of Parkinson's disease, apomorphine is administered by infusions or by injections subcutaneously (s.c.). The commercially available product APO-go® used for the treatment of Parkinson's disease is provided with a pH of 3 to 4.

However, the administration of apomorphine to patients in need thereof can lead to the side effect of coagulative necrosis.

Therefore, the technical problem underlying the present invention can be seen in avoiding the above disadvantage, i.e. coagulative necrosis.

This has been achieved by the composition according to the present invention, which comprises apomorphine and a divalent metal cation in a molar ratio of 2 or less.

A further advantage of the composition is that it shows a relatively high stability with respect to apomorphine.

In a preferred embodiment the molar ratio of apomorphine and

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the divalent metal cation is from 2.0 to 0.2, preferably from 1.25 to 0.5, and more preferably from 1.25 to 0.83.

In another preferred embodiment the composition comprises apomorphine and the divalent metal cation in a stoichiometric amount ± 10%.

The term "in a stoichiometric amount ± 10 %" means that the divalent metal cation or, if more than one type of divalent metal cation is present, the total amount of divalent metal cations in the composition is present in the stoichiometric (equimolar) amount or in an excess of not more than 10 % or in a deficit of not more than 10 % in relation to apomorphine. Particularly, the deviation from the stoichiometric amount is not more than 5 %, more particularly not more than 1 %, even more particularly not more than 0.5 %. That is, the molar ratio of apomorphine to divalent metal cation is 1 : 1 with the deviation of ± 10 % or less as pointed out above.

As a divalent metal cation any metal cation having two positive charges can be used, which are pharmaceutically acceptable or do not cause any harm in the human body.

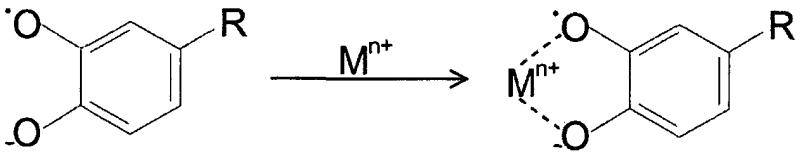
Preferably, the composition according to the present invention contains a chelate comprising apomorphine as a ligand and the divalent metal cation as a central atom in the above amount, wherein one or more, in particular two, separate coordinate bonds are formed between the apomorphine and the divalent cation.

Chelation describes a particular way that ions and molecules bind metal ions. According to the International Union of Pure and Applied Chemistry (IUPAC), chelation involves the formation or presence of two or more separate coordinate bonds between a polydentate (multiple bonded) ligand and a single

central atom. Usually these ligands are organic compounds, and are called chelants, chelators, chelating agents, or sequestering agents.

The molecule apomorphine has two hydroxyl groups. For forming the above mentioned coordinate bonds, it is preferable that at least one in particular both of the hydroxyl groups of the apomorphine involved in the formation of the coordinate bond are present in the deprotonated form. This can be achieved by suitably adjusting the pH value of the composition according to the present invention. The pH can be adjusted before or after apomorphine and the divalent metal cation have been mixed.

It is to be noted that the term "chelate" as used herein refers preferably to the typical structure involving the formation of coordinate bonds between the ligand and the central atom.



By this structure, the composition according to a preferred embodiment of the present invention is distinguishable from solutions containing apomorphine and divalent metal cations, in which no chelate is formed, but the constituents apomorphine and divalent metal cation are present separated from each other.

It is preferred that at least 50 % of the apomorphine contained in the composition of the invention are present in a chelated form with the divalent metal cation, preferably at least 80 %, and more preferably at least 90 %.

Preferably, water is present in the composition in particular as a solvent for the chelate compound formed by the apomorphine and the divalent metal cation. That is, the composition is an aqueous solution. This makes the composition according to the present invention suitable to be used as a medicament, for example for injection or as an infusion. For this applications, the composition shall be a sterile solution. Furthermore, it shall not contain any ingredients which are not pharmaceutically acceptable. Such a solution can be adapted to be used as an injection solution or as a concentrate for an infusion or directly itself as an infusion. Alternatively such a solution can be adopted for buccal administration, the composition being a buccally absorbed liquid.

Preferably, the divalent metal cation is selected from one or more cations of the group consisting of Ca^{2+}, Mg^{2+} and Zn^{2+}, which are particularly useful for avoiding coagulative necrosis as mentioned above.

In the composition according to the present invention, all three cations Ca^{2+}, Mg^{2+} and Zn^{2+} or the two cations Ca^{2+} and Mg^{2+} can be present. That is, the composition according to the present invention can contain apomorphine together with Ca^{2+}, Mg^{2+} and Zn^{2+} or together with Ca^{2+} and Mg^{2+}.

Preferably, the composition according to the present invention contains apomorphine together with Ca^{2+} and Mg^{2+} wherein said two divalent metal cations are present in a ratio of 1.37 : 1 to 1.72 : 1, preferably 1.545 : 1. With this preferred embodiment of the composition of the present invention, the occurrence of coagulative necrosis can be avoided very efficiently.

Preferably, the composition according to the present invention contains an antioxidant. The antioxidant is used to provide stability to the composition according to the present invention. That is, by using an antioxidant, in particular the preferred antioxidants described in detail in the following, the composition according to the present invention has an auto-oxidation self-protecting effect.

The term "stability" as used hereinafter means generally that the composition according to the present invention containing the antioxidant is more stable than a composition not containing the antioxidant. The stability can be determined for example by visually inspecting a discoloration (darkening) over time being an indication of destabilization. The stability can be measured for example in that the composition is kept at room temperature or elevated temperature (e.g. 40 °C) over a certain period of time, e.g. 14 days and thereafter the discoloration (darkening) of the composition is determined e.g. by the naked eye.

In particular, the antioxidant has a sulfur group. Examples of such antioxidants are N-acetyl-L-cysteine and sodium-2-sulfanylethane sulfonate. With an antioxidant having a sulfur group in its molecule, the composition according to the present invention can be stabilized in a particular efficient way.

As antioxidant also other antioxidants than the above antioxidants having a sulfur group in its molecule can be used, for example ascorbic acid and sodium metabisulfite. With such antioxidants, the composition according to the present invention can also be stabilized efficiently.

The composition according to present invention can contain at least one additive independently selected from the group

consisting of cosolvent, surfactant, pH-adjuster, tonicifier and inert gas.

Examples of the cosolvent are polyethylene glycoles (PEG), for example PEG 300, and propylene glycol. By adding cosolvents as additive to the composition according to the present invention, clear solutions can be obtained.

Examples of the surfactant are polysorbates, for example Polysorbat 80.

Examples of the tonicifier used for providing isotonisation are NaCl and/or carbohydrates, like glucose, mannitol or glycerol.

As an additive in the composition according to the present invention an inert gas can be present. An example of the inert gas is nitrogen. The inert gas can be used for removing oxygen from the composition according the present invention, and also the amount of antioxidant can be lowered.

The amount of the additives can be easily determined by the skilled person by routine experiments with the aim to achieve the particular beneficial effect of the additive in view of its function.

As pointed out above, a pH adjuster can be present as an additive. Examples of the pH adjuster are HCl and NaOH which can be added to the composition according to the present invention depending on the pH to be adjusted. The pH range can be pH 3 to 10, with which a stability optimum can be achieved. Generally speaking, the pH of the composition according to the present invention is preferably adjusted to override the solubility barrier of pH 6.2 and being close to the physiological pH of 7.4.

According to another embodiment of the invention the composition is a pharmaceutical solution or suspension, preferably a pharmaceutical solution for parenteral administration.

According to another embodiment of the invention the composition has a concentration of apomorphine from 0.1 mg/ml to 50 mg/ml, more preferably from 0.1 mg/ml to 40 mg/ml, more preferably from 0.1 mg/ml to 20 mg/ml, more preferably from 1 mg/ml to 15 mg/ml, and more preferably from 3 mg/ml to 10 mg/ml.

The following table 1 illustrates and exemplifies preferred ingredients of the composition according to the present invention wherein it is to be explicitly noted that these ingredients are mentioned hereinafter independently from each other so that in the composition according to the present invention the following ingredients can be present independently from each other.

Table 1:

Ingredient	**Function**	**Aim or Skill**	**Requirement/s**
Apomorphine HCl (APO)	Active substance	Clear solution	No formation of particles
Water	Solvent	Clear solution	No formation of particles
Sodium metabisulfite (SM)	Antioxidant	Enhanced stability	
Ascorbic acid (AA)	Antioxidant	Enhanced stability	
N-Acetyl-L-cysteine (NAC)	Antioxidant	Enhanced stability	
Sodium-2-sulfanyl-ethane sulfonate (MESNA)	Antioxidant	Enhanced stability	
Polyethylene glycole 300 (PEG) and/or propylene glycol	Cosolvent	Clear solution	enhanced APO solubility and enhanced solubility of APO chelate with divalent metal cation
HCl	pH-adjuster	pH 3 - 6.2	Adjust pH-stability optimum without formation of particles
NaOH	pH-adjuster	pH 3 - 6.2	Adjust pH-stability optimum without formation of particles
NaCl	tonicifier (isotonisation)	Osmolality adjuster	
Carbohydrate (e.g. mannitol, glucose, glycerol)	tonicifier (isotonisation)	Osmolality adjuster	May also enhance APO solubility
Zn^{2+} (preferably added as chloride)	Central atom in the chelate	lesser or no tanning (erythema, grade < 4)	enhanced APO stability, formation of water soluble apomorphine complex without particles
Ca^{2+} (preferably added as chloride)	Central atom in the chelate	lesser or no tanning (erythema, grade < 4)	enhanced APO stability, formation of water soluble apomorphine complex without

			particles
Mg^{2+} (preferably added as chloride)	Central atom in the chelate	lesser or no tanning (erythema, grade < 4)	enhanced APO stability, formation of water soluble apomorphine complex without particles
Nitrogen	Oxygen removal	Lowering total oxygen and needed antioxidant amount	

Preferred compositions according to the present invention are represented in the following table 2

Table 2

APO	H_2O	PEG	PS	SM	AA	NAC	MESNA	Zn^{2*}	Ca^{2*}	Mg^{2*}	NaCl	Man	Gluc
X	X	X				X			X	X	X		

"PS" means polysorbate

"Man" means mannitol

"Glu" means glucose

"X" means that the ingredient is present in the composition

Remaining abbreviations are indicated in table 1.

Particularly preferred compositions according to the present invention can comprise the following ingredients in the following amounts:

1.) 5.00 mg/ml APO HCl (corresponding to 16.46 mmol/l APO)
1.32 mg/ml $MgCl_2$ (corresponding to 6.50 mmol/l; as hexahydrate; Ph. Eur.)
1.47 mg/ml $CaCl_2$ (corresponding to 10.0 mmol/l; as dihydrate, Ph. Eur.)

2.) 10.0 mg/ml APO HCl (corresponding to 32.92 mmol/l (APO)
2.64 mg/ml $MgCl_2$ (corresponding to 13.0 mmol/l; as hexahydrate; Ph. Eur.)
2.94 mg/ml $CaCl_2$ (corresponding to 20.0 mmol/l; as dihydrate, Ph. Eur.)

In contrast to hitherto known pharmaceutical preparations of apomorphine, the administration of the composition according to the present invention to a patient in need thereof does not cause coagulative necrosis. In other words, the severe drawback of the coagulative necrosis can be avoided by using

the composition according to the present invention in the diagnosis, prevention and treatment of diseases, e.g. the Parkinson's disease. The composition according to the present invention has generally speaking a good tissue protective effect. Furthermore, the composition according to the present invention has a very good bioavailability. Moreover, a very good tolerable apomorphine solution for injection/concentrate for continuous infusion in particular for the treatment of Parkinson is provided. Further, the storage stability is enhanced. The above mentioned advantages are achievable with the composition according to the present invention.

The present invention also relates to a process for preparing the composition as described above in detail, wherein the apomorphine and the divalent cation and optionally antioxidant and/or at least one of the additives are mixed together. The ingredients of the composition according to the present invention are described in detail above so that in so far it is referred to the above explanations.

The mixing is carried out in solution, preferably in a solution containing water as mentioned above. The order in which the ingredients are added to each other can be chosen by the skilled person according to the requirements of the particular case. For example, the apomorphine (in water) can be provided to which the divalent metal cations optionally contained in water can be added. Alternatively the divalent metal cation (in water) can be provided and thereto the apomorphine, optionally in water, can be added thereto.

The addition of the above mentioned antioxidant and/or the above mentioned additive/s can be carried out during any stage of the above mixing of the apomorphine and the divalent metal cation.

Preferably, apomorphine is provided in an aqueous solution optionally with at least one of the above indicated additives and/or antioxidant. To this mixture the divalent metal cation is added, followed by subsequently adjusting the pH, if necessary.

The above discussed composition according to the present invention cannot be further defined by indicating structural details as it has been done above. Therefore, it is suitable to define the product by the above process so that the subject matter of the present invention is also a composition containing the above mentioned ingredients and being obtainable by mixing them as explained above.

As pointed out above, apomorphine is used in the field of medicine, in particular Parkinson's disease. Therefore, the compositions according to the present invention can be used as a medicament, in particular for diagnosing, preventing and treating Parkinson's disease. The composition according to the present invention can therefore be provided in the form of a pharmaceutical preparation as commonly known by the skilled person, e.g in the form of a solution or a water soluble solid like buccal, tablet, waiver, ointment, transdermal plaster or powder for inhalation. In particular the composition can be provided in a way to be used for injection, for example s.c. injection, or as a concentrate for continuous infusion as it is known in this field by the skilled person.

The present invention as outlined in detail above will be illustrated hereinafter by way of examples. It is explicitly pointed out that the following examples shall not be construed to restrict the present invention to the examples.

Examples

Examples 1 and 2 and Comparative Examples 1 and 2

The following compositions were prepared (the compound apomorphine is abbreviated as APO):

1.) 5.00 mg/ml APO HCl (corresponding to 16.46 mmol/l APO)
1.32 mg/ml $MgCl_2$ (corresponding to 6.50 mmol/l; as hexahydrate; Ph. Eur.)
1.47 mg/ml $CaCl_2$ (corresponding to 10.0 mmol/l; as dihydrate, Ph. Eur.)

2.) 10.0 mg/ml APO HCl (corresponding to 32.92 mmol/l APO)
2.64 mg/ml $MgCl_2$ (corresponding to 13.0 mmol/l; as hexahydrate; Ph. Eur.)
2.94 mg/ml $CaCl_2$ (corresponding to 20.0 mmol/l; as dihydrate, Ph. Eur.)

As a Comparative Example commercially available APO-go (5 mg/ml APO HCl) (=Comparative Example 1) and APO-go (10 mg/ml APO HCl) (=Comparative Example 2) were used.

The compositions according to Examples 1 and 2 as well as according to Comparative Examples 1 and 2 were administered to various test persons. As a result it was found that less coagulative necrosis was caused in the test persons receiving the compositions of Example 1 and 2 compared to the administration of compositions of Comparative Examples 1 and 2.

These results show that the compositions according to the present invention in which the apomorphine is present together with divalent metal cations suppress the adverse side effect of coagulative necrosis.

Stability Tests

To the above composition prepared according to Example 1 (C1) the antioxidant sodium metabisulfite (SM) in an amount of 2 mg/ml or the antioxidant N-acetyl-L-cysteine (NAC) in an amount of 4 mg/ml was added. The pH was adjusted to be in the range between 3 and 7. Discoloration (darkening, indication of destabilization) was observed with the naked eye after preparation of the composition (t = 0), after 14 days stored at room temperature (14d/RT) and after 14 days stored at 40 °C (14d/40).

The results are summarized in the following table 3

Table 3:

	pH = 3	pH = 4	pH = 5	pH = 6	pH = 7
C1 t=0	--	--	X	X	X
C1 14d/RT	X	X	X	X	X
C1 14d/40	X	X	X	X	X
C1 + SM t=0	--	--	--	--	X
C1 + SM 14d/RT	--	--	--	--	X
C1 + SM 14d/40	--	--	--	--	X
C1 + NAC t=0	--	--	--	--	X
C1 + NAC 14d/RT	--	--	--	--	X
C1 + SM 14d/40	--	--	--	--	X

"--" means that no discoloration was observed with the naked eye
"X" means that discoloration was observed with the naked eye

As can be seen from the above stability tests, the addition of an antioxidant does further improve the stability of the compositions according to the present invention.

Claims

1. Composition comprising apomorphine and a divalent metal cation in a molar ratio of 2 or less.

2. Composition according to claim 1, wherein the molar ratio of apomorphine and the divalent metal cation is from 2 to 0.2, preferably from 1.25 to 0.5, and more preferably from 1.25 to 0.83.

3. Composition according to any of the preceding claims, comprising apomorphine and the divalent metal cation in a stoichiometric amount ± 10%.

4. Composition according to any of the preceding claims, containing a chelate comprising apomorphine as a ligand and the divalent metal cation as a central atom, wherein one or more separate coordinate bonds are formed between apomorphine and the divalent metal cation.

5. Composition according to any of the preceding claims, wherein water is present as a solvent for apomorphine and the divalent metal cation.

6. Composition according to any of the preceding claims, wherein the divalent metal cation is selected from the group consisting of Ca^{2+}, Mg^{2+} and Zn^{2+}.

7. Composition according to any of the preceding claims, wherein the composition contains apomorphine and Ca^{2+} and Mg^{2+} which are present in a ratio of 1.37 : 1 to 1.72 : 1, preferably 1.545 : 1.

8. Composition according to any of the preceding claims, wherein an antioxidant is present.

9. Composition according to any of the preceding claims, wherein the pH-value of the composition is adjusted to override the solubility barrier of pH 6.2 and being close to the physiological pH of 7.4.

10. Composition according to any of the preceding claims, wherein the composition is a pharmaceutical solution or suspension, preferably a pharmaceutical solution for parenteral administration.

11. Composition according to any of the preceding claims, having a concentration of apomorphine from 0.1 mg/ml to 40 mg/ml, preferably from 1 mg/ml to 15 mg/ml, and more preferably from 3 mg/ml to 10 mg/ml.

12. Process for preparing the composition according to any of the preceding claims, wherein apomorphine and the divalent metal cation and optionally antioxidant and/or at least one of the additives are mixed together.

13. Composition obtainable by a process according to claim 12, comprising dissolving apomorphine and the divalent metal cation in a solvent.

14. Composition as defined in any of claims 1 to 11 and 13 for use as a medicament.

15. Composition as defined in any of claims 1 to 11 and 13 for use in diagnosing, preventing and treating Parkinson's disease.