



**PRIORITY DOCUMENT**  
SUBMITTED OR TRANSMITTED IN  
COMPLIANCE WITH  
RULE 17.1(a) OR (b)

# Kongeriget Danmark

Patent application No.: PA 2001 01052

REC'D 29 NOV 2002

WIPO PCT

Date of filing: 04 July 2001

Applicant: Novo Nordisk A/S  
Novo Allé  
DK-2880 Bagsværd

This is to certify the correctness of the following information:


The attached photocopy is a true copy of the following information:

- The specification and claims as filed with the application on the filing date indicated above.



**Patent- og Varemærkestyrelsen**  
Økonomi- og Erhvervsministeriet

TAASTRUP 20 November 2002

  
Karin Schlichting  
Head Clerk



**Title**

Physically stable formulation of modified GLP-1

**Background**

Peptides are widely used in medical practice, and since they can be produced by re-  
combinant DNA technology it can be expected that their importance will increase also in the  
years to come.

The hormones regulating insulin secretion belong to the so-called enteroinsular  
axis, designating a group of hormones, released from the gastrointestinal mucosa in re-  
sponse to the presence and absorption of nutrients in the gut, which promote an early and  
potentiated release of insulin. The enhancing effect on insulin secretion, the so-called incretin  
effect, is probably essential for a normal glucose tolerance. Many of the gastrointestinal hor-  
mones, including gastrin and secretin (cholecystokinin is not insulinotropic in man), are insu-  
linotropic, but the only physiologically important ones, those that are responsible for the in-  
cretin effect, are the glucose-dependent insulinotropic polypeptide, GIP, and glucagon-like  
peptide-1 (GLP-1). Because of its insulinotropic effect, GIP, isolated in 1973 immediately at-  
tracted considerable interest among diabetologists. However, numerous investigations car-  
ried out during the following years clearly indicated that a defective secretion of GIP was not  
involved in the pathogenesis of insulin dependent diabetes mellitus (IDDM) or non insulin-  
dependent diabetes mellitus (NIDDM). Furthermore, as an insulinotropic hormone, GIP was  
found to be almost ineffective in NIDDM. The other incretin hormone, GLP-1 is the most po-  
tent insulinotropic substance known. Unlike GIP, it is surprisingly effective in stimulating insu-  
lin secretion in NIDDM patients. In addition, and in contrast to the other insulinotropic hor-  
mones (perhaps with the exception of secretin) it also potently inhibits glucagon secretion.  
Because of these actions it has pronounced blood glucose lowering effects particularly in pa-  
tients with NIDDM.

GLP-1, a product of the proglucagon, is one of the youngest members of the se-  
cretin-VIP family of peptides, but is already established as an important gut hormone with  
regulatory function in glucose metabolism and gastrointestinal secretion and metabolism.  
The glucagon gene is processed differently in the pancreas and in the intestine. In the pan-  
creas, the processing leads to the formation and parallel secretion of 1) glucagon itself, oc-  
cupying positions 33-61 of proglucagon (PG); 2) an N-terminal peptide of 30 amino acids  
(PG (1-30)) often called glicentin-related pancreatic peptide, GRPP; 3) a hexapeptide corre-  
sponding to PG (64-69); 4) and, finally, the so-called major proglucagon fragment (PG (72-  
158)), in which the two glucagon-like sequences are buried. Glucagon seems to be the only

biologically active product. In contrast, in the intestinal mucosa, it is glucagon that is buried in a larger molecule, while the two glucagon-like peptides are formed separately.

While much attention has been focused on the pharmacological properties of acylated GLP-1 compounds, hitherto little is known about their physico-chemical and solution structural properties. Such knowledge is a prerequisite for rational handling during e.g. production, purification and formulation work and is eventually important for understanding of the structural basis for the protraction mechanism.

GLP-1 and analogues of GLP-1 and fragments thereof are potentially useful *i.a.* in the treatment of type 1 and type 2 diabetes. However, solubility limitations and the low stability against the actions of endogenous diaminopeptidyl peptidase limits the usefulness of these compounds, and thus there still is a need for improvements in this field.

In WO 99/43341 are disclosed certain pharmaceutical formulations comprising GLP-1 having a lipophilic substituent. All of the disclosed formulations are maintained at pH 7.4.

In WO 00/37098 are disclosed shelf-stable formulations comprising GLP-1, a preservative, and a tonicity modifier, at pH 8.2 to 8.8. It is specifically stated that maintaining pH in a range of about 8.2 to about 8.8 unexpectedly improves the chemical stability of the formulation. In addition it is stated that the concentration of the GLP-1 molecule also plays a role in the stability of the formulations. In this respect it is stated that a GLP-1 concentration equal to or greater than 1mg/ml was physically unstable.

### Summary of the invention

Human GLP-1 is a 37 amino acid residue peptide originating from preproglucagon which is synthesised *i.a.* in the L-cells in the distal ileum, in the pancreas and in the brain. Processing of preproglucagon to give GLP-1(7-36)amide, GLP-1(7-37) and GLP-2 occurs mainly in the L-cells. A simple system is used to describe fragments and analogues of this peptide. Thus, for example, Gly<sup>8</sup>-GLP-1(7-37) (or Gly<sup>8</sup>GLP-1(7-37)) designates a fragment of GLP-1 formally derived from GLP-1 by deleting the amino acid residues Nos. 1 to 6 and substituting the naturally occurring amino acid residue in position 8 (Ala) by Gly. Similarly, Lys<sup>34</sup>(N<sup>ε</sup>-tetradecanoyl)-GLP-1(7-37) designates GLP-1(7-37) wherein the ε-amino group of the Lys residue in position 34 has been tetradecanoylated. For convenience the amino acid sequence of GLP-1 (7-37) is given below, wherein the N-terminal His is no. 7 and the C-terminal Gly is no. 37:

His-Ala-Glu-Gly-Thr-Phe-Thr-Ser-Asp-Val-Ser-  
Ser-Tyr-Leu-Glu-Gly-Gln-Ala-Ala-Lys-Glu-Phe-  
Ile-Ala-Trp-Leu-Val-Lys-Gly-Arg-Gly.

Where reference in this text is made to C-terminally extended GLP-1 analogues, the amino acid residue in position 38 is Arg unless otherwise indicated, the optional amino acid residue in position 39 is also Arg unless otherwise indicated and the optional amino acid residue in position 40 is Asp unless otherwise indicated. Also, if a C-terminally extended analogue extends to position 41, 42, 43, 44 or 45, the amino acid sequence of this extension is as in the corresponding sequence in human preproglucagon unless otherwise indicated.

We have discovered that certain modified GLP-1 or analogues thereof when formulated in aqueous solution together with a buffer, are physically stable at low and high concentrations of the modified GLP-1 or analogues thereof, when kept in the pH range from about 7 to about 10. The present formulations are physically stable within a given shelf life period at the recommended storage temperature (typically 2-3 years at 2-8°C). Furthermore, the present formulations are physically stable during in-use (typically 1 month at accelerated temperatures e.g. 25°C or 37°C). The formulations of the invention are also chemically stable thus rendering them shelf-stable and suitable for invasive (eg. injection, subcutaneous injection, intramuscular, intravenous or infusion ) as well as non-invasive (eg nasal or pulmonary, transdermal or transmucosal e.g. buccal ) means of administration. When the inventive formulation comprising a GLP-1 compound was compared to the same formulation comprising GLP-1(7-37) substituted for the GLP-1 compound, the physical stability was increased considerably, and typically the shelf-life was increased from a few seconds to several months in the tests used.

In one aspect the invention relates to a pharmaceutical formulation comprising a GLP-1 compound, and a buffer, wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof wherein an amino acid residue of the parent peptide has a lipophilic substituent attached optionally via a spacer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml to 100 mg/ml, and wherein said formulation has a pH from 7.0 to 10;

provided that if an isotonic agent is present and pH is 7.4 then mannitol or NaCl is not the isotonic agent.

In another aspect the invention relates to a pharmaceutical formulation comprising a GLP-1 compound, and a buffer, wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof wherein an amino acid residue of the parent peptide has a lipophilic substituent attached optionally via a spacer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml or above, and wherein said formulation has a pH from 7.0 to 10.

In a further aspect the invention relates to a pharmaceutical formulation comprising a GLP-1 compound, and a buffer, wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof, wherein an amino acid residue of the parent peptide has a lipophilic substituent

attached optionally via a spacer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml to 100 mg/ml, and wherein said formulation has a pH from 7.0 to 10.

In a further aspect the invention relates to a method of preparing a physically stable pharmaceutical formulation of a GLP-1 compound wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof, wherein an amino acid residue of the parent peptide has a lipophilic substituent attached optionally via a spacer, comprising preparation of a formulation containing the GLP-1 compound, and a buffer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml or above, and wherein said formulation has a pH from 7.0 to 10.

In a further aspect the invention relates to a method of preparing a physically stable pharmaceutical formulation of a GLP-1 compound wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof, wherein an amino acid residue of the parent peptide has a lipophilic substituent attached optionally via a spacer, comprising preparation of a formulation containing the GLP-1 compound, and a buffer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml to 100 mg/ml, and wherein said formulation has a pH from 7.0 to 10.

In a further aspect the invention relates to a method of preparing a physically stable pharmaceutical formulation of a GLP-1 compound wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof, wherein an amino acid residue of the parent peptide has a lipophilic substituent attached optionally via a spacer, comprising preparation of a formulation containing the GLP-1 compound, and a buffer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml to 100 mg/ml, and wherein said formulation has a pH from 7.0 to 10; provided that if an isotonic agent is present and pH is 7.4 then mannitol or NaCl is not the isotonic agent.

In one embodiment of the invention the pharmaceutical formulation is an aqueous formulation. Such formulation is typically a solution or a suspension. In a further embodiment of the invention the pharmaceutical formulation is an aqueous solution.

In a further aspect the invention relates to a pharmaceutical formulation comprising an aqueous solution of a GLP-1 compound, and a buffer, wherein said GLP-1 compound is GLP-1(7-37) or an analogue thereof wherein an amino acid residue of the parent peptide has a lipophilic substituent attached optionally via a spacer, wherein said GLP-1 compound is present in a concentration from 0.1 mg/ml or above, and wherein said formulation has a pH from 7.0 to 10.

In a further aspect the invention relates to a pharmaceutical formulation comprising an aqueous solution of a GLP-1 compound, and a buffer, wherein said GLP-1 compound is

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.