# SULFONAMIDES FOR THE PREVENTION OF DIABETES

## Field of the invention

The present invention relates to the prevention of diabetes.

## Background of the invention

Diabetes is a disease in which the body does not produce enough or is unable to respond to insulin, a hormone secreted by the pancreatic β-cells (Langerhans islet cells) that turns glucose into energy.

In greater detail, diabetes distinguishes into Type 1 diabetes, in which Langerhans islet cells do not produce insulin and which is in most cases of autoimmune origin, and Type 2 diabetes, a condition due to a defective responsiveness of the cells to insulin, usually combined with a reduced insulin secretion.

The therapy of Type 1 diabetes consists in the administration of artificial insulin via subcutaneous injections combined with a careful monitoring of blood glucose levels. The therapy of Type 2 diabetes in its initial stages consists in the administration of oral medicaments that improve insulin resistance, decrease glucose release by the liver and stimulate the increase of insulin secretion, but at later stages it requires also insulin administration.

Since both Type 1 and Type 2 diabetes are at least partially inherited, subjects with relatives suffering from this pathology have a certain risk of developing diabetes.

Furthermore, a series of predictive markers have been identified that are able to foretell the onset of diabetes, in particular Type 1 diabetes (Curr Diabetes Rev, 208, May 4(2), 110-121; Autoimmune Rev 2006 Jul, 5(6), 424-428). It is therefore

possible to identify at low cost and with easy procedures individuals with high risk of developing the disease.

A number of attempts to control and/or delay the onset of diabetes in individuals at risk have been made; however, these require the use of therapies with too a high costs/benefits ratio. Therefore, at present, in spite of the availability of tools able to predict this disease, there is no adequate pharmacological treatment able to prevent or at least delay its onset.

The only strategy that can be adopted in subjects at risk is periodic monitoring of glycaemia and a healthy lifestyle, including control of body weight, physical exercise and adequate dietary regimen. However, this has a very limited efficacy.

Thus, there is a long felt need for medicaments for the prevention of diabetes.

EP 1 123 276 discloses N-(2-aryl-propionyl)-sulfonamides, among them R(-)-2-[(4-isobutylphenyl)propionyl]-methanesulfonamide (I), and their pharmaceutically acceptable salts, for use as inhibitors of neutrophil chemotaxis and degranulation induced by IL-8, in particular for use in the treatment of pathologies like psoriasis, rheumatoid arthritis, ulcerative colitis, acute respiratory insufficiency (ARDS), idiopathic fibrosis and glomerulonephritis.

EP 1 355 641 discloses the use of R(-)-2-[(4-isobutylphenyl)propionyl]-methanesulfonamide and pharmaceutically acceptable salts thereof, in particular its lysine salt, in the prevention and treatment of ischemia/reperfusion injury of transplanted organs and of

functional injury resulting from rejection reactions after solid organ transplantation, in particular kidneys, which need to be retrieved from a donor and stored before transplantation. Such injuries are deemed to be responsible for delayed graft function, which makes dialysis necessary in case of renal transplantation.

EP 1 579 859 discloses the use of N-(2-aryl-propionyl)-sulfonamides, among them R(-)-2-[(4-isobutylphenyl)propionyl]-methanesulfonamide and its lysine salt, for the preparation of medicaments for the treatment of spinal cord injury.

**Description of the Figures**

Figure 1 shows the diabetes-free survival percentage over time (days) in mice treated with (ML)-streptozotocin (STZ) at day 0 for 5 days, following administration from day-1 of Vehicle (dotted line) or Reparixin (solid line) for 7 days.

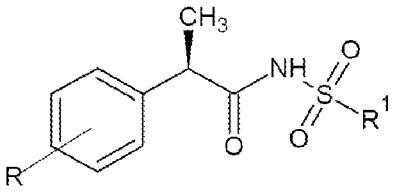
Figure 2 shows the glycemia levels (mg/dl) over time (days) in mice treated with (ML)-streptozotocin (STZ) at day 0 for 5 days, following administration from day -1 of Vehicle (Panel A) or Reparixin (Panel B) for 7 days.

Figure 3 shows the diabetes-free survival percentage over time (days) in mice treated with (ML)-streptozotocin (STZ) at day 0 for 5 days, following administration from day -1 of Vehicle, Meraxin (15 mg/Kg) for 7 days or Meraxin (15 mg/Kg) for 14 days.

Figure 4 shows the glycemia levels (mg/dl)) over time (days) in mice treated with (ML)-streptozotocin (STZ) at day 0 for 5 days, following administration from day +5 of Vehicle (Panel A) or Meraxin (15 mg/Kg) (Panel B) for 14 days.

**Detailed description of the invention**

It has now been found that compounds of formula I, or pharmaceutically acceptable salts thereof:



(I)

wherein R is selected from linear or branched 4-($C_1$-$C_6$)alkyl, 4-trifluoromethanesulfonyloxy and 3-benzoyl and $R^1$ is linear or branched ($C_1$-$C_6$)alkyl are able to protect pancreatic β-cells from structural and/or functional damage and to significantly delay the onset of diabetes as well as to reduce the severity of the disease, once this develops.

Particularly preferred compounds according to the invention are R(-)-2-[(4-isobutylphenyl)propionyl]-methanesulfonamide (commonly known as Repertaxin or Reparixin, hereinafter referred to as Reparixin) and R(-)-2-[(4'-trifluoromethanesulfonyloxy)phenyl]propionyl-methanesulfonamide (commonly known and hereinafter referred to as Meraxin).

Preferred salts of the compounds of the invention are the sodium and the lysine salt. Particularly preferred salts of the compounds of the invention are the lysine salt of Reparixin and the sodium salt of Meraxin.

As it will be described in the Experimental Section, mice injected with STZ, a compound able to induce a condition with clinical and histoimmunological features of human Type 1 diabetes, develop the disease in more than double the time in the presence of a treatment with Reparixin or Meraxin compared to controls. More importantly, in mice treated with Reparixin or

Meraxin, even after development of diabetes, glycemic levels remain significantly lower than in control mice. These results clearly demonstrate that Reparixin and Meraxin are able to protect β-cells from injuries.

Thus, a first object of the present application is the use of the compounds of formula I or pharmaceutically acceptable salts thereof, preferably the lysine or sodium salts, for the preparation of a medicament for the protection of pancreatic β-cells from structural and/or functional injury.

Preferably, the compound of formula I is Reparixin or Meraxin.

A further object of the invention is the use of the compounds of formula I, preferably Reparixin or Meraxin, for the prevention of diabetes, preferably of Type 1 diabetes. The medicament is preferably administered to individuals having a predisposition to diabetes or starting to show the very first symptoms of diabetes.

In particular, this application relates to the use of the compounds of the invention, preferably Reparixin or Meraxin, for the manufacture of a medicament for delaying the onset and/or reducing the progression of diabetes, preferably of Type 1 diabetes.

The compounds of formula I can be prepared with procedures well known in the art. For example, Reparixin can be prepared as disclosed in Example 1 of EP 1 123 276 and in Example 1 of EP 1 355 641, while the lysine salt can be prepared as disclosed in Example 7 and Example 2, respectively, of the aforementioned patents. Meraxin can be prepared, for example, according to Example 1 of EP 1776336.

For the purposes of the present invention, the above compounds are formulated in pharmaceutical compositions suitable for use by oral administration, such as tablets, capsules, syrups, preferably in the form of controlled release formulations, or by parenteral administration, preferably in the form of sterile solutions suitable for intravenous or intramuscular administration. The pharmaceutical compositions can be prepared according to conventional methods, for example as disclosed in Remington, "The Science and Practice of Pharmacy", 21st ed. (Lippincott Williams and Wilkins). Preferably, the amount of Reparixin or its pharmaceutically acceptable salt in each of the above-mentioned administration forms will be such as to provide between 2 and 15 mg compound or salt/kg body weight, while the amount of Meraxin or its pharmaceutically acceptable salt will be such as to provide between 10 and 20 mg compound or salt/kg body weight. In any case, the regimen and amount of medicament to be administered will be determined by the physician according to the patient's need.

The invention will be now further illustrated in greater detail in the following experimental section.

**Experimental section**

**Effect of Reparixin on diabetes induction after multiple low dose (MLD)-streptozotocin (STZ) injections.**

Injection of susceptible mice strains with multiple low doses of (STZ) provokes a condition with clinical and histoimmunological features similar to human Type 1 diabetes mellitus (DM). It has been established that five daily doses of 40 mg/kg/day of STZ

are required for delayed onset, sustained and progressive hyperglycemia and insulitis in male C57BL/6 mice.

This model was previously used to study the role of proinflammatory cytokines in the development of Type 1 diabetes.

12 male C57BL/6J mice received MLD-STZ treatment. STZ was injected i.p. at a dose of 40 mg/kg/day, for 5 consecutive days. Glucose concentrations in venous blood was measured every day starting from the first day of treatment. Mice with glycemia over 250 mg/dl on three consecutive tests were considered diabetic, with the first detection of hyperglycemia taken as the date of diabetes onset. The mice were monitored for up to 60 days post first STZ injection. Reparixin was administered by s.c. continuous infusion starting from day -1 up to day 7 after first STZ injection at a dose of 8 mg/h/kg.

The administration of Reparixin significantly influenced the timing of diabetes development. The median diabetes free time was 27±15 days (n=8, p=0.026vs ctrl) and 7±0.5 days (n=8) respectively for Reparixin- and vehicle-treated mice (Figure 1). More importantly, even after diabetes development, for the whole two-month observation period, glycaemia levels remained constantly and significantly lower in the Reparixin-treated group than in the vehicle-treated group (Figure 2).

**Effect of Meraxin on diabetes induction after multiple low dose (MLD)-streptozotocin (STZ) injections.**

Male C57BL/6J mice were injected i.p. with (ML)-streptozotocin (STZ) at a dose of 40 mg/kg/day, for 5 consecutive days. Glucose concentrations in venous blood were measured every day starting from the first day of treatment (day 0). Mice with glycaemia

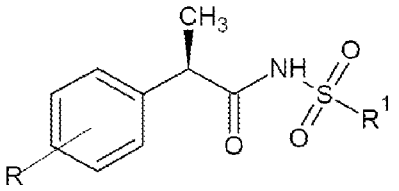
over 250 mg/dl on three consecutive tests were considered diabetic, with the first detection of hyperglycemia taken as the date of diabetes onset. The mice were followed for up to 60 days post first STZ injection. Meraxin was administered per os at a dose of 15 mg/kg for 7 or 14 days, starting from day -1 of first STZ injection.

In both cases, the treatment with Meraxin was able to prolong the diabetes-free time compared with control. The median diabetes-free time was 13±2.8 days (p=0.67 vs ctrl, n=8) and 29±16 (p=0.016 vs. ctrl, n=8) respectively for 7 and 14 days of treatment (Figure 3).

In a second set of experiments, the treatment with Meraxin for 14 days was started +5 (n=4) days after the first STZ injection to mimic the clinical setting of diabetes onset. As shown in Figure 4, treatment with Meraxin up to day 19 clearly prevented diabetes onset. Furthermore, glycaemic levels remained constantly and significantly lower in Meraxin-treated mice compared to vehicle-treated mice for the whole 2-month observation period.

## Claims

1. Use of a compound of formula I, or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from linear or branched 4-($C_1$-$C_6$)alkyl, 4-trifluoromethanesulfonyloxy and 3-benzoyl and $R^1$ is ($C_1$-$C_6$)alkyl for the preparation of a medicament for the protection of pancreatic β-cells from structural and/or functional injury.

2. The use as claimed in claim 1 wherein the medicament is for the prevention of diabetes.

3. The use according to claim 1 or 2, wherein the medicament is for delaying the onset and the progression of diabetes.

4. The use according to any one of claims 1 to 3, wherein diabetes is Type 1 diabetes.

5. The use according to any one of claims 1 to 4 wherein the compound of formula I is selected from R(-)-N-2-[(4-isobutylphenyl)propionyl]-methanesulfonamide and R(-)-2-[(4'-trifluoromethanesulfonyloxy)phenyl]propionyl-methanesulfonamide.

6. The use according to any one of claims 1 to 5 wherein the salt is selected from lysine and sodium salts.