separation of mixtures of oxygen and nitrogen. The comparative performance of the various ionic forms of the zeolites is described in US3140933, more particularly that of the lithium form, which is presented as being the most effective in terms of selectivity.

[0006] Patent application FR2766476 describes an enhanced zeolitic adsorbent for the separation of the gases in the air, and its production process. Said document describes an adsorbent material based on LSX zeolite and comprising lithium, optionally potassium, and having a zeolitized binder. This adsorbent material has a nitrogen adsorption capacity of greater than or equal to 26 $cm^3.g^{-1}$. Said material is produced starting from at least 95% of LSX zeolite (Si/Al atomic ratio = 1) exchanged with lithium. It is found, however, that the mechanical strength of these agglomerates may prove to be insufficient in certain applications.

[0007] Document WO 2014/176002 describes a process for the preparation of a zeolitic adsorbent that can be used to separate gaseous compounds, such as oxygen and nitrogen. The size of the beads of the zeolitic adsorbent is typically 1.8 mm.

[0008] Patent application US20130340612 describes the preparation and use of an adsorbent powder, such as a zeolite, mixed with a binder to form a zeolite agglomerate in the form of beads. The goal in this publication is to optimize the porous profile in order to optimize separation efficiency. For this purpose, it is indicated, in § [0063], that the bead diameter/crystal diameter ratio must be between 100 and 1000, for an approximately uniform porous structure and good mechanical strength.

[0009] The current importance of non-cryogenic processes for separating industrial gases, employing zeolitic adsorbent materials (also called “molecular sieves”), shows that the discovery and the development of increasingly highly performing adsorbents constitutes a major objective both for the gas-producing companies and for the companies supplying said molecular sieves.

[0010] One of the objectives of the present disclosure is consequently the provision of zeolitic adsorbent materials with improved adsorption capacity compared to existing zeolitic adsorbent materials, for example of LiLSX type, for the separation of industrial gases, in particular for the separation of nitrogen and oxygen, and more particularly for obtaining high-purity oxygen gas for medical use.

[0011] Another objective is to further improve the efficiency of medical oxygen concentrators, and in particular to miniaturize the size of the concentrators, for example by reducing the size of the adsorbent beds (“bed size”). To improve the efficiency of such concentrators, one solution could for example be to reduce the size of zeolitic agglomerated materials which constitute the beds of adsorbents present in said concentrators.

[0011a] In an aspect, there is provided a zeolitic agglomerated material in the form of a zeolite agglomerate particle comprising at least FAU-type zeolite crystals, said material having an Si/Al atomic ratio of between 1 and 2.5 measured by X-ray fluorescence, with a measurement uncertainty of ± 0.05 and at least one binder,

- said zeolitic agglomerated material having a ratio of the volume-average diameter of said zeolite agglomerate particle relative to the number-average diameter of the zeolite crystals between 5 and 70, limits inclusive,
- and of which the volume-average diameter of said zeolite agglomerate particle is between 50 µm and 380 µm, limits included
- and wherein the zeolite crystals have a number-average diameter (d_{50}) of between 5.0 µm and 20.0 µm,
- and wherein the lithium content, expressed by weight of Li_2O, is between 8.0% and 12.0% by weight, limits included, relative to the total weight of the zeolitic agglomerated material,
- and wherein the amount of non-zeolite phase (NZP) is such that $0 < NZP \leq 25\%$ measured by X-ray diffraction (XRD), by weight relative to the total weight of the zeolitic agglomerated material.

[0011b] In yet another aspect, there is provided a process of preparing the zeolitic agglomerated material as defined above, comprising the following steps:

a) agglomeration of zeolite crystals, with an agglomeration binder, preferably containing at least 80% by weight of clay(s), shaping, drying and calcining,

b) optional zeolitization of at least a portion of the binder,

c) cationic exchange,

d) optional drying and

e) activation of the zeolitic agglomerated material obtained.

[0011c] In yet another aspect, there is provided a use of the material as defined above as a nitrogen adsorbent material for the separation of industrial gases and also for the separation of gases from the air and in particular for the production of high-purity medical oxygen, and most particularly in pressure swing processes, such as, for example, the industrial N_2/O_2 VPSA, industrial N_2/O_2 PSA, medical N_2/O_2 VPSA and medical N_2/O_2 PSA processes.

[0011d] In yet another aspect, there is provided a consumable cartridge of zeolitic adsorbent, comprising at least one zeolitic agglomerated material as defined above.

[0011e] In yet another aspect, there is provided an oxygen concentrator for respiratory assistance, which is transportable, mobile, preferably portable, comprising at least one zeolitic adsorbent material as defined above.

[0012] It has now been discovered that the abovementioned objectives are achieved, entirely or at least in part, by virtue of the present disclosure. Other further objectives will become apparent from the description of the disclosure which follows.

[0013] The present invention thus proposes new high-capacity zeolitic adsorbent materials from crystals of LSX zeolite, containing lithium, for the non-cryogenic separation of industrial gases by (V)PSA, more particularly for the separation of nitrogen and oxygen (N_2/O_2), and very particularly for the preparation of medical oxygen from air, and also for the industrial preparation of oxygen by (V)PSA.

[0014] Thus, and according to a first aspect, a subject of the present invention is a zeolitic agglomerated material in the form of a zeolite agglomerate particle comprising at least one zeolite and at least one binder, said zeolitic agglomerated material having a ratio of the volume-average diameter of said zeolite agglomerate particle relative to the number-average diameter of the zeolite crystals less than or equal to 70, and of which the volume-average diameter of said zeolite agglomerate particle is between 20 µm and 400 µm, preferably between 50 µm and 380 µm, limits included.

[0015] The ratio of the volume-average diameter of said zeolite agglomerate particle relative to the number-average diameter of the zeolite crystals is generally and advantageously greater than 1, preferably greater than 2, even

more preferably greater than 4. According to one preferred embodiment, this ratio is between 70 and 4, more preferably between 70 and 5.

[0016] According to one preferred embodiment, the zeolitic agglomerated material according to the invention comprises at least FAU-type zeolite crystals, said material having an Si/Al atomic ratio of between 1 and 2.5, preferably between 1 and 2.0, more preferably between 1 and 1.8, and entirely preferably between 1 and 1.6, measured by X-ray fluorescence, with a measurement uncertainty of ± 0.05.

CLAIMS

1. A zeolitic agglomerated material in the form of a zeolite agglomerate particle comprising at least FAU-type zeolite crystals, said material having an Si/Al atomic ratio of between 1 and 2.5 measured by X-ray fluorescence, with a measurement uncertainty of ± 0.05 and at least one binder,

- said zeolitic agglomerated material having a ratio of the volume-average diameter of said zeolite agglomerate particle relative to the number-average diameter of the zeolite crystals between 5 and 70, limits inclusive,
- and of which the volume-average diameter of said zeolite agglomerate particle is between 50 µm and 380 µm, limits included
- and wherein the zeolite crystals have a number-average diameter (d_{50}) of between 5.0 µm and 20.0 µm,
- and wherein the lithium content, expressed by weight of Li_2O, is between 8.0% and 12.0% by weight, limits included, relative to the total weight of the zeolitic agglomerated material,
- and wherein the amount of non-zeolite phase (NZP) is such that $0 < NZP \leq 25\%$ measured by X-ray diffraction (XRD), by weight relative to the total weight of the zeolitic agglomerated material.

2. The zeolitic agglomerated material as claimed in claim 1, comprising at least FAU-type zeolite crystals, said material having an Si/Al atomic ratio of between 1 and 2.0, more preferably between 1 and 1.8, and entirely preferably between 1 and 1.6, measured by X-ray fluorescence, with a measurement uncertainty of ± 0.05.

3. The zeolitic agglomerated material as claimed in claim 1 or claim 2, having a lithium content, expressed by weight of Li_2O, of between 9.0% and 12.0%, limits included, preferably between 10% and 12.0% by weight, limits included, relative to the total weight of the zeolitic agglomerated material.

4. The material as claimed in any one of the preceding claims, wherein the zeolite crystals have a number-average diameter (d_{50}) of between 5.0 µm and 15.0 µm.

5. The material as claimed in any one of the preceding claims, wherein the amount of non-zeolite phase (NZP) is such that 0 < NZP ≤ 20%, preferably 0 < NZP ≤ 15%, advantageously 0 < NZP ≤ 10%, even more advantageously 0 < NZP ≤ 8%, measured by X-ray diffraction (XRD), by weight relative to the total weight of the zeolitic agglomerated material.

6. The material as claimed in any one of the preceding claims, having a bulk density of between 0.50 $kg.m^{-3}$ and 0.80 $kg.m^{-3}$, preferably of between 0.55 $kg.m^{-3}$ and 0.75 $kg.m^{-3}$, more preferably of between 0.60 $kg.m^{-3}$ and 0.70 $kg.m^{-3}$.

7. A process of preparing the zeolitic agglomerated material as claimed in any one of claims 1 to 6, comprising the following steps:
a) agglomeration of zeolite crystals, with an agglomeration binder, preferably containing at least 80% by weight of clay(s), shaping, drying and calcining,
b) optional zeolitization of at least a portion of the binder,
c) cationic exchange,
d) optional drying and
e) activation of the zeolitic agglomerated material obtained.

8. The process as claimed in claim 7, wherein the optional zeolitization step may be carried out by immersing the agglomerate in an alkaline basic solution, which is generally aqueous, for example an aqueous solution of sodium hydroxide and/or of potassium hydroxide, the concentration of which is preferably greater than 0.5 M.

9. The use of the material as claimed in any one of claims 1 to 6 as a nitrogen adsorbent material for the separation of industrial gases and also for the separation of gases from the air and in particular for the production of high-purity medical

oxygen, and most particularly in pressure swing processes, such as, for example, the industrial N_2/O_2 VPSA, industrial N_2/O_2 PSA, medical N_2/O_2 VPSA and medical N_2/O_2 PSA processes.

10. The use as claimed in claim 9 as an adsorption element in oxygen concentrators for respiratory assistance.

11. A consumable cartridge of zeolitic adsorbent, comprising at least one zeolitic agglomerated material as claimed in any one of claims 1 to 6.

12. The cartridge as claimed in claim 11, further comprising at least one resin, preferably a polymeric resin selected preferably from thermoplastic homo- and/or copolymers, and polycondensates.

13. An oxygen concentrator for respiratory assistance, which is transportable, mobile, preferably portable, comprising at least one zeolitic agglomerated material as claimed in any one of claims 1 to 6.