

Spherical Mixed Metal Hydroxides and Processes for the Preparation Thereof

The present invention relates to spherical mixed metal hydroxides, processes for the preparation thereof, and the use thereof as precursors for cathode active materials of Li ion/polymer batteries.

Li ion/polymer batteries (LIB) are employed mainly in portable devices with a high energy requirement, such as mobile phones, tablet computers, laptops, and power tools. Recently, their importance within the scope of progressing electromobility has increased further. Here, they serve as energy stores in electric cars and pedelecs, and in hybrid vehicles. In the future, the demand for LIBs within the scope of the expansion of electromobility and the increasing demand for electric cars will become even higher.

All the materials employed in the LIBs have in common that, in addition to their limited abundance, the expensive way of recovering them is being criticized, which is usually associated with massive interventions into nature and the water balance of the mining regions. Therefore, for some time, the focus has been on the development of effective methods for recycling the valuable metals contained in the LIBs. Also, in the future, it will not be possible to cover the above mentioned multiplication of the need only from primary raw material sources of the different valuable metals, for both availability and sustainability reasons. In addition to lithium itself, this applies mainly to nickel and cobalt, as well as in a limited way, under environmental aspects, also manganese, which are employed as main constituents of LIB cathode materials.

The prior art already describes a number of methods for processing used LIBs.

Thus, US 2013/0302226 describes a method of recycling batteries comprising: generating a solution of aggregate battery materials from spent cells; precipitating impurities from the generated solution; adjusting the solution to achieve a predetermined ratio of desirable materials; and precipitating the desirable material in the predetermined ratio to form cathode material for a new battery having the predetermined ratio of the desirable transition metals.

US 2017/0077564 discloses a method in which the elements Co, Ni, Al and Mn are detached from used lithium ion batteries by extraction, in which further raw materials can be added as a function of the respective proportions of the elements, in order to achieve a desirable ratio of the elements.

The presented methods have in common that the process control introduced considerable amounts of sodium into the process, which have to be separated and discharged in the end of the process. First approaches of performing the processing without the use of Na are described, for example, in "A novel closed loop process for recycling spent Li-ion battery cathode materials", issued in *International Journal of Green Energy*, 18:15, 1597-1612. In this article, J. Zhang et al. present an approach in which LiOH and Li₂CO₃ are used as precipitation reagents instead of the usually employed NaOH and Na₂CO₃. At the end of the recycling process, Li₂SO₄ obtained is recovered by electrolysis as LiOH and H₂SO₄.

EP 4 023 610 describes a wet synthesis method for preparing NCMA precursors having a high nickel content. At first, in a first reactor, tiny NCMA crystal nuclei are continuously produced in an upper feed mode, and the particle growth thereof is then induced in a second reactor using a dual feed mode until a desired particle size is obtained.

US 11142466 describes a process for preparing cathode materials for lithium ion batteries in which a metal sulfate is reacted with LiOH, optionally in the presence of a chelating agent, to the corresponding hydroxide, wherein NaOH may also be used instead of LiOH.

EP 3916857 discloses an Ni-Co-Al composite hydroxide constituted of secondary particles, which are in turn aggregated from primary particles containing Ni, Co and Al. The Na content of such hydroxides is less than 0.0005% by mass.

EP 3 642 160 relates to β -nickel(II) hydroxides doped with Al and Co ions. The content of Na in these hydroxides is reported to be 23 ppm, and their tapped density to be 1.97 g/cm³.

CN 102432070 discloses LiMn₂O₄ with a tapped density of 2.1 to 2.4 g/cm³ and an Na content of ≤ 10 ppm.

However, the thus obtained cathode materials and the precursor compounds recovered from recycling processes, usually mixed oxides or carbonates, often have an insufficient sphericity. The latter, however, is a precondition of high packing densities and thus high energy densities in the battery, in addition to chemical purity.

Thus, there is still a need for cathode materials that are suitable for use in LIBs for high performance applications. The object of the present invention is to respond to this need and provide corresponding materials and processes for the preparation thereof.

Surprisingly, it has been found that this object is achieved by a mixed metal hydroxide having a spherical morphology and a low sodium content.

Therefore, the present invention firstly relates to a spherical mixed metal hydroxide as a cathode precursor material for batteries, in which said mixed metal hydroxide is characterized by a sodium content of 250 ppm or less, in which said mixed metal hydroxide comprises or consists of a mixture of at least two, preferably three, metals selected from the group consisting of Ni, Mn, Co, and Al.

The ppm values are based on the total weight of the mixed metal hydroxide. The sodium content in the mixed metal hydroxide can be determined, for example, by atomic absorption spectrometry.

Within the scope of the present invention, the term "metal" includes the metal in all of its oxidation states unless stated otherwise.

Within the scope of the present invention, the term "spherical" describes the morphology of the powder.

In the conventional precipitation of mixed hydroxides by reacting solutions of metal salts with aqueous sodium hydroxide solution, high Na contents may represent a problem, especially for compact larger spherical particles, in which the sodium ions cannot be washed out so easily from the fine pores of the particles. In order to address this problem, the precipitation of the mixed hydroxides could be performed with LiOH instead of NaOH, as proposed already in the prior art. However, in this precipitation method, it also has to be ensured that the particles are obtained in sufficiently spherical shapes.

For use in LIBs, in particular, powders having a spherical morphology are preferred that are at the same time characterized by low contents of impurities, such as sodium. Surprisingly, it has been found that mixed metal hydroxides that combine the advantages of a spherical morphology and of a low Na content and thus are particularly suitable as a precursor for the active materials in Li ion/polymer batteries (hereinafter referred to as LIBs) can actually be prepared from the corresponding mixed metal salt solutions by reacting with LiOH.

Accordingly, an embodiment is preferred in which the sodium content of the mixed metal hydroxide is 100 ppm or less, more preferably 50 ppm or less, especially 10 ppm or less, specifically 5 ppm or less, or 0.5 ppm or less.

In a preferred embodiment, the mixed metal hydroxide according to the invention has a content of Na of 0.01 ppm or more, preferably 0.05 ppm or more.

For use as precursors for cathode materials in LIBs, NCM (NiCoMn) and NCA (NiCoAl) mixed hydroxides or mixtures thereof are mainly used. Therefore, an embodiment is preferred in which said mixed metal hydroxide has the general formula $M^{(w)}(OH)_{w-2a}O_a$, with $M = Ni_xCo_yMn_zAl_{1-(x+y+z)}$, in which $0 \leq x \leq 1$; $0 \leq y \leq 1$; $0 \leq z \leq 1$; $0 \leq a \leq 1$; $0 \leq w \leq 1$.

1; $0 \leq z \leq 1$; and $0.8 \leq (x+y+z) \leq 1$, w represents the average oxidation state of the metal, and $0 \leq a \leq 1$.

Further, an embodiment is preferred in which $2 \leq w \leq 3+z$. Also preferred is an embodiment in which $2 \leq w \leq 3$, more preferably $2 \leq w \leq 3-x$ and even more preferably $2 \leq w \leq 3-(x+y+z)$.

A particularly preferred embodiment is characterized in that $0 \leq a \leq 1-x$ and more particularly $0 \leq a \leq 1-(x+y+z)$.

The stated formulas and the ranges of the indices are not to be understood as a restriction to the inventive concept. For example, those skilled in the art would complete the formula for a typical NCA composition with $M = \text{Ni}_{0.8}\text{Co}_{0.15}\text{Mn}_0\text{Al}_{1-(0.80+0.15+0)}$ to $\text{Ni}_{0.8}\text{Co}_{0.15}\text{Al}_{0.05}(\text{OH})_{1.95}\text{O}_{0.05}$. In this case, the Al^{3+} ion would be perfectly incorporated into the crystal lattice of the M^{2+} ions in the mixed hydroxide. While there is an OH ion for each M^{2+} ion above and below the M^{2+} layers, one OH ion is replaced by a divalent O^{2-} ion at the site where the Al^{3+} ion is located. However, the aluminum may also be separate as AlOOH or even $\text{Al}(\text{OH})_3$, as long as an intimate mixture of the primary crystallite exists on a microscopic level, and the sodium content with within the range according to the invention, and the powder particles have a sufficiently spherical shape. The above statement holds not only for Al, but also, for example, for Co and Mn, which can be easily oxidized to CoOOH and MnOOH by complete or partial oxidation, for example, when air is not completely excluded. In the case of manganese, even 2 oxide ions per Mn ion would be possible in the common crystal lattice, if the Mn ion was oxidized to the tetravalent oxidation state. But even a segregation of manganese dioxide MnO_2 on a microscopic level would not adversely affect the particles' character according to the invention, as long as there is a low Na content and a sufficient sphericity.

In the following, some compositions are summarized in an exemplary way without having a limiting effect. Those skilled in the art can easily derive therefrom further examples, for example, by interpolation or with the above defining formulas.

Ni	Co	Mn	Al
x	y	z	1-(x+y+z)
0,999	0,001	0,000	0,000
0,001	0,999	0,000	0,000
0,001	0,000	0,999	0,000
0,800	0,000	0,000	0,200
0,800	0,200	0,000	0,000
0,800	0,150	0,000	0,050
0,900	0,100	0,000	0,000
0,900	0,050	0,000	0,050
0,900	0,000	0,100	0,000
0,100	0,000	0,900	0,000
0,333	0,333	0,333	0,000
0,500	0,250	0,250	0,000
0,600	0,200	0,200	0,000
0,800	0,100	0,100	0,000
0,800	0,050	0,100	0,050
0,900	0,050	0,050	0,000
0,900	0,000	0,050	0,050
0,900	0,000	0,100	0,000

In addition to the low sodium content, the mixed metal oxides according to the invention are characterized, in particular, by their sphericity, which suggests it for use in high performance batteries, in particular. This sphericity is a characteristic indicating to what extent the morphology of the powder particles approximates the shape of a sphere, in which a sphericity of 1 corresponds to a perfect sphere. The mixed metal hydroxides according to the invention are specifically characterized by the spherical shape of the particles, whose form factor has a value of more than 0.7, more preferably more than 0.9, more preferably more than 0.95, more preferably from 0.98 to 1.

The form factor of the particles can be determined from scanning electron micrographs of the powders according to the method mentioned in US 5476530, columns 7 and 8, and Figure 5. The form factor is determined by evaluating the particle perimeter and the particle area and determining the diameter derived from the respective quantity. The mentioned diameters result from

$$d_U = U / \pi$$

$$d_A = (4A/\pi)^{1/2}$$

The form factor of the particles, f , is derived from the particle perimeter U and the particle area A according to:

$$f = \left(\frac{d_A}{d_U} \right)^2 = \left(\frac{4\pi A}{U^2} \right)$$

In the case of an ideal spherical particle, d_A and d_U are equal, and a form factor of exactly one would result.

Various dopants can be added to the cathode material in order to increase the performance and properties of LIBs. Therefore, an embodiment is preferred in which the mixed metal hydroxide according to the invention further contains dopants. These may be derived, in particular, from the alkaline earth group, the rare earth elements, or other secondary groups of the Periodic Table, preferably selected from the group of elements Mg, Sc, Y, Ti, Zr, V, Nb, Ta, Cr, Mo, and W. Other main group elements, such as Sn, may also be contained as dopants. Thus, according to the invention, embodiments are provided in which the Al is completely or partially replaced by dopants.

The performances of batteries as expected and required nowadays represent a material challenge. In order to achieve as high capacities as possible, it has proven advantageous if powders are used that have as spherical a morphology as possible and thus achieve a high packing density. The tapped density of the material has proven to be a good measure for the later packing density. Therefore, an embodiment of the mixed metal hydroxide according to the invention is preferred in which the mixed metal hydroxide has a tapped density of 1.5 g/cm³ or more, preferably 1.8 /cm³ or more, more preferably 2.0 g/cm³ or more, and specifically 2.2 g/cm³ or more, as determined according to ASTM 527.

The present invention further relates to a process for producing the mixed metal hydroxides according to the invention, said process comprising:

a) providing a solution containing MSO₄;

b) adding LiOH in the presence of NH_3 to obtain the mixed metal hydroxide and Li_2SO_4 ,

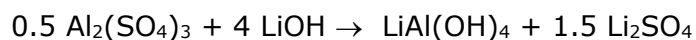
in which M represents a mixture of at least two metals selected from the group consisting of Ni, Mn, Co, and Al.

In an alternative embodiment, the mixed metal hydroxide according to the invention is preferably prepared by

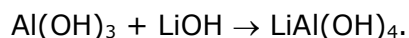
- a) providing a solution containing $\text{Al}_2(\text{SO}_4)_3$;
- b) combining the solution provided in step a) with a solution comprising LiOH;
- c) providing another solution comprising $(\text{Ni,Co,Mn})\text{SO}_4$;
- d) combining the solution obtained in step b) with the solution provided in step c) in the presence of NH_3 to obtain the mixed metal hydroxide and Li_2SO_4 , preferably continuously, in the reactor; and
- e) separating the thus obtained mixed metal hydroxide.

Within the scope of the present invention, those skilled in the art understand the designation $(\text{Ni,Co,Mn})\text{SO}_4$ as a mixed sulfate including at least two, preferably three, of Ni, Co and Mn.

The $\text{Al}_2(\text{SO}_4)_3$ solution employed in this embodiment, when mixed with the LiOH solution, reacts to form lithium aluminate $\text{LiAl}(\text{OH})_4$ and Li_2SO_4 according to the following equation:



More preferably, the lithium aluminate can also be prepared by dissolving aluminum hydroxide in an LiOH solution according to the equation:



The provision of aluminum as lithium aluminate offers the advantage that the aluminum is incorporated into the lattice of the mixed metal hydroxides in a particularly uniform way, rather than precipitating separately as aluminum hydroxide.

Irrespective of which variant of the process is preferred, the solvent for preparing the solutions can be selected according to need in the process according to the invention, wherein aqueous solvents, especially water and water-alcohol mixtures, are preferred, however.

The process according to the invention can be operated both in a discontinuous mode and continuously, or semi-continuously. Preferably, the process according to the invention is operated semi-continuously or continuously. A semi-continuous operating mode differs from a continuous process mode in that the product is continuously produced, but there is not continuous withdrawal of the product. In this way, the solids concentration in the production process can be increased, for example, which has a positive impact on the obtaining of as spherical powder particles as possible.

Especially in order to obtain as spherical powder particles as possible and to achieve as high a sphericity as possible, it has proven advantageous within the scope of the process according to the invention to operate at comparably high solids concentrations. Without being bound by theory, it is assumed that the sphericity of the particles can be increased by the impacts and friction experienced by the particles among themselves.

Therefore, an embodiment of the present invention is preferred in which the process is performed at a solids concentration of 50 g/l or more, preferably 200 g/l or more, more preferably 400 g/l or more, especially 600 g/l or more.

The advantageous solids concentration of the process according to the invention can be achieved, for example, by uniformly concentrating the suspension obtained of the mixed metal hydroxide, for example, by at least partially removing the mother liquor during the precipitation. Therefore, an embodiment is preferred in which the process according to the invention is performed with continuous separation of part of the mother liquor. Within the scope of the

present invention, "mother liquor" designates the liquid from which the mixed metal hydroxide is deposited.

The separating of part of the mother liquor can be effected by different methods. Within the scope of the present invention, in particular, separating by means of a static lamella separator has proven advantageous, whereby a further increase of the sphericity of the mixed metal hydroxide obtained could be achieved. Therefore, an embodiment is preferred in which the partial separation of the mother liquor is effected by using a lamella separator.

The morphology of the powder can further be influenced through the concentration of LiOH and NH_3 , in addition to the solids concentration. In a preferred embodiment, the LiOH concentration is preferably from 0.01 to 4 g/l, preferably from 0.1 to 4 g/l, more preferably from 0.1 to 2 g/l, especially from 0.3 to 2 g/l. Further, an embodiment is preferred in which the NH_3 concentration is from 2 to 20 g/l, preferably from 5 to 20 g/l, more preferably from 5 to 15 g/l. The stated concentrations are respectively based on the volume employed.

The present invention further relates to a spherical mixed metal hydroxide having a sodium content of 250 ppm or less, wherein said mixed metal hydroxide is obtained by a process including the following steps:

- a) providing a solution containing MSO_4 ;
- b) adding LiOH in the presence of NH_3 to obtain the mixed metal hydroxide and Li_2SO_4 ,

in which M represents a mixture of at least two, preferably three, metals selected from the group consisting of Ni, Mn, Co, and Al.

A continuous or semi-continuous process mode, in which the individual reagent solutions are continuously and separately fed into the stirred suspension, has proven advantageous. In continuous operation, the mixed metal hydroxide is continuously withdrawn, while in semi-continuous operation, merely the reagents are continuously fed.

The present invention further relates to a spherical mixed metal hydroxide having a sodium content of 250 ppm or less, wherein said mixed metal hydroxide is obtained by a process including the following steps:

- a) providing a solution containing $\text{Al}_2(\text{SO}_4)_3$;
- b) combining the solution provided in step a) with a solution comprising LiOH ;
- c) providing another solution comprising $(\text{Ni,Co,Mn})\text{SO}_4$;
- d) combining the solution obtained in step b) with the solution provided in step c) in the presence of NH_3 to obtain the mixed metal hydroxide and Li_2SO_4 ; and
- e) separating the thus obtained mixed metal hydroxide.

The mixed metal hydroxide according to the invention can be obtained within the scope of the processing of used LIBs. In this case, an embodiment is preferred in which the solution comprising MSO_4 or $(\text{Ni,Co,Mn})\text{SO}_4$ is derived from a process of processing used LIBs.

An application envisioned for the mixed metal hydroxide according to the invention is the use as a precursor of cathode materials in LIBs. For this field of application, a particular ratio of the components of the mixed metal hydroxide is desirable, which may vary depending on the type of battery and kind of application, and is critical for the performance of the battery. In the nickel-cobalt-manganese (NCM) mixtures used in conventional LIBs, the metals are typically in a ratio of 1:1:1. Recently, however, the trend tends towards nickel-enriched powders, in which the components are contained in a ratio of Ni:Co:Mn of $6/10:2/10:2/10$, $8/10:1/10:1/10$ or even $9/10:0.5/10:0.5/10$ or intermediate forms, such as $8/10:1.5/10:0.5/10$ thereof. Advantageously, the ratio of the components of the mixed metal hydroxide can be adjusted already during its preparation process. Therefore, an embodiment is preferred in which the process further comprises a step in which the stoichiometry of the mixed metal hydroxide is adjusted. Said adjusting of the stoichiometry may be effected either by adding the corresponding component or components, or by a selective partial separation.

Within the scope of the present invention, the selective separation for adjusting the stoichiometric ratio is preferred, since the use of additional material and the associated disadvantages can be avoided thereby. This approach is particularly advantageous since it can tackle the conversion of the previous cathode material, in which Ni, Co and Mn are present in a ratio of 1:1:1, to the higher nickel materials.

Various dopants can be added to the cathode material in order to increase the performance and properties of LIBs. It has proven advantageous within the scope of the process according to the invention to introduce such dopants into the mixed metal hydroxide, for example, by coprecipitation. Therefore, an embodiment of the process according to the invention is preferred in which further metals are added, preferably in the form of their sulfates. The further metals may be derived from the alkaline earth group, the rare earth metals, or other secondary groups of the Periodic Table, preferably selected from the elements Mg, Sc, Y, Ti, Zr, V, Nb, Ta, Cr, Mo, and W. Other main group elements, such as Sn, may also be added as dopants. Preferably, dopants are added to the sulfate solutions MSO_4 and $(\text{Ni,Co,Mn})\text{SO}_4$.

According to the invention, the mixed metal hydroxide is obtained from the corresponding sulfates by reacting them with LiOH , in which Li_2SO_4 is obtained as a by-product. Advantageously, such Li_2SO_4 can be used in further applications. Preferably, the Li_2SO_4 obtained within the scope of the process according to the invention is converted to LiOH and H_2SO_4 by electrolysis. Preferably, both is recycled to the reaction cycle, so that a closed process cycle is formed. For the electrolysis, a membrane electrolysis is preferred, especially electrodialysis, more specifically electrodialysis with bipolar membranes. Particularly preferred is a multicompartment electrolysis with a cation exchange membrane and an anion exchange membrane.

Because of its sphericity and its low sodium content, the mixed metal hydroxide according to the invention is suitable, in particular, for use in LIBs. Therefore, the present invention further relates to the use of the mixed metal hydroxide according to the invention as a cathode precursor material in the production of batteries, especially LIBs.

The present invention is further explained by means of the following Example, which should by no means be understood as limiting the idea of the invention.

Example:

For the preparation of spherical NCM material using LiOH as a precipitating reagent, 0.41 l/h of metal sulfate solution containing 10 g/l of metal sulfate salt solution containing 32.76 g/l of nickel, 1.70 g/l of manganese and 1.83 g/l of cobalt as well as 0.31 l/h of an LiOH solution containing 98.7 g/l of LiOH and 0.11 l/h of an NH₃ solution containing 225 g/l of NH₃ were continuously metered in to a 10-liter stirring reactor. The reactor was subjected to thorough mixing by using a stirrer at 500 rpm, and maintained at a temperature of 50°C using jacket heating. Every hour, about 0.87 l of suspension was conveyed from the reactor using a dip tube within one minute, in order to prevent sedimentation in the withdrawal tube. Therefore, the filling level in the reactor showed a sawtooth profile over time, in which the dwelling time characteristic was close to that of a fully continuous operation.

Figure 1 shows optical micrographs of the mixed metal hydroxide obtained after 36 hours of dwelling time at 500 times magnification (left) and 200 times magnification (right). The spherical shape of the particles is clearly seen.

C L A I M S :

1. A spherical mixed metal hydroxide as a cathode precursor material for batteries, characterized in that said mixed metal hydroxide has a sodium content of 250 ppm or less, in which said mixed metal hydroxide comprises or consists of a mixture of at least two, preferably three, metals selected from the group consisting of Ni, Mn, Co, and Al.
2. The mixed metal hydroxide according to claim 1, characterized in that said mixed metal hydroxide has the general formula $M^{(w)}(OH)_{w-2a}O_a$, with $M = Ni_xCo_yMn_zAl_{1-(x+y+z)}$, in which $0 \leq x \leq 1$; $0 \leq y \leq 1$; $0 \leq z \leq 1$; and $0.8 \leq (x+y+z) \leq 1$, w represents the average oxidation state of the metal, and $0 \leq a \leq 1$.
3. The mixed metal hydroxide according to at least one of the preceding claims, characterized in that the form factor of the particles has a value of more than 0.7, more preferably more than 0.9, more preferably more than 0.95, more preferably from 0.98 to 1.
4. The mixed metal hydroxide according to at least one of the preceding claims, characterized in that the mixed metal hydroxide has a sodium content of 100 ppm or less, more preferably 50 ppm or less, even more preferably 10 ppm or less, and specifically 5 ppm or less, or 0.5 ppm or less.
5. The mixed metal hydroxide according to at least one of the preceding claims, characterized in that the mixed metal hydroxide has a tapped density of 1.5 g/cm³ or more, preferably 1.8 g/cm³ or more, more preferably 2.0 g/cm³ or more, specifically 2.2 g/cm³ or more, as determined according to ASTM 527.
6. A process for preparing spherical mixed metal hydroxides according to at least one of the preceding claims, said process comprising:
 - a) providing a solution containing MSO_4 ;

b) adding LiOH in the presence of NH_3 to obtain the mixed metal hydroxide and Li_2SO_4 ,

in which M represents a mixture of at least two metals selected from the group consisting of Ni, Mn, Co, and Al.

7. The process for preparing spherical mixed metal hydroxides according to at least one of 1 to 5, characterized in that

a) providing a solution containing $\text{Al}_2(\text{SO}_4)_3$;

b) combining the solution provided in step a) with a solution comprising LiOH;

c) providing another solution comprising $(\text{Ni}, \text{Co}, \text{Mn})\text{SO}_4$;

d) combining the solution obtained in step b) with the solution provided in step c) in the presence of NH_3 to obtain the mixed metal hydroxide and Li_2SO_4 ; and

e) separating the thus obtained mixed metal hydroxide.

8. The process according to at least one of claims 6 to 7, characterized in that said process is operated in a semi-continuous or continuous mode.

9. The process according to at least one of claims 6 to 8, characterized in that the process is performed with continuous separation of part of the mother liquor.

10. The process according to claim 9, characterized in that the separation of the mother liquor is effected by using a lamella separator.

11. The process according to at least one of claims 6 to 10, characterized in that the process is performed at a solids concentration of 50 g/l or more, preferably 200 g/l or more, more preferably 400 g/l or more, especially 600 g/l or more.

12. The process according to at least one of claims 6 to 11, characterized in that the process further comprises a step of adjusting the stoichiometry of the mixed metal hydroxides.
13. The process according to at least one of claims 6 to 12, characterized in that the process further comprises a step in which the Li_2SO_4 obtained is converted to LiOH and H_2SO_4 by electrolysis.
14. The process according to claim 13, characterized in that LiOH and/or H_2SO_4 is recycled into the reaction cycle.
15. Use of a mixed metal hydroxide according to at least one of claims 1 to 5 as a cathode precursor material for batteries, especially Li ion/polymer batteries.