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General principles of sodium ion battery cathode materials

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Foreword

This document is a guiding technical document of the specification type.

This document was drafted in accordance with the rules given in GB/T 1.1-2020, Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents.

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This document was proposed by the China Nonferrous Metals Industry Association and is under the jurisdiction of the National Technical Committee on Nonferrous Metals of Standardization Administration of China (SAC/TC 243).

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1 Scope

This document specifies the classification and naming, the technical requirements, the inspection rules, the marking, packaging, transport and storage, the accompanying

documents and the content of the order form for sodium ion cathode materials, and describes the corresponding test methods.

This document applies to the production and inspection of cathode materials for sodium ion batteries.

2 Normative references

The following documents contain provisions which, through normative reference in this text, constitute indispensable provisions of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document, including any amendments, applies.

GB/T 5162, Metallic powders - Determination of tap density

GB/T 5211.6, General methods of test for pigments and extenders - Part 6: Determination of pH value of an aqueous suspension

GB/T 5314, Powders for powder metallurgical purposes - Sampling

GB/T 19077, Particle size analysis - Laser diffraction methods

GB/T 35924, Determination of moisture content in solid chemical products - Thermogravimetry

GB/T 44330, Cathode materials for lithium ion batteries - Determination of powder compacted density

GB/T 45330, Cathode materials for lithium ion batteries - Determination of moisture content - Karl Fischer coulometric method

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 sodium ion battery - an electrochemical cell based on the migration of sodium ions in the electrolyte and their reversible intercalation into and deintercalation from the cathode and anode materials.

3.2 sodium ion battery cathode materials - materials in a sodium ion battery in which a sodium-bearing compound is the cathode active substance.

3.3 transition metal oxide cathode materials - materials made up of a compound of transition metal elements, such as nickel, cobalt, manganese and iron, with oxygen, serving as the cathode active substance of a sodium ion battery.

3.4 prussian blue cathode materials - compounds with an open three-dimensional channel structure obtained by introducing other metal ions into the prussian blue structure

[Fe(CN)6]4-, serving as the cathode active substance of a sodium ion battery.

3.5 polyanionic cathode materials - compounds made up of a series of anionic tetrahedra (XO4)n- or their derived groups (XmO3m+1)n-, where X is B, S, P, Si, As, Mo, W or similar, together with transition metal-oxygen polyhedra (MOx), serving as the cathode active substance of a sodium ion battery.

3.6 specific capacity - the electrochemical capacity charged or discharged by unit mass of active substance under specified conditions. Note: the unit is milliampere-hours per gram. [Source: GB/T 20252-2014, 3.1, modified]

3.7 efficiency - the percentage ratio of the discharge capacity to the charge capacity of the active substance under specified conditions. [Source: GB/T 20252-2014, 3.2]

4 Classification and naming

4.1 Classes. 4.1.1 Cathode materials for sodium ion batteries comprise transition metal oxide cathode materials, prussian blue cathode materials and polyanionic cathode materials. 4.1.2 Transition metal oxide cathode materials are divided by the number of metal elements into four classes: unary, binary, ternary and quaternary. 4.1.3 Prussian blue cathode materials are classified by the principal metal element into four classes: manganese-based, denoted M; iron-based, denoted F; nickel-based, denoted N; and copper-based, denoted C. 4.1.4 Polyanionic cathode materials are classified by differences in chemical composition, mainly into four classes: phosphate, denoted P; fluorophosphate, denoted f; pyrophosphate, denoted J; and sulfate, denoted S.

4.2 Transition metal oxide cathode materials. 4.2.1 These comprise layered and tunnel-type transition metal oxide materials, with the general formula NaxM'O2, where M' is a transition metal representing cobalt, iron, manganese, titanium, nickel and others. 4.2.2 They are named by the principal metal and the battery class, and the code is formed from the code of the principal metal element and the battery class code N. The classification, names and codes of typical transition metal oxide cathode materials are given in Table 1. Example: a transition metal oxide cathode material whose principal metals are nickel, iron, manganese and copper is named sodium nickel iron manganese cuprate cathode material and coded NNFMC.

Table 1 lists the unary materials NaxCoO2 (NC'), NaxMnO2 (NM), NaxVO2 (NV) and NaxFeO2 (NF), and the binary materials Na[NixCo1-x]O2 (NNC'), Na[NixFe1-x]O2 (NNF), Na[NixTi1-x]O2 (NNT), Na[FexCo1-x]O2 (NFC'), Na2/3[FexMn1-x]O2 (NFM), Na2/3[Mn1/3Co2/3]O2 (NMC') and Na2/3[Ni1/3Mn2/3]O2 (NNM).

Table 3 lists the typical polyanionic materials: the phosphates NaFePO4 (NFP), Na3V2(PO4)3 (NVP) and NaFe2Mn(PO4)3 (NFMP); the sulfate Na2Fe(SO4)2 (NFS); the pyrophosphates Na2FeP2O7 (NFJ), Na2CoP2O7 (NC'J) and Na4Fe3(PO4)2(P2O7) (NFPP); and the fluorophosphates Na3V2(PO4)2F3 (NVPf), Na2FePO4F (NFPf) and