

Claims

1. Catalytically active material, comprising grains of non-graphitizing carbon with iron nanoparticles dispersed therein,
wherein
 - 5 d_p , the average diameter of iron nanoparticles in the non-graphitizing carbon grains, is in the range of 1 nm to 20 nm,
 D , the average distance between iron nanoparticles in the non-graphitizing carbon grains, is in the range of 2 nm to 150 nm, and
 ω , the combined total mass fraction of metal in the non-graphitizing carbon grains, is in the
10 range of 30 wt% to 70 wt% of the total mass of the non-graphitizing carbon grains,
wherein d_p and D are measured by TGZ-TEM as described herein,
and wherein
 d_p , D and ω conform to the following relation:
 $4.5 d_p / \omega > D \geq 0.25 d_p / \omega$.
- 15 2. Material according to claim 1, wherein the non-graphitizing carbon grains exhibit the following particle size distribution: $d_{10} = 5 \mu\text{m}$, $d_{50} = 40 \mu\text{m}$, $d_{90} = 150 \mu\text{m}$
3. Material according to any one of claims 1 to 2, wherein the total mass fraction of nitrogen in the non-graphitizing carbon grains is less than 1 wt% of the total mass of the non-graphitizing carbon grains.
- 20 4. Material according to any one of claims 1 to 3, wherein d_p is in the range of 4 nm to 18 nm.
5. Material according to any one of claims 1 to 4, wherein d_p is in the range of 6 nm to 14 nm.
6. Material according to any one of claims 1 to 5, wherein the material has been doped with dopant metal,
and wherein the dopant metal is selected from Na (sodium), K (potassium), Ca (calcium), Mg
25 (magnesium) or mixtures thereof,
and wherein the non-graphitizing carbon grains exhibit a molar ratio $\text{RDM} = n(\text{iron}) : n(\text{dopant metal})$ in the range of 5 to 1000.
7. Material according to any one of claims 1 to 5, wherein the material has been combined with secondary metal,
30 and wherein the secondary metal is selected from group 1 or group 2,

with group 1 defined as: Mo (molybdenum) or W (tungsten) or mixtures thereof, and

with group 2 defined as: Co (cobalt) or Cu (copper) or Mn (manganese) or mixtures thereof,

and wherein the non-graphitizing carbon grains exhibit a molar ratio $RSM = n(\text{iron}) : n(\text{secondary metal})$ in the range of 1 to 50,

- 5 8. Process for the manufacture of material according to any one of claims 1 to 7, comprising the following steps:
- (a) providing an aqueous solution comprising metal precursor and organic carbon source, wherein the metal precursor comprises one or a combination of more than one organic, at least partially water soluble, salts of iron, and
- 10 wherein the organic carbon source is one or a combination of more than one saturated, aliphatic di-, tri-, or polycarboxylic acids,
- (b) spray drying or freeze drying the aqueous solution of metal precursor and organic carbon source and, thus, obtaining intermediate product P,
- (c) thermo-treating intermediate product P at a temperature in the range from 200 °C to 380 °C.
- 15 9. Process according to claim 8, wherein the organic carbon source is selected from malonic acid, tartaric acid, citric acid and mixtures thereof.
10. Process according to any one of claims 8 to 9, wherein intermediate product P is thermo-treated at a temperature in the range from 255 °C to 375 °C for 1 to 4 hours.
- 20 11. Process according to any one of claims 8 to 10, wherein intermediate product P is thermo-treated at a temperature in the range from 300 °C to 350 °C for 1 to 4 hours
12. Use of material according to any one of claims 1 to 7 as a catalyst.
13. Use according to claim 12, wherein the catalyst is a catalyst for the hydrogenation of organic compounds and/or the reductive amination of carbonyl compounds.
- 25 14. Use according to claim 12, wherein the catalyst is a catalyst for the conversion of carbon monoxide, carbon dioxide or mixtures thereof with hydrogen, to alkenes, alkanes or mixtures thereof.