Claims

1. A composite ZSM-5 molecular sieve whose a single crystal comprises a main crystal and a twin crystal; wherein the main crystal and the twin crystal are both ZSM-5 crystals; a crystal plane [010] of the main crystal is covered by a crystal plane [100] of the twin crystal; the ratio of the number of sinusoidal pore openings to the number of straight pore openings on the external surface of the single crystal of the composite ZSM-5 molecular sieve is (0.7-10:1); the molar ratio Y_1 of Si element to Al element within 10nm of the surface of the composite ZSM-5 molecular sieve is (300-2,000):1, wherein a single crystal of the composite ZSM-5 molecular sieve has a length of 10-50μm, a height of 1-20μm and a width of 1-20μm; and a single crystal of the composite ZSM-5 molecular sieve has a specific surface area of 200-600 m^2/g.

2. The composite ZSM-5 molecular sieve of claim 1, wherein the ratio of the number of sinusoidal pore openings to the number of straight pore openings on the external surface of the single crystal of the composite ZSM-5 molecular sieve is (0.9-3.2):1.

3. The composite ZSM-5 molecular sieve of claim 1 or 2, wherein the molar ratio Y_1 of Si element to Al element within 10nm of the surface of the composite ZSM-5 molecular sieve is (500-1,200):1.

4. The composite ZSM-5 molecular sieve of any one of claims 1-3, wherein the molar ratio Y_2 of Si element to Al element of the composite ZSM-5 molecular sieve as a whole is (20-600):1, preferably (50-300):1.

5. A method for preparing a composite ZSM-5 molecular sieve comprising:
(1) mixing a silicon source and an aluminum source in the presence of water, a first templating agent and a second templating agent, adjusting the pH to be within a range of 11-13.5, and then performing crystallization;
(2) subjecting the crystallized product to a solid-liquid separation, and calcining the obtained solid phase to prepare the composite ZSM-5 molecular sieve;
wherein the first templating agent is at least one selected from the group consisting of tetraethylammonium hydroxide, tetrapropylammonium hydroxide, tetrapropylammonium bromide and tetrabutylammonium hydroxide, the second templating agent is at least one selected from the group consisting of ethylenediamine, n-butylamine, hexamethylenediamine, ethylamine, ethanol and ethanolamine; and the

used amount of the first templating agent to the second templating agent in a molar ratio is 1: (1-30),

wherein a molar ratio of the used amount of the silicon source, the aluminum source, the first templating agent, the second templating agent and water is 100: (0.08-2.5): (0.5-6): (0.5-60): (100-4,000); wherein the silicon source is calculated in terms of SiO_2, the aluminum source is calculated in terms of Al_2O_3;

preferably, a molar ratio of the used amount of the silicon source, the aluminum source, the first templating agent, the second templating agent and water is 100: (0.4-2): (1-6): (3-30): (500-4,000).

6. The method of claim 5, wherein a molar ratio of the used amount of the first templating agent to the second templating agent is 1: (3-20).

7. The method of claim 5 or 6, wherein the pH in step (1) is adjusted to 11.2-13.

8. The method of any one of claims 5-7, wherein the crystallization conditions in step (1) comprise a temperature of 120-250°C and a time of 12-72h; preferably, a temperature of 150-180°C and a time of 24-60h;

the calcination conditions in step (2) comprise a temperature of 500-700°C, and a time of 1-24h, preferably, a time of 4-12h.

9. The method of any one of claims 5-8, wherein the solid phase obtained from the solid-liquid separation is subjected to drying prior to calcining; preferably, the drying conditions comprise a temperature of 90-200°C and a time of 2-12h.

10. The composite ZSM-5 molecular sieve produced with the preparation method of any one of claims 5-9.

11. A catalyst comprising the composite ZSM-5 molecular sieve of any one of claims 1-4 and 10.

12. A use of the composite ZSM-5 molecular sieve of any of claims 1-4 and 10 or the catalyst of claim 11 in the alkylation reaction of toluene methanol to prepare p-xylene.